Effect of fruit coatings and packaging on chilling injury of 'Hass' avocados

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ABSTRACT

Previous work had indicated that external chilling injury of 'Hass' fruit could be decreased by controlling post-harvest water loss using micro-perforated polypropylene packs. However, air delivery temperature was set at 2ºC and fruit from mid season was most successfully stored. The question arose as to whether lower temperatures and longer periods of harvest, particularly at the end of the season, would result in greater chilling injury risk. Thus, work was conducted from early to late in the season, and air delivery decreased to 1ºC. Work on citrus implied that addition of gibberellic acid (GA) can decrease chilling sensitivity. Thus, treatments included polypropylene bags, waxing, GA, as well as an untreated control. The GA treatments were also combined with bags and waxing. Fruits were externally evaluated in terms of chilling-like discoloration after removal from 30 days storage. Results showed that no treatments eliminated external rind discoloration, although fruit appeared to ripen and colour normally. Rind collapse did not occur. For early fruit, the best treatment appeared to be the bags, while waxing was particularly deleterious. GA on its own was also not useful, although when combined with bags indicated further work may be useful. Later fruit showed more intense external symptoms, but this was not consistent, and nor did it match apparent maturity levels. There is considerable doubt that the rind coloration is chilling damage and may be a reflection of stress resulting in the development of a protective mechanism against chilling injury. While more work is necessary to decrease the risk of chilling injury occurring, it is believed that low temperature shipping is viable, with good outturn at ripe stage.

INTRODUCTION

Potential new markets will probably require a set of phytosanitary mitigating treatments. This will most likely be, at least in part, a cold treatment. In addition, traditional markets require an assumed internal quality implying no mesocarp discoloration and extended shelf life for market flexibility with good external appearance showing no chilling injury or pathological disorders. Based on previous work (Bower, 2005) a low temperature storage regime (2ºC), provided fruit water loss is controlled, appeared to work well. However, before such a programme can be confidently used commercially, there are still a number of issues to be clarified. Although a storage temperature of 2ºC appeared acceptable for 'Hass', in reality a lower air delivery temperature will be needed to ensure (particularly if temperature variation in containers is taken into account) that fruit flesh is held at the required temperature.

In addition to the lower temperature which required testing, there appeared to be some uncertainty over the effects of maturity. Although Bower (2005) found that 'Hass' fruit appeared able to tolerate a 2ºC temperature for 30 days, work was conducted primarily during the mid-season period, and there is general consensus that early season fruit is more susceptible to chilling injury than later harvested fruit (Kosiyachinda & Young, 1976; Swarts, 1980).

Some evidence form the work of Bower & Magwaza (2004) implies that late season fruit, perhaps due to the lower water content of the fruit at harvest, could also be more susceptible to damage. This seemed to be confirmed by work (unpublished) conducted in Limpopo Province.

The objectives of the work conducted during the 2005 season were therefore to evaluate the effects of a lower than previously tested air delivery temperature, as well as time of harvest during the season, on external and internal quality of 'Hass' fruit. The role of chilling injury mitigating treatments previously found useful, such as polypropylene packaging (Bower & Jackson, 2003), wax and plant growth regulators previously found successful in citrus (El-Zeftawi *et al*., 1989) were included.

MATERIALS AND METHODS

All fruit was sourced from the KwaZulu-Natal midlands. Fruit had been sized and graded, as well as brushed, but no further treatments were applied in the packhouse. All fruit were of the same count size. Fruit was harvested from early through to late in the season, with three dates reported on in this paper.

After arrival at the laboratory, the following treatments were applied:

- Control (no treatment)
- Wax (a standard avocado wax was applied by hand)
- Packaging with polypropylene packaging containing 9 µ perforations and anti-mist coating
- Fruit dipped in gibberellic acid (GA) at 10 and 20 ppm, with and without wax coating
- Fruit dipped in ISR2000® at 300 mls product / 100 ℓ water with and without wax coating (product has an auxin-like activity and also acts as a phytoallexin).

After treatment, fruit was placed in storage with an air delivery temperature of 1ºC. In order to check air temperature, Hobo data loggers were used. In addition, fruit mesocarp temperature was checked using a fruit probe attached to a Hobo data logger.

Both before and after storage, each fruit was weighed to determine fruit water loss. In addition, an estimate of fruit moisture content at harvest was made, and packhouse fruit moisture content results across the season obtained.

After storage, fruit were scored for external and internal disorders, with particular emphasis on chilling injury. External damage was scored as a percentage of the fruit surface damaged or coloured (black or purple colour) and if present, exocarp collapse noted as in chilling injury (Shewfelt,1993).

