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Post-Harvest Vapour Heat Treatment of Hass and Fuerte Avocado

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ABSTRACT

Haas and Fuerte avocado (Persea Americana Mill) *were exposed to a variety of vapour heat treatments with respect to duration and temperature. The vapour heat treatment temperature regimes were 36, 38, 40 and 42°C for a duration of one, two, four and eight hours for each temperature. Fruit after each vapour heat treatment were placed in cold storage at 3,5°C for a five week and six week period respectively. On removal from cold storage fruit were evaluated for firmness, and then allowed to ripen. Once ripe, fruit were evaluated for heat/cold damage, days to ripening, weight loss and physiological disorders. When evaluating the best time/temperature combination vapour heat treatment for each cultivar, the extension of shelf life and heat damage to fruit were most important. For Fuerte best results exist at 38°C between four and eight hours, 40°C between four and eight hours and 42°C between two and four hours. For Haas best results exist for 38°C between four and eight hours.*

INTRODUCTION

Due to overseas 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 export of avocados is fruit must arrive with acceptable firmness i.e. less than 300. It is thought that vapour heat treatment of avocados has the following benefits:

- reduces rate of ripening in climacteric fruit and hence extend shelf life,
- increase tolerance of harvested products to low temperatures, thereby reducing chilling injury,
- reducing incidence of post-harvest diseases, and
- pest control such as with fruit fly found in papaya (*Carica papaya* L.) in Hawaii (Klein & Lurie, 1991).

A variety of heat treatments have been considered such as dry heat, vapour heat and hot water in subtropical fruit such as avocado and papaya (Donkin & Wolstenholme, 1995). Beneficial effects of heat treatments have been displayed in mango (McCollum *et al,* 1993), citrus (Kaiser *et al,* 1995), papaya (Paul & Chen, 1990) and avocado (Florissen *et al,* 1996; Woolf *et al,* 1996; Nishijima *et al,* 1995; Bard & Kaiser, 1996; Donkin & Wolstenholme, 1995). Heat treatment temperatures differ according to type of fruit, oil storing avocado appear to be more heat sensitive than sugar storing fruit, hence lower temperatures for heat treatment in avocados are used (Bard & Kaiser, 1996). Heat treatment alters protein synthesis which changes cellular metabolism. An example of this is prevention of cellulase, a cell enzyme, being initiated and hence ripening delayed (Klein & Lurie, 1991). In response to heat treatments heat-shock proteins (HSPs) are synthesised which give the fruit or vegetable its thermotolerance to otherwise nonpermissive temperatures as well as delaying ripening. This phenomenon is known as the heat-shock response (HSR) (Harrington *et al,* 1994).

METHODOLOGY

In this experiment two cultivars of avocado were used, Fuerte kindly donated by Everdon estate and Hass kindly donated by Cooling farm. Both cultivars were exposed to the same treatments. A lattice design was the experimental design (figure 1) and both cultivars of avocado received temperatures of 36, 38, 40 and 42°C for a duration of one, two, four and eight hours. The fruit were treated in a vapour heat chamber, a Paxton Electrotherm® heater and humidification unit attached to a shipping container. For each treatment air and fruit pulp temperatures were recorded with the use of a data logger attached to several thermocouples. Fruit pulp temperatures were measured by inserting thermocouples into fruit. From information obtained by the data logger, graphs were drawn to ensure treatments were correct for every treatment. Once fruit had been treated, they were placed in cold storage at approximately 3,5°C. Every treatment had a storage period of five and six weeks. The temperature of cold storage was recorded, for the entire trial, every six minutes with a data logger (figure 2), an average of 3,49°C was achieved. Following cold storage, fruit were removed and allowed to ripen at room temperature.

