EFFECT OF FRUIT COATING AND PACKAGING ON EXERNAL AND INTERNAL QUALITY

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ABSTRACT

In order to reach the major markets for South African avocados, it is necessary to hold fruit at low temperature for up to 30 days. The lower the temperature used the less likely the incidence of internal disorders, provided the temperature is not below the threshold for inducing chilling injury. However, the temperature used is often one of compromise, as external chilling injury often occurs at the temperature required to ensure internal quality. This is particularly notable for the green skin cultivars such as 'Pinkerton'. Previous work on cultivar Fuerte showed an interaction between water loss and chilling injury at low temperature, which could be modified by postharvest treatments. The objective of the study was to investigate options for decreasing external injury but at the same time maintaining high internal quality. Both 'Pinkerton' and 'Hass' were used in the study. Two wax formulations were applied to fruit, and two types of poly-bag packaging were used. In the latter case fruit were not waxed. One bag was micro-perforated and the other contained an ethylene scrubber. Fruit were stored for 30 days at 2^{0}C, 5.5^{0}C and 8^{0}C. After removal from storage ripening was at 20^{0}C. After each week of storage samples were removed from the cold store to evaluate fruit condition before and after ripening. In addition, respiration rate of each fruit was determined as was time to ripening and thus shelf life. From the results, it is intended to develop an appropriate protocol for quality maintenance.

INTRODUCTION

The quality of avocado fruit shipped from South Africa to European markets is often compromised by internal disorders, particularly in the case of 'Pinkerton'(van Rooyen & Bower, 2002), and chilling injury as an external form of damage, notable in the green skins (Nelson, Bezuidenhout & Donkin, 2002). Previous work has shown that storage at temperatures lower than presently used for shipping, had a positive effect on internal quality, particularly 'Pinkerton' (van Rooyen & Bower, 2002). Unfortunately, external damage appears to be enhanced at the temperature most useful for preventing internal discoloration (Bower, Dennison & Fowler, 2003). The latter authors, however, also found that there was a significant interaction between temperature and fruit water loss, and that if one can prevent water loss during storage, then it may be possible to ship at temperatures low enough to ensure good internal quality, and at the same time prevent external damage.

Water loss control has traditionally been achieved by waxing or other surface coatings applied to the fruit (Rose, 1992). The effectiveness may, however, be questioned, as the composition can affect the properties of the coating (Amerante & Banks, 2001). Coatings will also modify the gas exchange properties of the fruit, thereby altering the ripening pattern (Banks, 1984; Smith, Geeson & Stow, 1987; Banks, Cleland & Yearsley, 1993; Baldwin, 1994 and Amerante, Banks & Siva, 1997). The coating type did affect the incidence of external damage in a study conducted by Bower, Dennison & Fowler (2003).

Previous work investigated the use of polyethylene bags as a packaging form, with the intention of decreasing the incidence of both external and internal disorders (Eksteen & Truter, 1985). While achieving positive results, an enhanced danger of postharvest pathogens due to excessive moisture within the bags was noted. Similar results were reported by Bower, Dennison & Fowler (2003), using polypropylene bags.

The intention of the work was to investigate various forms of packaging for avocados, so as to decrease the potential for external and internal damage during shipment, while at the same time maintaining fruit firmness followed by normal ripening without the problems associated with polyethylene bags as previously noted.

MATERIALS AND METHODS

Both 'Hass' and 'Pinkerton' fruit were used in the investigation. These were obtained from growers in the KwaZulu-Natal midlands. In both cases fruit was treated the day after collection. 'Hass' fruit were all of count 16, while the 'Pinkerton' were selected so as to be of common size.

The freshly harvested avocado fruit were cleaned to remove any surface residues, and weighed. The various treatments were then applied. These included two waxes, one perforated (nine micron) polypropylene bag which included an anti-mist coating on the inner surface, one perforated polyethylene bag which included an ethylene scrubber bonded to the inner surface and a control. Fruit which were placed in the bags were subjected to a normal atmosphere at the start. Bags were heat sealed. The wax treatments were applied using a cloth and fruit allowed to dry before further processing. The fruits were placed into 4kg cartons and randomly distributed into the three respective cold rooms. Each of the treatments was subjected to three different temperatures, 2^0C, 5.5^0C and 8°C, for a period of 30 days. For all treatments, sufficient fruit was packed such that destructive sampling could be undertaken every 10 days during the storage period.

At each evaluation, fruit were checked for mass change, carbon dioxide exchange and internal and external quality. Carbon dioxide exchange was determined by placing each fruit into a three litre jar, which was sealed for 10 minutes. The change in CO_2 concentration during this period was determined with a PP Systems infrared gas analyser. Concentration was adjusted for head space volume in the jar by subtracting the fruit volume, determined by water displacement at the end of the experiment, and results expressed in relation to fruit mass.

