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Hot water treatment of avocado fruit to induce cold tolerance

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ABSTRACT

Fuerte and Hass fruits were dipped for 5 minutes in 46°C hot water, dried for two hours at ambient temperature and then stored at 1.5°C for 28 days. This treatment was applied on the day of picking, as well as 1, 2 and 3 days after picking. The experiment was repeated several times with inconsistent results. In Fuerte, the hot water treatment reduced black cold damage in one trial, and brown cold damage in three trials. In Hass, no black cold damage occurred. Brown cold damage was only observed in one Hass trial, in which the incidence of brown cold damage of heat treated fruit did not differ from that of untreated control fruit. In Fuerte and Hass, the incidence of internal physiological disorders was very low. Days to ripening after cold storage were not affected by the heat treatment.

INTRODUCTION

Cold tolerance of avocado fruit would bring about potential trade benefits in simultaneous disinfestation and the possibility of long-term storage. A number of researchers have tested various post-harvest heat treatments to induce cold tolerance in avocado fruit (Donkin & Wolstenholme, 1995; Bard & Kaiser, 1996; Woolf, 1997; Kritzinger *et al.,* 1998; Weller *et al.,* 1998). Heat has been applied as hot air, vapour heat or hot water, and temperatures varied from 36° to 48°C while treatment durations varied from 5 minutes to 48 hours. Storage temperatures varied between 0.5° and 3.5°C and the storage periods from 3 to 6 weeks.

Australian research (Jessup, 1993) showed that a 5 minute dip treatment in 46°C warm water made it possible to store Hass fruit at 1°C for at least 16 days. After this treatment, the fruit were in good condition, internally and externally. It was assumed that the 4 day delay between harvest and heat treatment had a positive effect. In 1997, such delayed treatments were tested at Merensky Technological Services and gave promising preliminary results. This paper reports on heat treatment trials that were subsequently carried out in 1998.

MATERIALS AND METHODS

Fuerte and Hass avocado fruits were obtained from Westfalia Estate and hot water treated by immersing fruit in water at 46°C for 5 minutes in a water bath. This treatment was applied on the day of picking, as well as 1, 2 and 3 days after picking. During the

period between picking and treatment the fruit were kept at ambient temperature. After heat treatment, fruit were dried for two hours at ambient temperatures and then stored at 1.5°C for 28 days. For comparison, another batch of fruit was dipped in hot water and stored at 5.5°C. Untreated control fruit were also stored at 1.5° and 5.5°C respectively. 15 fruits were used per treatment. This experiment was repeated several times during the 1998 season, on both Fuerte and Hass avocados (Table 1).

The fruit were stored for four weeks to simulate sea shipment and were then ripened at 18°C. Ripe fruit were inspected and assessed for black and brown cold damage symptoms, lenticel damage, anthracnose, stem end rot, as well as the internal physiological disorders vascular browning, pulp spot and grey pulp. The days to ripening were recorded.

Table 1. Heat treatment experiments 1998.

Fuerte		Hass	
Experiment	**Date (picked)**	**Experiment**	**Date (picked)**
1	01/06/98	1	30/06/98
2	30/06/98	2	06/07/98
3	06/07/98	3	13/07/98
4	13/07/98	4	25/08/98

RESULTS

Black cold damage only occurred in the first Fuerte experiment (Table 2). In this experiment, black cold damage in untreated control fruit stored at 1.5°C increased the longer the delay between picking and placing the fruit into cold storage. The heat treatment reduced black cold damage and worked best when applied on the day of picking. On Hass fruit, no black cold damage was observed.

In Fuerte, brown cold damage did not occur in the first experiment (Table 3). In experiments 2 to 4, brown cold damage increased in the untreated control fruit stored at 1.5°C. The heat treatment reduced brown cold damage and worked best when applied on the day of picking. In Hass, brown cold damage only occurred in experiment 4 in both untreated control and heat treated fruit when stored at 1.5°C.

In Fuerte and Hass, lenticel damage occurred in all experiments and increased with increasing number of days after picking (Table 4). The incidence of lenticel damage was considerably higher in Hass than in Fuerte. In Fuerte, lenticel damage increased in heat treated fruit stored at 1.5°C when compared to untreated control fruit stored at 1.5°C.

Grey pulp was the only physiological disorder recorded which occurred at a very low incidence throughout all treatments in Fuerte and Hass (data not shown). The diseases anthracnose and stem-end rot did not occur.

With regard to days to ripening, Fuerte and Hass fruit stored at 1.5°C took longer to ripen than those stored at 5.5°C (Table 5). Heat treatment did not affect days to ripen at the same storage temperature.

