South African Avocado Growers' Association Yearbook 1998. 21:88-92

Post-Harvest Vapour Heat Treatment of Hass and Fuerte Avocado for the 1997 Season

P.L.Weller[1], B.N. Wolstenholme[1] & M.J. Savage[2]
[1]Department of Horticultural Science, University of Natal, Private Bag X01. Scottsville, Pietermaritzburg 3209
[2]Department of Agronomy, University of Natal, Private Bag X01, Scottsville, Pietermaritzbug 3209

ABSTRACT

In an attempt to extend storage life, Hass and Fuerte avocado *(Persea Americana* Mill) fruit were exposed to post-harvest vapour heat treatments of varying duration and temperature. The vapour heat treatment temperature regimes were 36, 38, 40 and 42°C for durations of 1, 2, 4 and 8 hours each. On removal from cold storage fruit were evaluated for firmness, and ripened at room temperature. Ripe fruit were evaluated for heat/cold damage, days to ripening, weight loss and physiological disorders. These experiments were conducted during the 1996 and 1997 Fuerte and Hass avocado seasons.

For both seasons it was found that appropriate vapour heat treatment extended Fuerte and Hass avocado storage and shelf life. When evaluating the best time/temperature combination vapour heat treatment for each cultivar for both seasons, the extra extension of shelf life was, in some cases, limited by rind heat damage. In 1996, the best time/temperature combination for Fuerte was at 38°C between 4 and 8 hours, 40°C between 4 and 8 hours and 42°C between 2 and 4 hours. For Hass, best results were achieved at 38°C between 4 and 8 hours. In 1997, Fuerte's best time/temperature combination was at 36°C between 4 and 8 hours. For Hass the best time/temperature combination was achieved at 38°C and 40°C for 8 hours.

INTRODUCTION

Due to the traditional European avocado markets reaching saturation, alternative markets should be considered to avoid oversupply and lower prices. Markets such as Japan and Canada are an option if one can increase the storage life of fruit and meet the specific phytosanitary requirements. A major concern with the export of avocados is that fruit must arrive with acceptable firmness. The South African avocado industry is investigating various options for remunerative marketing of the expected larger crops, especially once the effects of prolonged drought and other climatic upsets have been overcome. The export crop of 6.5-7 million cartons in 1996 and 1997 will inevitably be followed by a crop far exceeding the record of over 10 million cartons. New markets and the adoption of CA storage are inevitable. The industry has also noted the promising reports of post-harvest heat treatments in Israel and New Zealand, and is supporting

local research in this field.

Klein and Lurie (1991) stated that vapour heat treatment of avocados has the following benefits:

- It reduces rate of ripening in climacteric fruit and hence extends shelf life.

- Increases tolerance of harvested products to low temperatures, thereby reducing chilling injury.

- Reduces incidence of post-harvest diseases.

- Controls pests (disinfestation) such as with fruit fly found in papaya *(Carica* papaya L.) in Hawaii.

A variety of heat treatments have been tested such as dry heat, vapour heat and hot water in subtropical fruit such as avocado and papaya (Donkin and Wolstenholme, 1995). Heat treatment temperatures differ according to type of fruit. The oil storing avocado appears to be more heat sensitive than sugar storing fruit; hence lower temperatures are used for heat treatment in avocados (Bard and Kaiser, 1996).

MATERIALS AND METHODS

In this experiment two cultivars of avocado were used, viz. Fuerte donated by Everdon Estate near Howick and Hass donated by Cooling farm in the Bruyns Hill area. Both are large, well-managed farms where the objective is to maximise the quantity and quality of export fruit. Both cultivars were exposed to the same treatment. The experimental design for the vapour heat treatments used on both cultivars is illustrated in figure 1. Both cultivars were exposed to temperatures of 36, 38, 40 and 42°C for a duration of 1, 2, 4 and 8 hours respectively. Control fruit were not heat treated and placed in cold storage. The statistical design was completely randomised, with 17 treatments and 32 (Fuerte) or 36 (Hass) single-fruit replicates.

For each treatment and storage period there were 32 replications for Fuerte and 36 for Hass. For example, 32 Fuerte avocados were treated at 38°C for 4 hours, and stored for 5 weeks. The count size used (per 4 kg export carton) for Fuerte was 16 (236-265g) and for Hass was 18 (21-235g). Fruit were treated in a vapour heat chamber, a Paxton Electrotherm heater and humidification unit constructed by Agrilek, Cedara College and attached to a modified shipping container. For each treatment, air and fruit pulp temperatures were recorded with the use of a Campbell Scientific® data logger attached to several thermocouples. Fruit pulp temperatures were measured by inserting thermocouples (1 cm) into fruit mesocarp. From information obtained by the data logger, graphs were obtained to ensure conditions were correct (figure 2) for every treatment. Once fruit had been treated, they were placed in cold storage at approximately 3.5°C, which is lower than the traditional 5.5°C used in South Africa. Every treatment had a storage period of 5 and 6 weeks, respectively.