After 30 days, the remaining fruit were removed, analysed and then stored at room temperature to determine their shelf life. Fruit softening was determined with a densimeter with a 0 to 100 scale. Hard fruit would result in a reading of 100 while fruit considered eating ripe result in a reading of 50 to 55.

For each evaluation date and treatment seven replications in the form of single fruits were used. Statistical analysis was conducted using ANOVA with GENSTAT.

RESULTS AND DISCUSSION

Fruit mass loss

The mass loss of fruits during the storage period is shown in Figures 1 and 2, for 'Hass' and 'Pinkerton' respectively. It is assumed that the majority of mass loss is due to water loss. The control treatment resulted in the greatest loss of moisture. The two bag treatments reduced water loss considerably with the perforated polyethylene ethylene scrubber bag treatment resulting in the least water loss. The two wax treatments showed less water loss than the control but more than the bag treatments. Wax 2 resulted in less water loss than wax 1 treatment.

Temperature influenced mass loss, with fruit stored at 2°C loosing less than those stored at 5.5°C and 8°C. The 5.5^{0}C storage temperature resulted in a higher mass loss than the 8^{0}C storage temperature. This may have been due to the environmental conditions prevailing at the time, but the general principle of the lower temperature resulting in less mass loss is noted, as was the different degree of mass loss resulting from the treatments. This is in accordance with previous work of Bower, Dennison & Fowler (2003).

CO_2 exchange

As can be expected, fruits stored at higher temperature showed higher rates of respiration as indicated by the CO_2 exchange levels. There were no significant differences on a rate of exchange per unit fruit mass between the two cultivars.

When considering the results over the entire storage period, the control fruits had a significantly (p=0.05) higher mean CO_2 exchange rate than all other treatments (Figure 3). While no significant differences were observed between the other treatments, there was a tendency for the polypropylene micro-perforated bags to induce a lower rate than other treatments in the case of 'Pinkerton'. This may be important, as it was found that CO_2 exchange was highest on the day of packing, decreasing rapidly and thereafter remaining constant throughout the storage period, but being suppressed by the packaging material. Over a long period, the difference may result in a lower cumulative amount of reserves used by the fruit. This could be of consequence in relation to total shelf life.

Rate of ripening

The rate of ripening for each cultivar was indicated by the change in densimeter readings over time. Figures 4 and 5 show the effect of treatment on this reading ten days after removing fruit from the 30 day storage regime. As expected, fruit stored at the higher temperature of 8^{0}C softened fastest while those stored at 2^{0}C slowest. However, postharvest treatment also played a role. The control fruit softened fastest, while the two bag treatments were slowest. Fruit in the bags containing an ethylene scrubber were the slowest to ripen, but there was no significant difference between this and the polypropylene bags, raising the question as to whether there is any value in ethylene scrubbing of the atmosphere during shipping of avocados. In the case of 'Pinkerton', all treatments other than the control resulted in the same effect on ripening rate, with no significant differences. For 'Hass', however, the two bag treatments were significantly better than both waxes at 5.5^{0}C and 8^{0}C, but not at the lowest temperature of 2^{0}C.

External chilling injury

Fruit stored at temperatures of 5.5^{0}C and 8 °C showed no chilling injury. Fruit stored at 2°C showed some chilling injury, but treatment linked. The control showed the largest amount of chilling injury, with the wax treatments showing less damage and the perforated bag treatments no damage. This is similar to the result obtained in the previous work by Bower, Dennison & Fowler (2003), where a significant interaction between temperature and water loss was found. It is suggested that there is an interaction between temperature and water loss, which dictates the overall level of stress to which the fruit is subjected. Thus, if water loss can be decreased, such as occurred in the bag treatments, a lower temperature threshold for chilling damage will occur.

Conclusions

The perforated bags performed better than the wax treatments, which outperformed the control. It is suggested that the bags reduced gaseous exchange by creating a modified atmosphere. This could have had the effect of reducing the respiratory requirement for carbohydrates, thus decreasing the potential for readily available energy source depletion, resulting in less chance of cellular collapse (King & O'Donoghue, 1995). The additional effect of decreasing water loss further enhanced the effect of decreasing overall stress on the fruit. Therefore, the fruit is able to withstand a lower temperature of storage. The fruit rind is probably the most sensitive in this regard, and thus the positive interaction between temperature and water loss on the incidence of damage usually referred to as chilling injury. Internally, fruit appears to be tolerant of the lowest temperature used (2^{0}C), and this has been confirmed in work by van Rooyen & Bower (2002) particularly for 'Pinkerton'. The decreased energy requirements during the storage period, created by the lower respiration rate due to temperature and perhaps the modified atmosphere surrounding the fruit as created by the bag packaging could be significant.