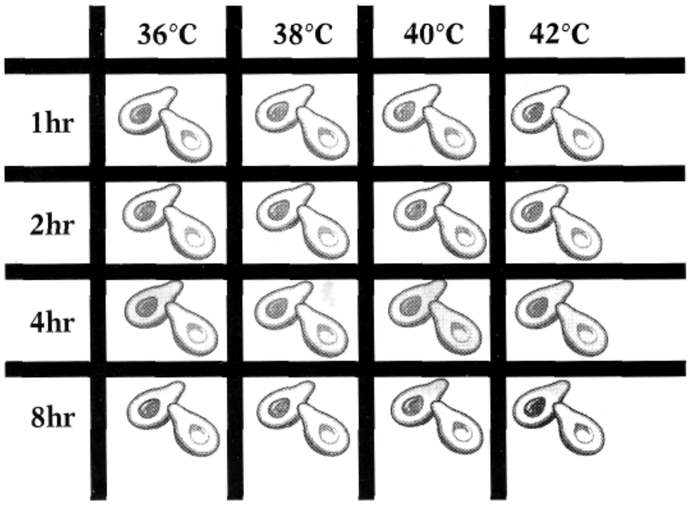

Figure 1
Experimental design for vapour heat treatments

Once fruit were removed from cold storage they were evaluated with regard to firmness, days to ripening, heat/cold damage, physiological disorders and weight loss. Firmness was measured with a firmometer and done immediately when fruit were removed from cold storage. Days to ripening was time taken from when fruit were removed from cold storage to eating ripe. 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 and cut open. Weight loss of fruit was determined after vapour heat treatments as well as after five and six week storage periods.

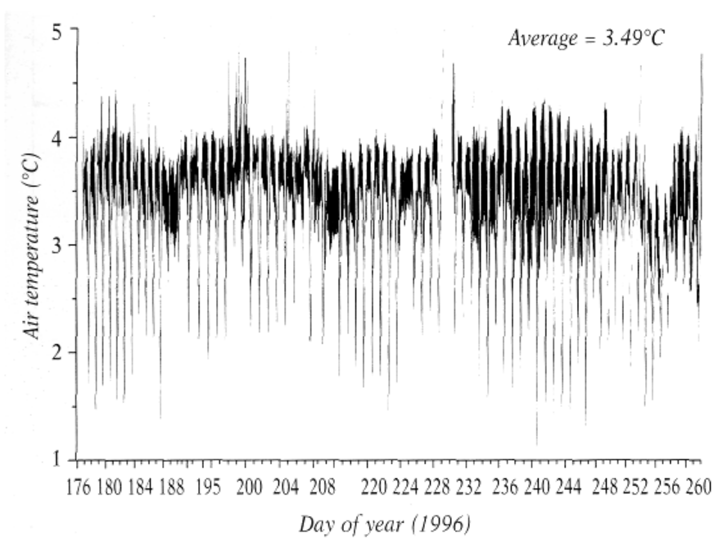

Figure 2
Graph displaying the cold storage temperature for entire project

RESULTS AND DISCUSSION

Firmness

Firmometer readings for Fuerte after five weeks of cold storage display a trend of fruits becoming firmer as duration and temperature of treatment increases (figure 3). After six weeks of cold storage (figure 4) the same trends were illustrated. Hass after five weeks (figure 5) did not display such clear trends and fruit tended to be roughly equal to control. At 42°C though, fruits displayed a slight decrease in firmness. Similar trends after six weeks for Hass were illustrated (figure 6). Of interest, all fruit of both cultivars including controls had acceptable firmness of less than 300, which is suitable for export markets.

Days to ripening

For Fuerte after five weeks as duration of treatments increased, so did shelf life (figure 7). After 6 weeks (figure 8) similar trends were observed although the 36°C treatment didn't seem to have much effect increasing shelf life above that of control. An extra four days of shelf life was achieved by the 40°C treatment at 8 hours. For Hass after five weeks (figure 9) only the longer treatments seem to have an effect increasing shelf life. This was highlighted for Hass after six weeks (figure 10) with a maximum of an extra four days of shelf life by 38°C for 8 hours.

Of interest, a treatment of Hass at 38°C after 5 weeks of cold storage illustrated vapour heat treatment slowing down ripening. After three days of removal from cold storage for this treatment, rind colour (figure 11) of Hass fruits were evaluated (table 1).

The effect of delaying ripening and increasing shelf life, induced by longer periods of vapour heat treatments is highlighted by the different rates of development of rind colour.