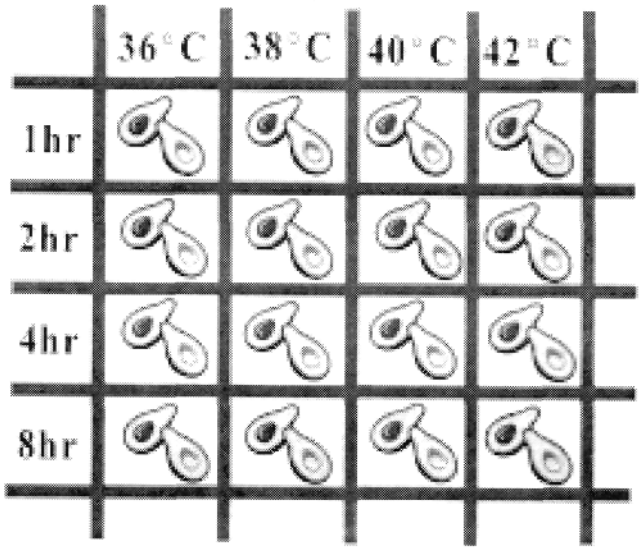

Figure 1 Experimental design for vapour heat experiment to be inserted.

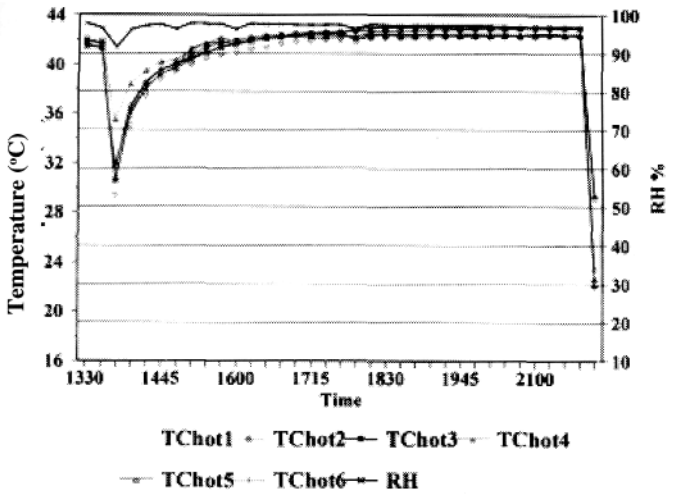

Figure 2 A typical graph displaying fruit pulp temperature of vapour heat treatment at 42°C (TC=thermocouple, RH = relative humidity)

Cold storage temperatures for the entire trial of the 1997 avocado season were recorded, to ensure conditions were correct (figure 3). For the 1997 season fruit pulp temperatures were also recorded (figure 3) and it can be seen that fruit pulp temperatures lagged behind the air temperature. Following cold storage, fruit were removed and allowed to ripen at room temperature. The overall experiment was geared to both the 1996 and 1997 Hass and Fuerte avocado export seasons for KwaZulu-Natal mid-lands. This was necessary as it is well known in the industry that fruit quality varies significantly from season to season.