Table 2. Average black cold damage rating (scale 0-3) for Fuerte avocado fruit as influenced by the delay between harvest and treatment (days after picking), heat treatment (46°C, 5 minutes) and storage temperature applied for 28 days. The experiment was repeated four times throughout the season.

			Fuerte			
Days after picking	Treatment	Storage temp (°C)	Exp 1	Exp 2	Exp 3	Exp 4
0	Heat	1.5	0	0	0	0
		5.5	0	0	0	0
	Control	1.5	0.07 ± 0.07	0	0	0
		5.5	0	0	0	0
1	Heat	1.5	0.20 ± 0.11	0.07 ± 0.07	0	0
		5.5	0	0	0	0
	Control	1.5	1.13 ± 0.26	0	0	0
		5.5	0	0	0	0
2	Heat	1.5	0.33 ± 0.16	0	0.07 ± 0.07	0
		5.5	0.20 ± 0.15	0	0	0
	Control	1.5	2.07 ± 0.15	0	0	0
		5.5	0	0	0	0
3	Heat	1.5	0.20 ± 0.15	0	0	0
		5.5	0	0	0	0
	Control	1.5	2.07 ± 0.23	0	0	0
		5.5	0	0	0	0

Table 3. Average brown cold damage rating (scale 0-3) for Fuerte and Hass avocado fruit as influenced by the delay between harvest and treatment (days after picking), heat treatment (46°C, 5 minutes) and storage temperature applied for 28 days. The experiment was repeated four times throughout the season.

			Fuerte				Hass			
Days after picking	Treatment	Storage temp (°C)	Exp 1	Exp 2	Exp 3	Exp 4	Exp 1	Exp 2	Exp 3	Exp 4
0	Heat	1.5	0	0	0	0.33 ± 0.16	0	0	0	0.93 ± 0.18
		5.5	0	0	0	0	0	0	0	0
	Control	1.5	0	0.27 ± 0.12	1.53 ± 0.17	1.40 ± 0.27	0	0	0	1.13 ± 0.13
		5.5	0	0.13 ± 0.13	0	0	0	0	0	0
1	Heat	1.5	0	0.07 ± 0.07	0.40 ± 0.13	0.93 ± 0.27	0	0	0	1.33 ± 0.13
		5.5	0	0	0	0	0	0	0	0
	Control	1.5	0	2.07 ± 0.15	2.87 ± 0.09	2.67 ± 0.16	0	0	0	1.07 ± 0.15
		5.5	0	0.53 ± 0.24	0.80 ± 0.26	0	0	0	0	0
2	Heat	1.5	0	0.07 ± 0.07	0.27 ± 0.15	0.93 ± 0.25	0	0	0	1.53 ± 0.13
		5.5	0	0	0	0	0	0	0	0
	Control	1.5	0	3.00 ± 0	3.00 ± 0	2.80 ± 0.11	0	0	0	1.53 ± 0.13
		5.5	0	0.53 ± 0.29	0	0	0	0	0	0
3	Heat	1.5	0	0	0.60 ± 0.24	1.20 ± 0.26	0	0	0	-
		5.5	0	0	0	0	0	0	0	-
	Control	1.5	0	3.00 ± 0	2.93 ± 0.07	2.87 ± 0.09	0	0	0	-
		5.5	0	0.33 ± 0.19	0	0	0	0	0	-

CONCLUSIONS

In conclusion, the hot water treatments tested in this project gave inconsistent results and can therefore not be recommended for commercial application in packhouses. With regard to the delay between harvest and heat treatment, the beneficial effects obtained in the 1997 season could not be repeated.

Nevertheless, the following results obtained in the above experiments are of importance for the successful postharvest handling of avocados: The cultivar Hass is less prone to cold damage than Fuerte. Untreated Hass stored at 1.5°C often showed no cold damage symptoms, and Hass fruit could thus be shipped at temperatures below those

used commercially at present. Furthermore, the lower the storage temperature, the longer the fruit take to ripen after storage, i.e. colder storage results in firmer fruit.

Table 4. Average lenticel damage rating (scale 0-3) for Fuerte and Hass avocado fruit as influenced by the delay between harvest and treatment (days after picking), heat treatment (46°C, 5 minutes) and storage temperature applied for 28 days. The experiment was repeated four times throughout the season.