It is therefore concluded that the advantages of low temperature shipment in preserving internal fruit quality, and decreasing the rate of softening after shipping, can be realised without the risk of external chilling injury if packaging such as the micro-perforated polypropylene with anti mist coating is used to decrease fruit water stress and modify respiration rate. Gaseous exchange needs to be adequate to prevent anaerobic conditions but low enough to allow a modified atmosphere to develop. The wax treatments reduced gaseous exchange and water loss, but less so than the perforated bags and are therefore not as effective. Further research will be necessary to incorporate the concepts outlined into an economically viable commercial packing process.

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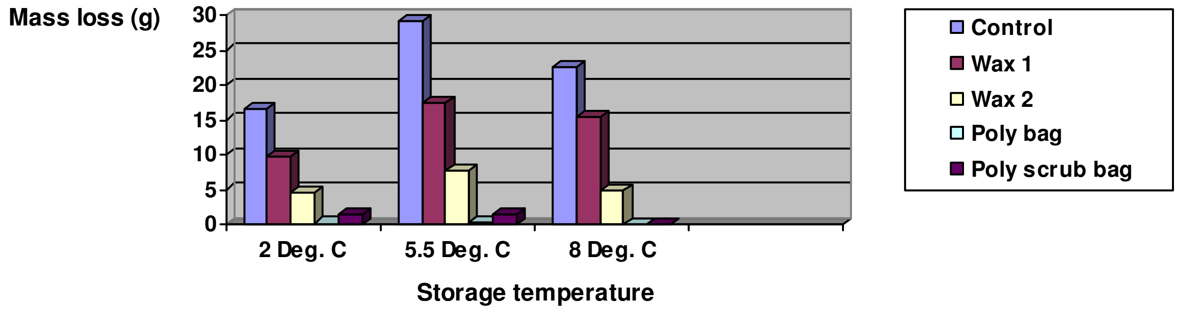

Figure 1: Fruit mass loss during storage as affected by temperature and postharvest treatment for cv Hass.

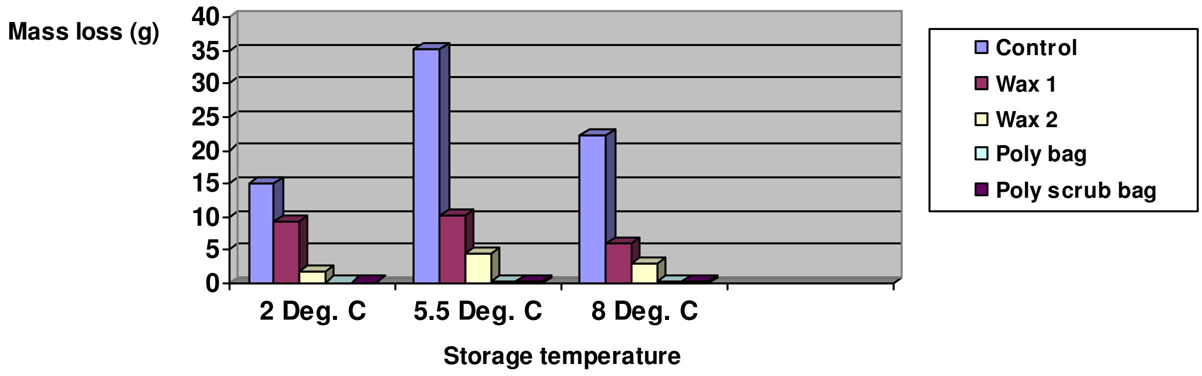

Figure 2: Fruit mass loss during storage as affected by temperature and postharvest treatment for cv Pinkerton.