Each treatment consisted of 10 fruits, each constituting a single replication. Statistical analysis was conducted using Genstat.

Treatment differences were separated by means of least significant differences at P=0.05.

RESULTS

As expected, fruit moisture content as an indicator of maturity, showed a decline during the season (Kruger *et al*., 1995). However, this decline was relatively slow between April and June, and small from early May to late June (**Figure 1**).

A rapid decline in fruit moisture content (with therefore perceived maturity) was noted late in the season, from August to September. It was also noted that within any group of fruit, a wide range of fruit moisture content was evident. For example, where a mean of 70% moisture was calculated, actual individual fruit moisture contents of the 10 fruits measured, ranged from 66% to 74%.

Externally, fruits showed considerable change. Within the first 10 days of storage, dark coloured patches developed on the surface, and appeared to be most extensive in the controls (**Figure 2**). The most significant treatment differences are shown in **Figure 3** for the early-harvested fruit. At the time of removal from storage, fruit in bags showed the least surface coloration.

This was significantly less (P=0.05) than the group of treatments showing the most coloration (control, wax and GA 20ppm + wax) which did not differ from each other. The differences were large, with the fruit in the bags showing approximately 35% of the surface coloured, while other treatments exceeded 70%.

In the case of fruits harvested at mid-season, (early July) a fairly similar pattern was observed (**Figure 4**). The treatments resulting in the least colouration were bags and ISR2000® + bags, which were again significantly (P=0.05) less coloured than other treatments, especially the controls (45% as opposed to almost 90%).

In the case of late-harvested fruit (harvested early September), the overall exocarp coloration across all treatments appeared to be considerably higher than previously found, with even the least colouration being almost 70% of rind surface (**Figure 5**). However, it was also found that none of the treatments showed any statistical difference.

On removal from storage, none of the fruits showed typical symptoms of chilling injury as indicated by exocarp collapse. Only coloration was evident. As fruit ripened, normal 'Hass' fruit colour developed (**Figure 6**), with no indication of true chilling injury. In fact, due to earlier concerns as to the cause of the changes exhibited, an additional treatment was included for the

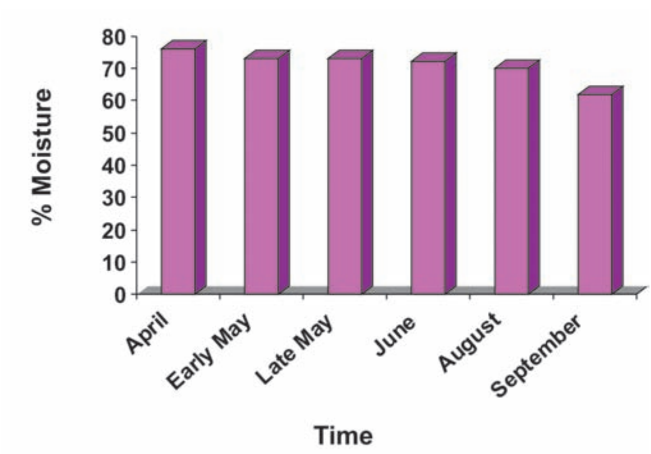

Figure 1. Mean fruit moisture content during the harvest season.

Figure 2. Fruit appearance (control treatment) after 30 days storage at 1ºC.

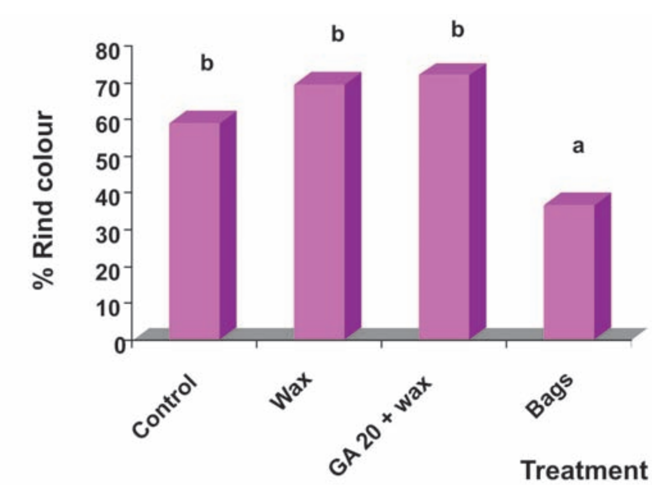

Figure 3. Effect of treatments on fruit rind colour after storage at 1ºC for 30 days (early harvest fruit).