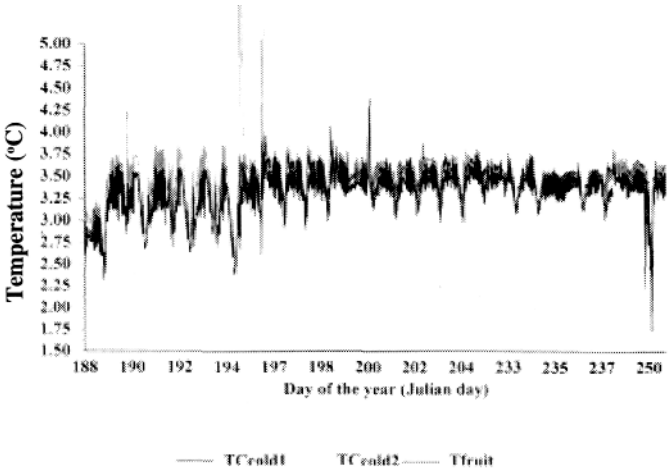

Figure 3. The cold storage air and fruit pulp temperatures for the 1997 season

Once fruit was removed from cold storage it was evaluated with regard to firmness, days to ripening, heat/cold damage, physiological disorders and weight loss. Firmness was measured, with a firmometer in the 1996 season and with a densimeter in the 1997 season, as soon as fruits were removed from cold storage. The reason for changing from a firmometer to a densimeter was to keep up to date with instrumentation as used by the South African Avocado Growers' Association to evaluate exported fruit arriving at the various ports of destination. Unlike the firmometer values, the higher the densimeters value the harder the fruit. Days to ripening was time taken from when fruits were removed from cold storage to eating ripe at room temperature (ca. 20°C) Heat/cold damage was evaluated on removal from cold storage, as well as at time of ripening. Physiological disorders were evaluated when fruit were ripe. Weight loss of fruit was determined after vapour heat treatments as well as after 5 and 6 week storage periods. The overwhelming bulk of this loss was believed to be due to water loss from the fruit.

RESULTS AND DISCUSSION FOR 1997 AVOCADO SEASON

Promising results were obtained from the 1996 avocado season, but many environmental factors can change from year to year. For this reason it was necessary to repeat the experiment for the 1997 avocado season to evaluate if vapour heat treatment of avocados is a post-harvest technique that can be considered to extend shelf life from year to year, and not be dependent on the varying fruit quality from year to year.

Firmness

Fuerte

Densimeter readings for Fuerte after 5 weeks of cold storage (figure 4) for treatments at 36°C and 38°C displayed no trend, while at 40°C increasing duration of treatment resulted in firmer fruit. At 42°C similar trends were noted except for the 8 hour treatment

which resulted in softer fruit, perhaps indicating that this treatment is the cut off point between beneficial and detrimental treatments. The densimeter readings for the control vs effect of treatment temperature, effect of time and temperature: time interaction were not significantly different. Densimeter readings for Fuerte after 6 weeks storage (figure 5) showed similar trends to the 5 week storage period, but slightly poorer results at 38°C. The differences in temperature were significant (P<0.01**) for the 6 week storage period.

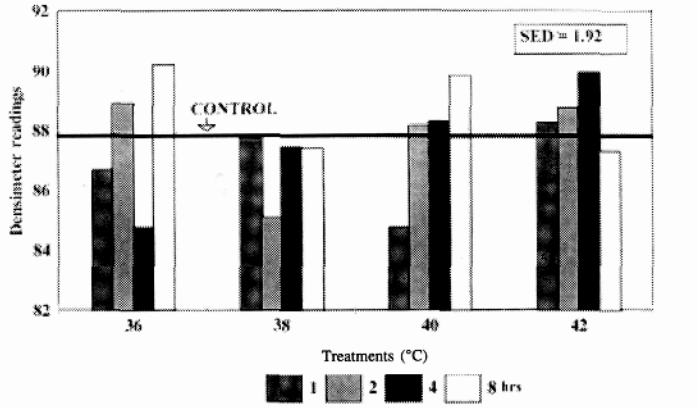

Figure 4. Fruit firmness (densimeter readings) for Fuerte after 5 weeks of cold storage at 3.5°C

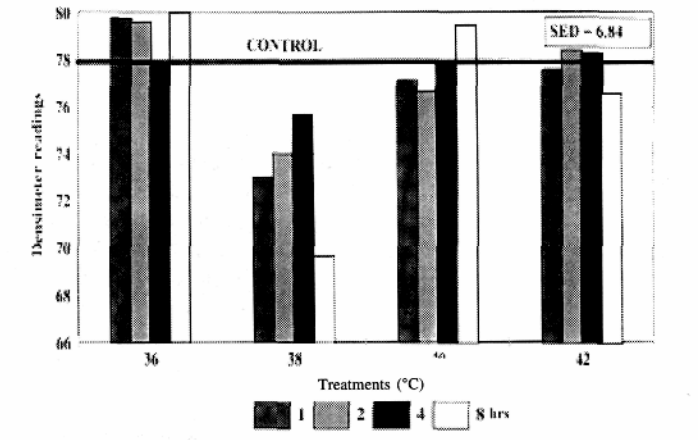

Figure 5. Fruit firmness (densimeter readings) for Fuerte after 6 weeks of cold storage at 3.5°C

Hass

Densimeter readings for Hass after *5* weeks of cold storage for all treatments were below that of the control, i.e. softer fruit, and no trends were observed (figure 6). Although, the densimeter readings for the treatments were below that of the control, the difference between the control and the lowest densimeter reading is only 7 units. The

differences in duration of temperatures and the time/temperature interaction between different temperatures were not significant. Untreated fruit (P<0.01**) and different temperatures (P<0.05**) were significantly different when comparing densimeter readings. For Hass after 6 weeks of cold storage (figure 7) no obvious trends were seen, and again al values for heat treated fruit were less than that of the control. The difference between the control and lowest value was 10 units. The controls treatment effects of temperature and temperature/time interaction were significantly different (P<0.001**). The differences in treatment time were not significant.