Heat/cold damage

For Fuerte after five weeks no chilling injury was observed (figure 12), hence any damage could perhaps be assumed to be heat damage or heat induced damage. As treatment increased in temperature and duration so did heat damage (rating of 0 10). Fuerte after six weeks displayed similar trends (figure 13). Hass after five weeks showed little signs of chilling injury and graph displaying heat/cold damage (figure 14) had to be magnified, as with a rating out of 10 it was difficult to obtain a visible presentation. Longer treatments at 42°C displayed higher levels of heat damage. After 6 weeks similar trends were illustrated and longer durations tended to increase heat damage (figure 15). It would appear that Hass is less sensitive to heat damage than Fuerte.

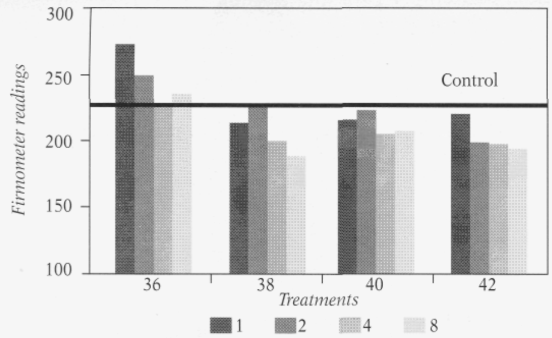

Figure 3
Firmometer readings for Fuerte after 5 weeks of cold storage

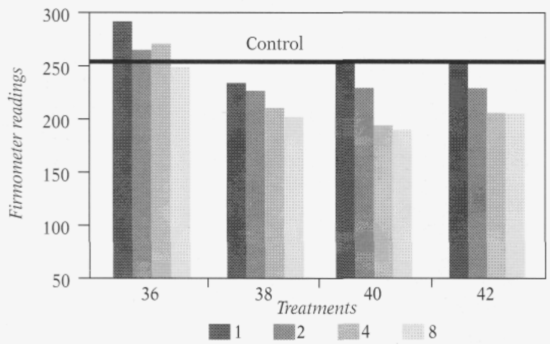

Figure 4
Firmometer readings for Fuerte after 6 weeks of cold storage

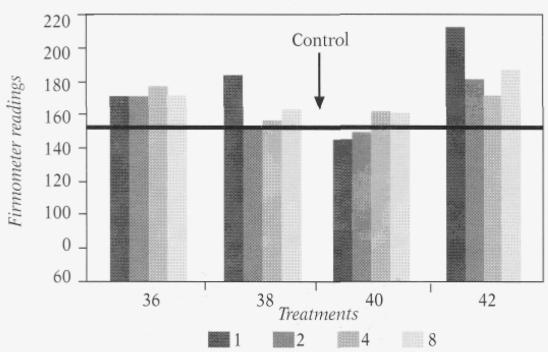

Figure 5
Firmometer readings for'Hass after 5 weeks of cold storage

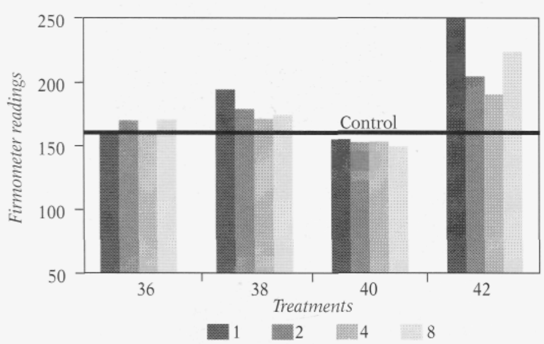

Figure 6
Firmometer readings for Hass after 6 weeks of cold storage

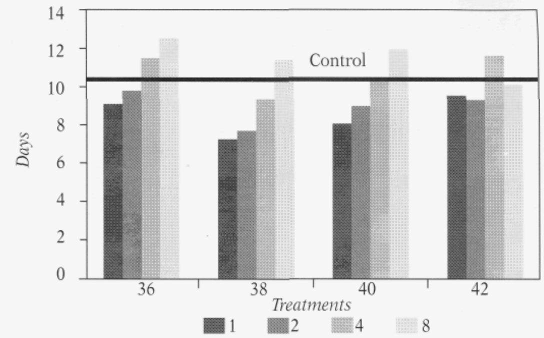

Figure 7
Days to ripening for Fuete after 5 weeks of cold storage

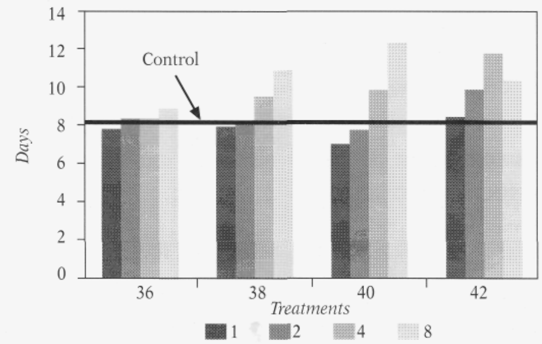

Figure 8
Days to ripening for Fuerte after 6 weeks of cold storage

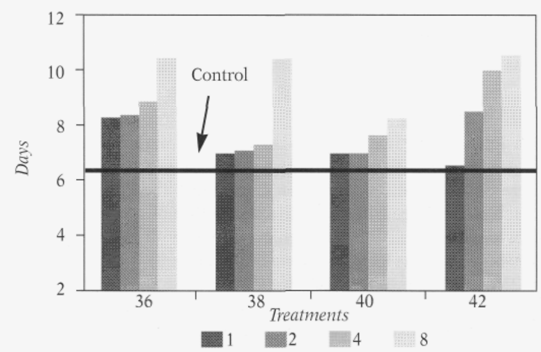

Figure 9
Days to ripening for Hass after 5 weeks of cold storage

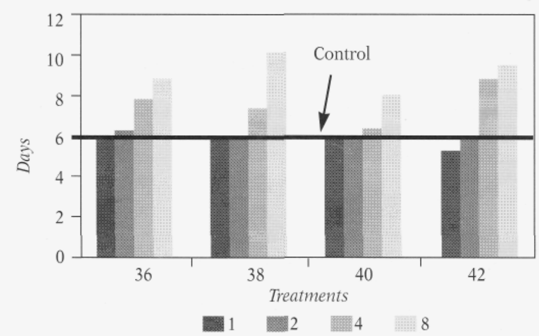

Figure 10
Days to ripening for Hass after 6 weeks of cold storage

Physiological disorders

Fuerte showed little signs of physiological disorders, 42°C at eight hours displayed physiological problems with respect to pulp spot, vascular browning and mesocarp discolouration. Mesocarp discolouration was greater at 36°C treatment than in control fruit. Hass showed very few physiological disorders for both storage periods.