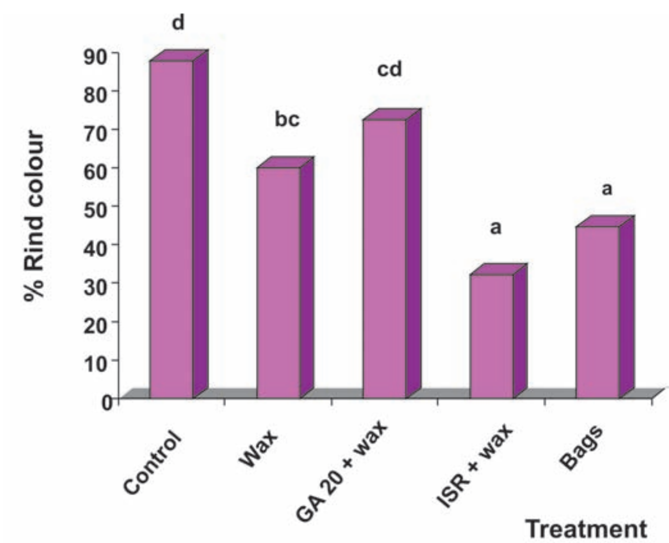

Figure 4. Effect of treatments on fruit rind colour after storage at 1ºC for 30 days (mid season fruit).

late-harvested fruit. The treatments were in this case stored at 5.5ºC as well as 1ºC. The results indicated the same high level of coloration at both temperatures, with no significant (P=0.05) differences.

From a fruit internal perspective, the mesocarp showed no chilling injury.

DISCUSSION AND CONCLUSIONS

It would appear that 'Hass' fruit react to chilling, especially very low temperature induced, in a manner different to that exhibited by green skins. It is assumed that the temperature imposed (1ºC) created a certain degree of stress, which may have been modified by the treatments imposed. Previous work has indicated the effects of water loss during the post-harvest period combined with other stress such as the low temperature (King & O'Donoghue, 1995) can create damage, and this may be especially so in green skins. 'Hass', however, shows far less tendency to such damage (Bower, 2005). The lower level of stress imposed by the presence of micro-perforated bags and the colour reaction noted may confirm this.

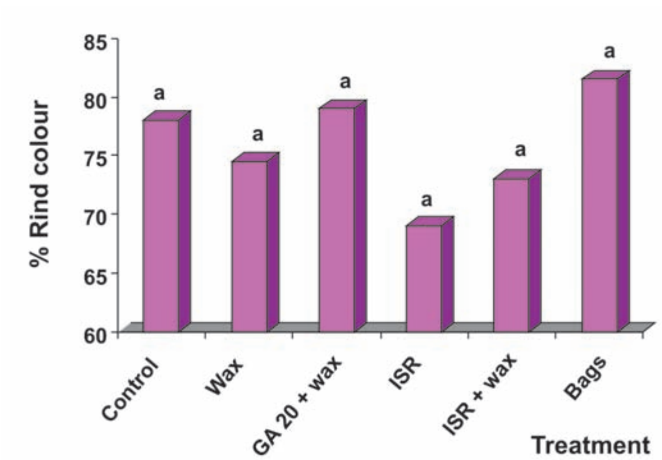

Figure 5. Effect of treatments on fruit rind colour after storage at 1ºC for 30 days (late season fruit).

The use of wax is questionable. While wax can be expected to decrease water loss, it may create other stresses, notably the restriction of gas exchange (Amerante & Banks, 2001). This may explain the apparent lack of effect for most of the wax treatments.

There seemed to be no consistency in the results obtained with the addition of ISR2000® or GA, with both showing variable fruit colour results. The ISR2000® may have had a slightly more marked effect, notably during the mid and late-season harvests. The auxin-like activity may have had a similar effect to the auxin compounds often used to retard senescence of the button in stored citrus. Whether the dosage used was optimal or not is unknown, and thus the compound perhaps deserves further investigation.

The coloration of the fruit would appear to be consistent with a stress response. The pigment in 'Hass' exocarp is considered to be of an anthocyanin nature, and these compounds may act as an anti-oxidant and free radical scavenger to protect tissue against excessive stress. It is therefore suggested that the stress imposed by the low temperature storage (similar temperature effects have been found in other fruits such as apples) (Harborne, 1980) stimulates the colour response as a protective mechanism. It was notable that as the season progressed, with fruit water content decreasing and thus inherent stress levels (King & O'Donoghue, 1995) increasing, so the percentage of fruit showing coloration seemed to increase. The effects of water loss modification mechanisms such as the micro-perforated bags also appeared to diminish.