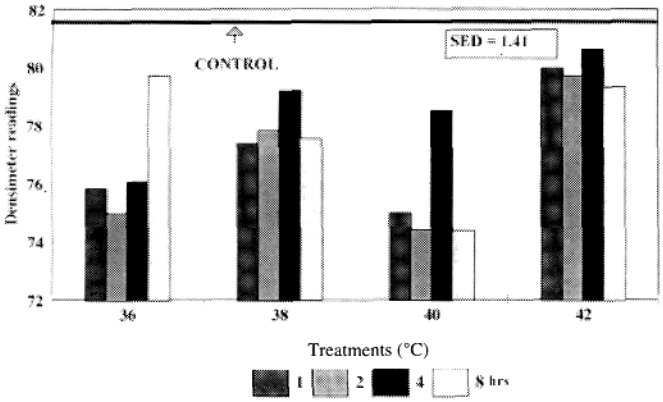

Figure 6. Fruit firmness (densimeter readings) for Hass after 5 weeks of cold storage at 3.5°C

In 1997 all heat treatments failed to keep fruits firmer than untreated fruits, unlike 1996. Although when the rest of the season's data were analysed, a positive result similar to 1996 was found with regard to extending shelf life. The results obtained from 1997 illustrating that the fruit are softer than that of the control could be due to the use of the densimeter. This could be due to the densimeter having a small ball bearing testing the pressure of the mesocarp as opposed to the firmometer which tests a far greater area and to a greater depth; hence it would suffice to say the readings from the firmometer could be more accurate.

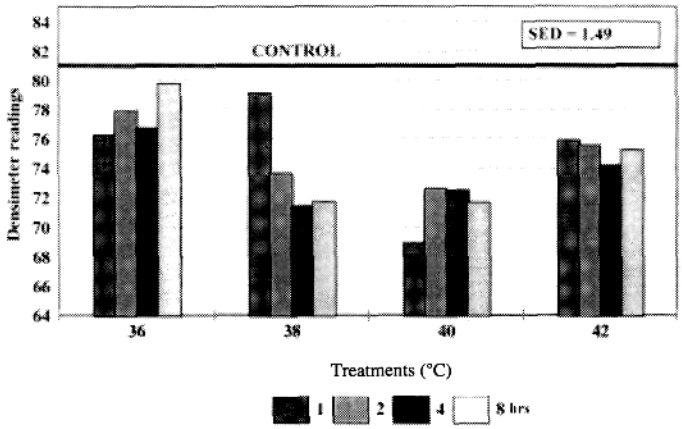

Figure 7. Fruit firmness (densimeter readings) for Hass after 6 weeks of cold storage at 3.5˚C

Days to Ripening

Fuerte

As each temperature treatment increased in duration, so too did days to ripening for Fuerte after 5 weeks of cold storage (figure 8). The days to ripening for the control vs treatment, differences in temperature, differences in duration and the time/temperature interaction were all significantly different (P<0.001**) The control was eating ripe 4 days after removal from cold storage while heat treatment at 40°C for 8 hours increased shelf life by 4 days and 38°C for 8 hours achieved an extra 3 days of shelf life. Fuerte after 6 weeks of cold storage illustrated similar trends to the 5 week storage period (figure 9), also at 40°C for 8 hours achieving a maximum extra storage life of 3 days above that of the control. The control vs treatments, differences in temperature, differences in duration and temperature/time interaction are all significantly different (P<0.001 **). The 42°C for 8 hours displays a decline in days to ripening perhaps illustrating the detrimental effect of this treatment.