Weight loss

Weight loss of both cultivars after vapour heat treatments at a maximum was around one gram, indicating vapour heat treatments do not extract moisture detrimental fruit. This would also indicate vapour heat is equal to or greater than 95% humidity.

After five weeks Fuerte displayed a loss of nine grams in control, while 38, 40, and 42°C treatments showed a decrease in weight loss of down to six grams as opposed to 36°C treatment which had a weight loss greater than control (figure 16). Fuerte displayed similar trends after six weeks although control fruit increased in moisture loss to 11 grams. Hass after five weeks showed a general weight loss less than control. Hass after six weeks displayed a loss of 8 grams in control while all treatments except for 42 °C were similar to control. For 42°C, weight losses were greater than control for all durations. This reduced weight loss induced by vapour heat treatments would perhaps suggest a conditioning of fruit.

CONCLUSION

For this past KwaZulu-Natal avocado season two major factors were important when considering which vapour heat treatments to use for Hass and Fuerte avocado to extend shelf life. These were an extension of shelf life and heat damage. Heat damage seems to be a limiting factor, for example Fuerte treated at 42°C for eight hours has an extension of storage life of up to four days but also has a heat damage rating five out of ten. For Fuerte and Hass treatments have been evaluated and are clearly represented in figures 17 and 18 respectively. For Fuerte possibilities exist at 38°C between four and eight hours, 40°C between 4 and 8 hours and 42°C between two and four hours. For Hass a possibility exists for 38°C between four and eight hours. On this past season one could suggest that vapour heat treatments do extend shelf life although there seems to be an offset with heat damage. In the forthcoming season the vapour heat treatments need to be refined in that a more exact time period and temperature should to be determined.