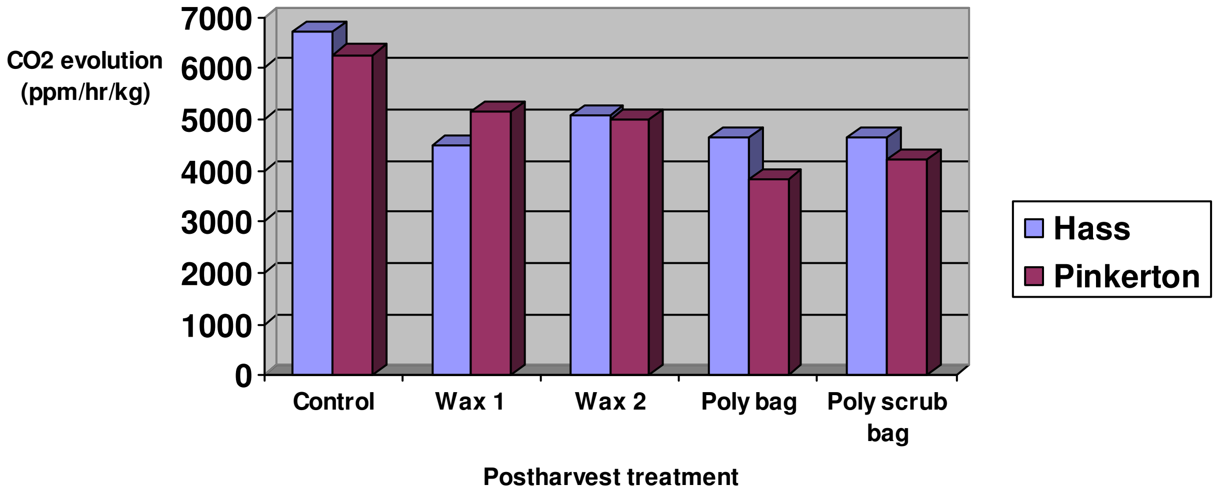

Figure 3: Fruit CO_2 evolution as influenced by postharvest treatment.

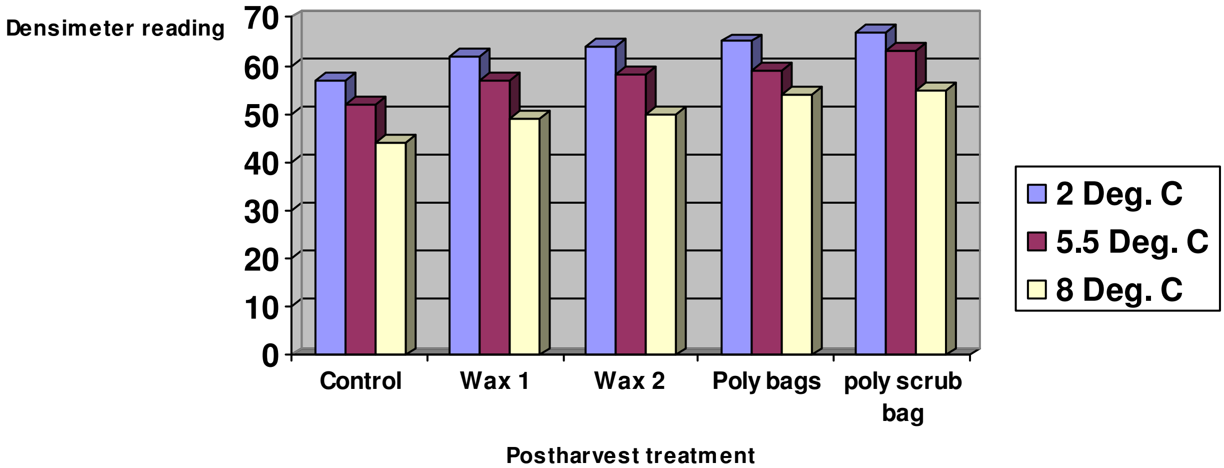

Figure 4: Effect of postharvest treatment on fruit softness 10 days after completion of 30 days storage for cv Hass.

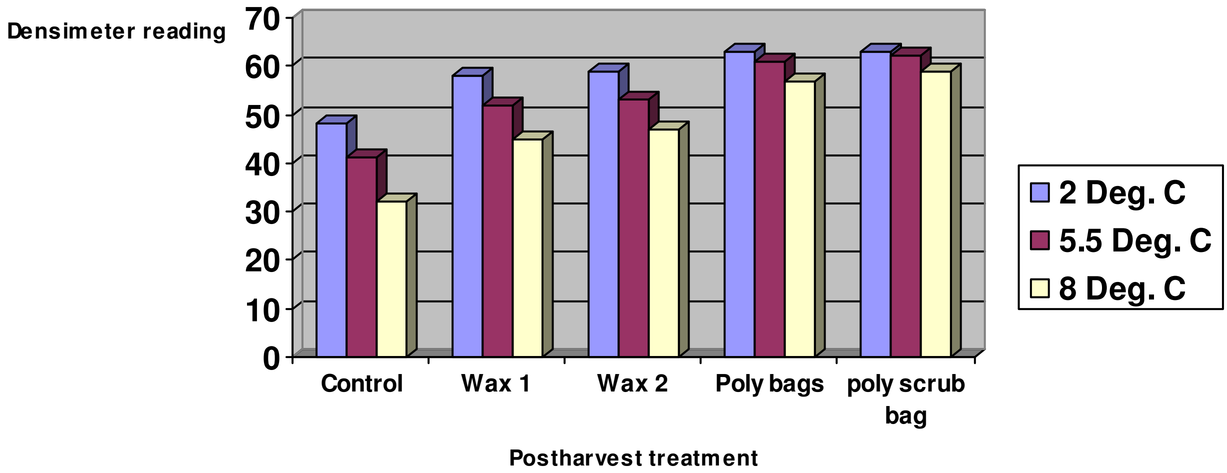

Figure 4: Effect of postharvest treatment on fruit softness 10 days after completion of 30 days storage for cv Pinkerton.