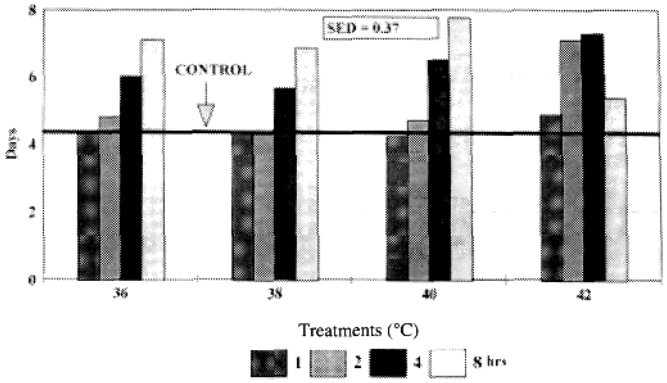

Figure 8 Days to ripening for Fuerte after 5 weeks of cold storage at 3.5˚C

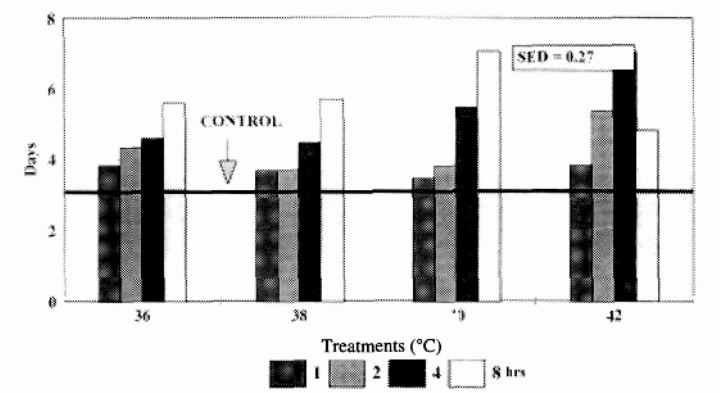

Figure 9. Days to ripening for Fuerte after 6 weeks of cold storage at 3.5°C

Hass

With Hass similar trends were clearly seen as with Fuerte when analysing an extension of shelf life. As the duration of the heat treatment increased, so too did the days to ripening for both storage periods except for 42°C for 8 hours (figures l0; 11). The days to ripening for the control vs treatments, differences in temperature, differences in duration and temperature/time interaction were all significantly different for both storage periods (P<0.008** for 5 weeks; P<0.001** for 6 weeks storage period).

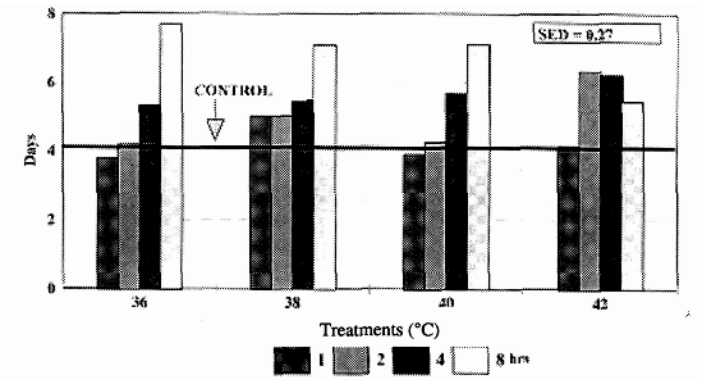

Figure 10. Days to ripening for Hass after 5 weeks of cold storage at 3.5°C

Temperatures of 40°C and 38°C for 8 hours produced roughly an extra 3 days of shelf life.

Physiological Disorders

Untreated Fuerte fruit displayed few physiological internal/mesocarp disorders on cutting, irrespective of cold storage period. There were however, signs of mesocarp discoloration, expressed more in the 6 week storage period. Untreated Hass fruit displayed no physiological disorders.

Physiological disorders were associated only with fruit exposed to high temperatures for long periods. Fuerte fruit was far more prone to internal disorders. At 42°C for 8 hours though, both cultivars displayed severe pulp spot, vascular browning and mesocarp discolouration. These physiological disorders seem to be as a result of heat damage.