Also with distant markets in mind phytosanitary regulations need to be considered with regard to vapour heat treatments, cold storage periods and temperatures.

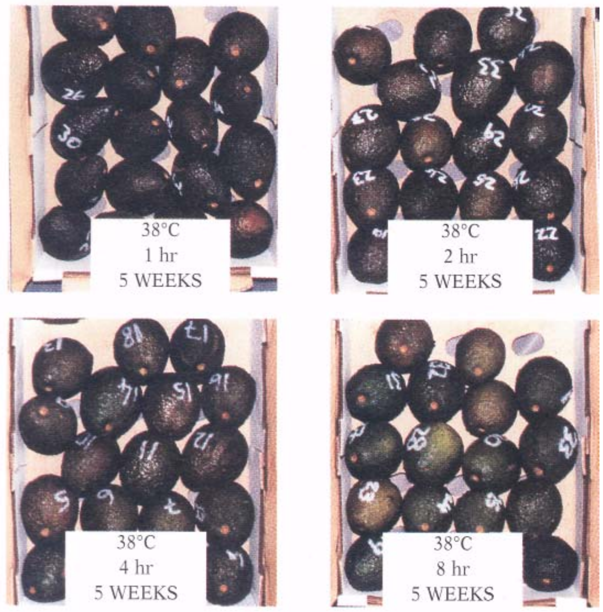

Figure 11
Photographs illustrating Hass after 5 weeks of cold storage treated at 38°C for 1, 2 ,4 and 8 hours. It is day 3 since removal from cold storage, 8 hour treatment highlighting delayed ripening due to green appearance of fruit

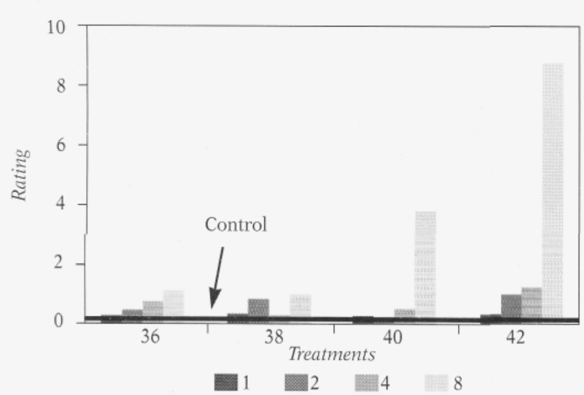

Figure 12
Heat/cold damage for Fuerte after 5 weeks of cold storage

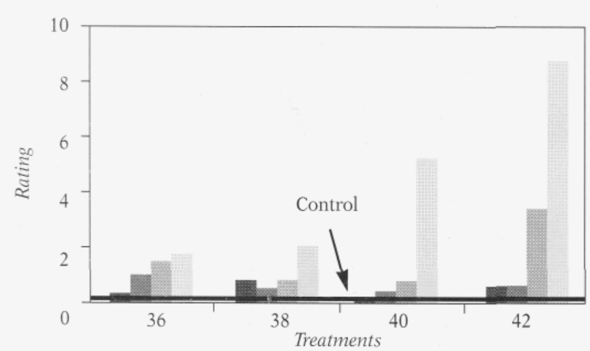

Figure 13
Heat/cold damage for Fuerte after 6 weeks of cold storage

Table 1
Hass rind colour at different durations of the vapour heat treatment
38°C

Duration	*Rind colour description*
1 hour	all black
2 hours	mostly black with a few green
4 hours	mostly green with a few black
8 hours	all green