It is presumed that the protectant function of the coloration pigments has some limits. Early in the season, factors such as lipid saturation in membranes could be important (Nilsen & Orcutt, 1996) in the chilling injury development. The other stress factors such as water loss may compound these effects. Based on present evidence, no change in presently used maturity standards for early season harvests is suggested. However, the increasing effect on coloration through the season, suggests an increased overall fruit stress level (combined inherent water content, post-harvest loss and temperature stress). Based on the

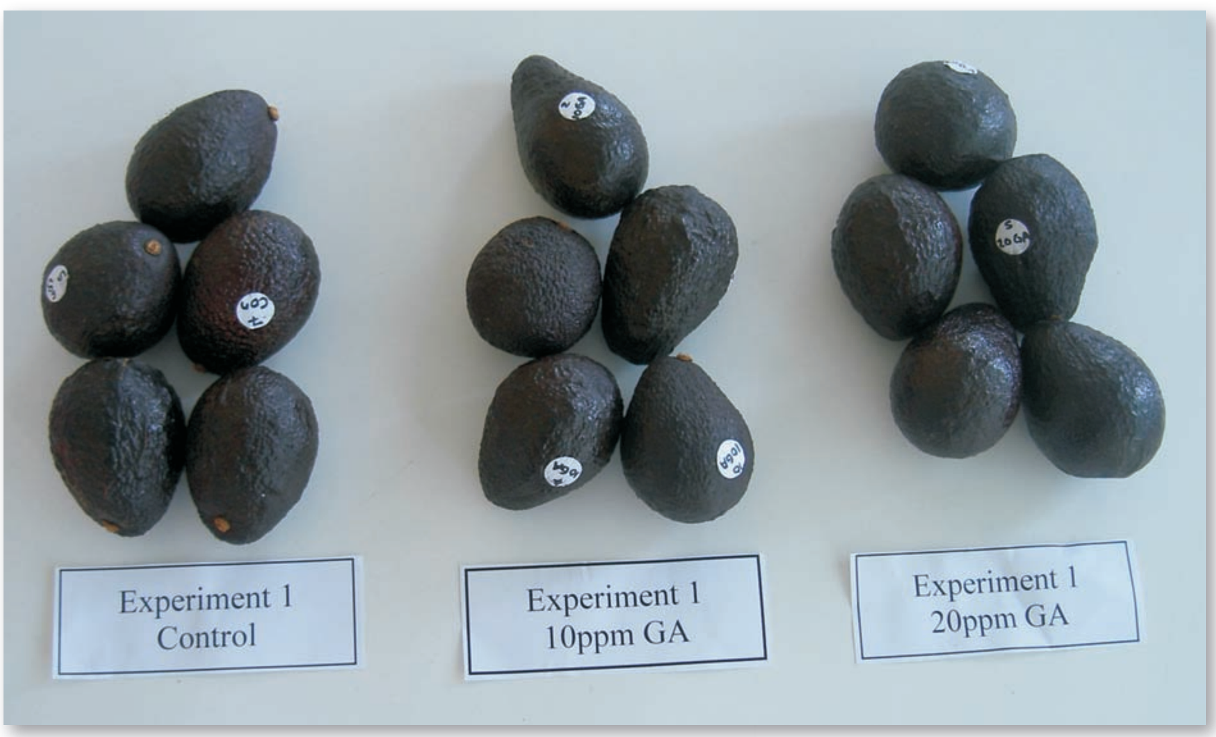

Figure 6. Fruit after ripening.

results presented, it is suggested that a fruit moisture cut-off level at harvest, be set at 70%. The rapid decrease in fruit moisture content during the period after August, co-incided with a marked increase in fruit coloration and no post-harvest treatment effect (**Figure 5**). While no exocarp collapse was visible, this lack of treatment effect may imply an unacceptable risk that the suggested protective function of the coloration may be nearing its limit in terms of the overall stress due to cell water content and temperature.

It is concluded that it is possible to ship 'Hass' fruit for 30 days at 1ºC, provided that overall fruit stress is suitably managed. This may include not harvesting the fruit too early (immature), or at less than 70% moisture content, and managing post-harvest water loss.

The colour development in response to the low temperature in particular, should not be considered as irreversible damage leading to classical chilling injury, and the trade would need to be informed of this. Thus, such fruit would be most suited to ripening programmes, where fruit would colour before distribution to final point of sale. The effects of shipping at temperature lower than 1ºC are not known, and a modification of the outlined parameters or other mitigating treatments to modify the stress response may be necessary.

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