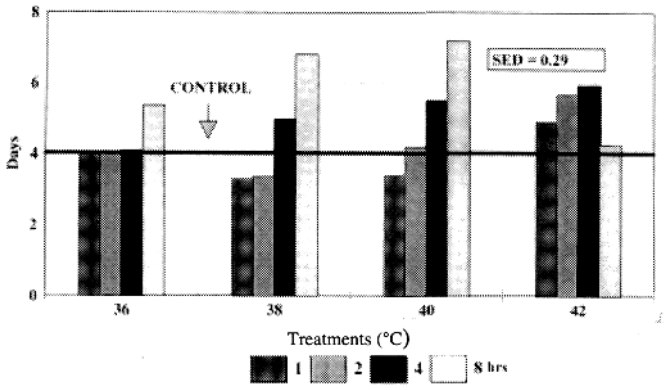

Figure 11. Days to ripening for Hass after 6 weeks of cold storage at 3.5°C

Heat/Cold Damage

Fuerte

For Fuerte after 5 weeks of cold storage, untreated (control) fruit had a rating of below 0.5 (figure 12), hence any rind damage present is due to heat damage. This is illustrated by the longer heat treatments having a higher heat damage rating. At 40°C for 8 hours and 42°C for 8 hours, scores were highly unsatisfactory at 6 and 10, respectively. The heat damage rating for the control, differences in temperature, differences in duration and temperature/time interaction were all significantly different ($P<0.001$ **) After 6 weeks of cold storage untreated Fuerte had a chilling injury rating of 2 (figure 13). The longer treatments induced severe heat damage e.g. at 42°C for 8 hours scoring 8.5. The heat damage rating for the control, differences in temperature, differences in duration and time/ temperature interaction are all significantly different ($P<0.001$**).

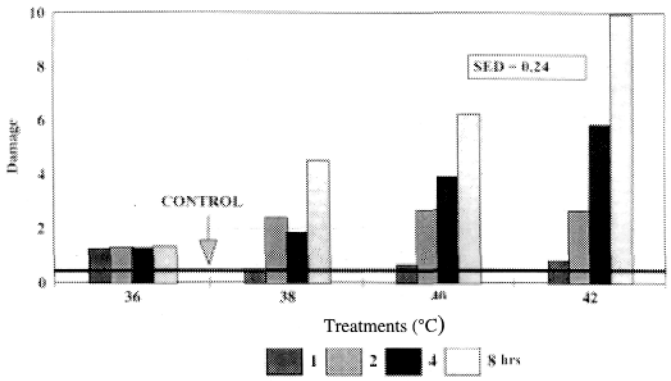

Figure 12. Heat/cold damage for Fuerte after 5 weeks of cold storage at 3.5°C (damage to the rind was rated on a scale of 0-10)

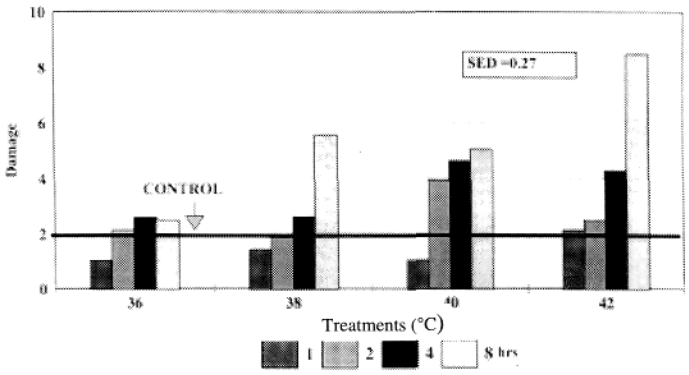

Figure 13. Heat/cold damage for Fuerte after 6 weeks of cold storage at 2.5°C (damage to the rind was rated on a scale of 0-10)

Hass

For untreated Hass after 5 weeks of cold storage almost no chilling injury was observed (figure 14). At 42°C, damage was noted at 1, 2 and 8 hours, with the 8 hour treatment scoring 7. Similar trends were seen for Hass after 6 weeks (figure 15) of cold storage, heat damage at 42°C for 8 hours, with a rating of 7 was present. The heat damage rating for the differences in temperature, differences in duration and time/temperature interaction were all significantly different ($P<0.01^{**}$).

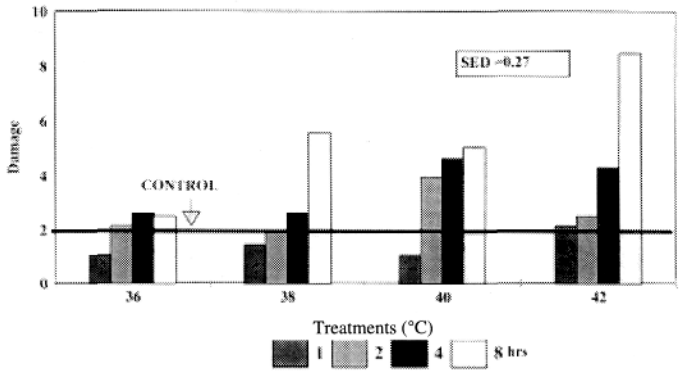

Figure 14. Heat/cold damage for Hass after 5 weeks of cold storage at 3.5°C (damage to the rind was rated on a scale of 0-10)