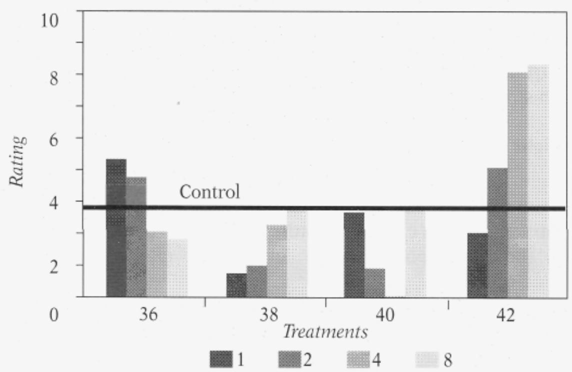

Figure 14
Heat/cold damage for Hass after 5 weeks of cold storage

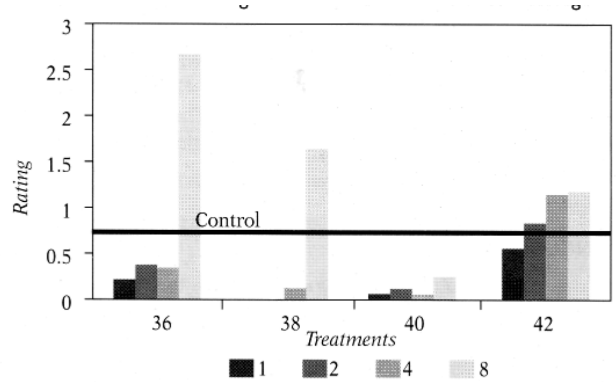

Figure 15
Heat/cold damage for Hass after 6 weeks of cold storage

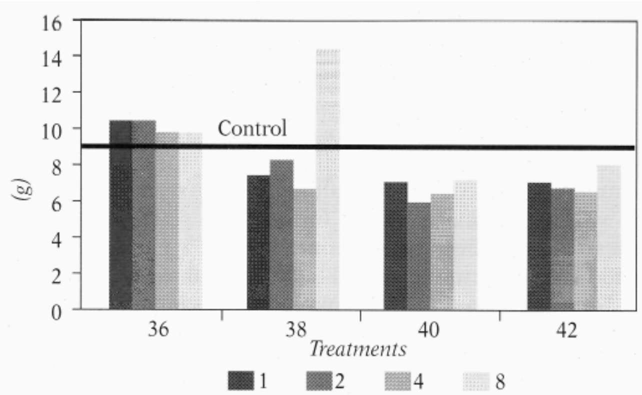

Figure 16
Weight loss for Fuerte after 5 weeks of cold storage

	36°C	38°C	40°C	42°C
1hr	✗	✗	✗	✗
2hr	✗	✗	✗	☺
4hr	✗	☺	☺	☹
8hr	✗	☹	☹	✗

Figure 17
Table displaying vapour heat treatment rating for Fuerte (cross = no good, happy face = good but could be extended, sad face = good, but induces heat damage)

	36°C	38°C	40°C	42°C
1hr	✗	✗	✗	✗
2hr	✗	✗	✗	✗
4hr	✗	☺	✗	✗
8hr	✗	☹	✗	✗

Figure 18
Table displaying vapour heat treatment rating for Hass

REFERENCES

BARD, Z.J. & KAISER, C. 1995. Post-harvest vapour heat shock treatment of Fuerte avocado fruit. *South African Avocado Growers' 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' Yearbook* 18: 15 - 19.

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 (*Persea Americana* Mill). *Post-harvest Biology and Technology* 8: 129 - 141.

HARRINGTON, H.M., DASH, S., DHARMASIRI, N. & DHARMASIRI, S. 1994. Heat shock proteins: a search for functions. *Aust. J. Plant Physiology* 21: 843 - 855.

KAISER, C., WRIGHT, M.J., BARD, Z.J. & WOLSTENHOLME, B.N. 1995. Pre-storage vapour heat effects on grapefruit *(Citrus paradisi* Macf.) 'Star Ruby' fruit at low temperatures. Proceedings of the VIII Congress of the International Society of Citriculture. Sun City, South Africa.

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

McCOLLUM, T.G., D'AQUINO, S. & McDONALD, R.E. 1993. Heat treatment inhibits mango chilling injury. *Hort Science* 28: 197 - 198.

NISHUIMA, 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.

PAUL, P.E. & CHEN, N.J. 1990. Heat shock response in field grown, ripening papaya fruit. *J. Amer. Soc. Hort. Sci.* 115:623 - 631.

WOOLF, A.B., WATKINS, C.B., BOWEN, J.H., LAY-YEE, M., MAINDONALD, J.H. & FERGUSON, I.B. 1995. Reducing external chilling injury in stored 'Hass' avocados with dry heat treatments. *J. Amer. Soc. Hort. Sci.* 120: 1050 - 1056.