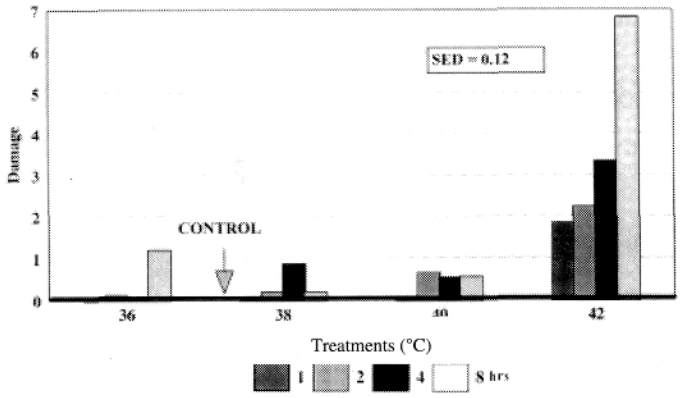

Figure 15. Heat/cold damage for Hass after 6 weeks of cold storage at 3.5°C (damage to the rind was rated on a scale of 0-10)

It seems that little cosmetic damage was caused except in the 42°C treated fruit. It is noteworthy that storage temperatures of 3.5°C, well below the industry standard, caused almost no rind chilling injury even for untreated fruit.

CONCLUSIONS

Similar conclusions for the 1997 KwaZulu Natal avocado seasons were reached as for the previous season, viz. that vapour heat treatment of Fuerte and Hass avocado fruits has shown potential to extend storage life. The two major factors to consider when choosing which vapour heat treatments to use for Fuerte and Hass avocados were an extension of storage life versus heat damage. A summary for both cultivare has been done on which treatments are suitable and are clearly represented in Figure 16 and 17 respectively. For Fuerte good possibilities exist at 36°C for 8 hours, 42°C between 4 and 8 hours and a marginal possibility at 38°C for between 4 and 8 hours. For Hass good possibilities exist at 38°C and 40°C for 8 hours.

CONCLUSIONS FOR 1996 AND 1997 AVOCADO SEASONS

In conclusion, vapour heat treatment of both Hass and Fuerte avocados has potential to extend shelf life. This can be achieved if the correct time/ temperature regime is utilised for each cultivar. The optimum time/temperature regime varied slightly between the two seasons.

For Fuerte 38°C between 4-8 hours for both seasons gave good results.

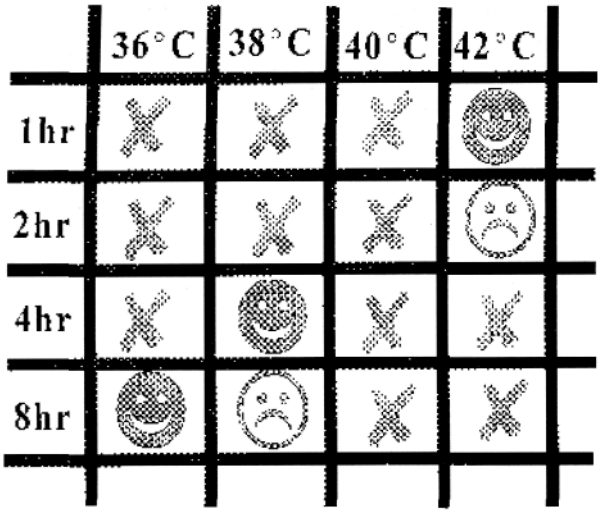

Figure 16. Vapour heat treatment ratings for fuerte for the 1997 season (cross = no good; happy face = good but the heat treatment could be longer due to lack of heat damage; sad face = good, but induces heat damage)

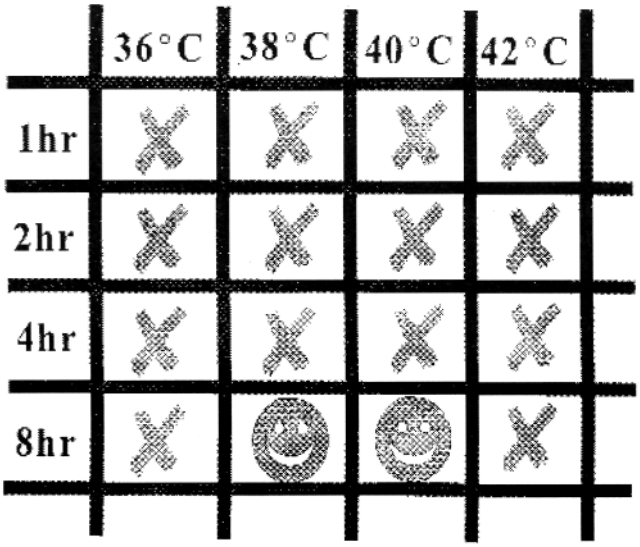

Figure 17. Vapour heat treatment ratings for Hass for the 1997 season (Cross = no good; Happy face = good but the heat treatment could be longer due to lack of heat damage; sad face = good, but induces heat damage)

In the 1996 season for Fuerte at 40°C between 4-8 hours was positive whereas in the 1997 season the 40°C treatment (figure 16) was not an option. The 42°C treatment of Fuerte in 1996 showed potential between the 2-4 hour duration, whereas in the 1997 season potential was shown between the 1-2 hour duration. In the 1997 season, treating Fuerte at 36°C for 8 hours also showed potential. The 38°C treatment for Fuerte between 4-8 hours, tends to correlate with work done on "Sharwil (Nishijima *et al,* 1995) and Hass (Woolf *et al,* 1995) Florissen *et al.,* 1996; Lurie *et al,* 1996; Woolf and Lay-Yee, 1997) avocado. Little work has been done on Fuerte avocado, although a preliminary trial by Bard and Kaiser (1996) who used short treatments with higher temperatures to reduce chilling injury. The majority of the work done though, has not been with vapour heat so it is difficult to compare the duration of possible treatments at 38°C if they were treated with hot water or dry heat.

Hass in the 1996 season had only one possible combination and that was at 38°C between 4-8 hours. In the 1997 season possibilities existed at 38°C and 40°C for 8 hours durations (figure 17). Again, as with Fuerte, the 38°C treatment between 4-8 hours seemed a good possibility if one combines both seasons' data. This would also tend to correlate with the literature that 38°C is a suitable temperature to consider.

ACKNOWLEDGEMENTS

The authors wish to express sincere thanks to Mr. W.P. Seele of Cooling and the management team from Everdon Estate for their generous contribution of fruit for this project.

REFERENCES

BARD, ZJ. & KAISER, C. 1996. Post-harvest vapour heat shock treatment of Fuerte avocado fruit. *South African Avocado Growers' Association Yearbook* 19:116 - 118

DONKIN, D.J. & WOLSTENHOLME, B.N. 1995. Post-harvest heat treatments with a view to reducing chilling injury in Fuerte avocado fruit. *South African Avocado Growers' Association Yearbook* 18:80 - 84

FLORISSEN, P., EKMAN, J.S., BLUMENTHAL, C., McGLASSON, W.B., CONROY, J. & HOLFORD, P. 1996. The effects of short heat treatment on the induction of chilling injury in avocado fruit. *Postharvest Biol. and Technol.* 8: 129 - 141

KAISER, C., WRIGHT, M.J., BARD, ZJ. & WOLSTENHOLME, B.N., 1996. Pre-storage vapour heat effects on grapefruit *(Citrus paradise* Macf.) 'Star Ruby' fruit stored at low temperatures. Proceedings of the VIII Congress of the International society of Citriculture Sun City, South Africa

KLEIN, J & LURIE, S. 1991. Post-harvest heat treatment and fruit quality. *Postharvest News and Information* 2: 15 - 19

LUME. S., HANDROS, A., ACKERMAN, M., SHAPIRA, R. & ZAUBERMAN, G. 1996. Prestorage heat treatment of avocados. Unpublished. Department of Post-harvest Science, Israel

NISHIJIMA, K.A., CHAN, H.T., SANXTER, S.S. & LINSE, E.S. 1995. Reduced heat shock period of 'Sharwil' avocado for cold tolerance in quarantine cold treatment.

Hort Science 30: 1052 – 1053
WOOLF, A.B. 1997 Reduction of chilling injury in stored Hass avocado fruit at 38°C water treatments, *Hort Science.* 32:1247 - 1251
WOOLF, A.B. & LAY-YEE, M. 1997. Pretreatments at 38°C of Hass avocado confer thermotolerance to 50°C hot water treatments. *Hort Science.* 32: 705 - 708
WOOLF, A.B., WATKINS, C.B., BOWEN, J.H., LAY-YEE, M., MAINDONALD, J.H. & FERGUSON, I.E. 1995. Reducing external chilling injury in stored Hass avocado with dry heat treatments. *J. Amer. Soc. Hort. Sci.* 120:1050 - 1056