			Fuerte				Hass			
Days after picking	Treatment	Storage temp (°C)	Exp 1	Exp 2	Exp 3	Exp 4	Exp 1	Exp 2	Exp 3	Exp 4
0	Heat	1.5	0.33 ± 0.13	0.07 ± 0.07	0.27 ± 0.12	0.47 ± 0.19	1.40 ± 0.13	1.13 ± 0.09	1.20 ± 0.11	1.13 ± 0.09
		5.5	0.33 ± 0.19	0.73 ± 0.15	1.27 ± 0.18	0.47 ± 0.17	1.07 ± 0.07	1.33 ± 0.13	1.13 ± 0.09	1.00 ± 0
	Control	1.5	0.07 ± 0.07	0.13 ± 0.13	0.33 ± 0.16	0.20 ± 0.11	1.60 ± 0.13	1.27 ± 0.12	1.27 ± 0.12	1.27 ± 0.12
		5.5	0.27 ± 0.15	0.87 ± 0.17	0.60 ± 0.19	0.13 ± 0.09	1.33 ± 0.13	1.13 ± 0.09	1.27 ± 0.12	1.20 ± 0.11
1	Heat	1.5	0.47 ± 0.17	0.27 ± 0.18	0.33 ± 0.13	0.60 ± 0.19	1.13 ± 0.09	1.40 ± 0.13	1.33 ± 0.13	1.20 ± 0.11
		5.5	0.20 ± 0.14	1.13 ± 0.13	0.60 ± 0.19	0.20 ± 0.11	1.33 ± 0.13	1.47 ± 0.13	1.33 ± 0.13	1.47 ± 0.17
	Control	1.5	0.27 ± 0.12	0	0	0.07 ± 0.07	1.27 ± 0.12	1.53 ± 0.13	1.60 ± 0.13	1.53 ± 0.13
		5.5	0.47 ± 0.19	0.20 ± 0.11	1.67 ± 0.19	0.40 ± 0.19	1.33 ± 0.13	1.47 ± 0.13	1.33 ± 0.13	1.67 ± 0.19
2	Heat	1.5	1.20 ± 0.20	0.80 ± 0.20	0.27 ± 0.12	0.20 ± 0.11	1.33 ± 0.13	1.67 ± 0.13	1.60 ± 0.13	1.13 ± 0.09
		5.5	0.47 ± 0.22	1.33 ± 0.21	0.73 ± 0.21	0.33 ± 0.13	1.27 ± 0.12	1.33 ± 0.16	1.33 ± 0.13	1.07 ± 0.07
	Control	1.5	0.53 ± 0.17	0	0	0	1.40 ± 0.13	1.47 ± 0.13	1.40 ± 0.13	1.53 ± 0.13
		5.5	0.73 ± 0.21	1.20 ± 0.17	0.73 ± 0.25	0.27 ± 0.12	1.27 ± 0.12	1.53 ± 0.13	1.47 ± 0.13	1.53 ± 0.13
3	Heat	1.5	1.13 ± 0.19	0.60 ± 0.13	0.33 ± 0.13	0	1.53 ± 0.13	1.87 ± 0.13	1.87 ± 0.17	-
		5.5	0.53 ± 0.19	0.93 ± 0.21	1.27 ± 0.28	0.60 ± 0.21	1.40 ± 0.13	1.47 ± 0.13	1.53 ± 0.13	-
	Control	1.5	0.20 ± 0.14	0	0	0	1.60 ± 0.13	2.07 ± 0.15	1.87 ± 0.19	-
		5.5	1.20 ± 0.20	1.00 ± 0.24	0.87 ± 0.22	0.33 ± 0.13	1.20 ± 0.11	1.60 ± 0.13	1.67 ± 0.16	-

Table 5. Average number of days to ripening for Fuerte and Hass avocado fruit as influenced by the delay between harvest and treatment (days after picking), heat treatment (46°C, 5 minutes) and storage temperature applied for 28 days. The experiment was repeated four times throughout the season.

			Fuerte				Hass			
Days after picking	Treatment	Storage temp (°C)	Exp 1	Exp 2	Exp 3	Exp 4	Exp 1	Exp 2	Exp 3	Exp 4
0	Heat	1.5	6.9 ± 0.3	7.0 ± 0.3	8.3 ± 0.4	7.1 ± 0.3	5.5 ± 0.1	5.6 ± 0.1	5.5 ± 0.1	4.0 ± 0.2
		5.5	4.2 ± 0.1	3.4 ± 0.1	3.7 ± 0.2	3.4 ± 0.1	3.7 ± 0.1	5.4 ± 0.1	3.5 ± 0.1	2.6 ± 0.2
	Control	1.5	7.0 ± 0.2	6.4 ± 0.3	7.8 ± 0.4	7.1 ± 0.3	5.3 ± 0.1	5.5 ± 0.1	5.7 ± 0.1	3.9 ± 0.2
		5.5	4.0 ± 0	3.5 ± 0.1	3.9 ± 0.3	3.5 ± 0.1	3.6 ± 0.1	5.4 ± 0.1	3.5 ± 0.1	2.7 ± 0.2
1	Heat	1.5	6.9 ± 0.3	6.6 ± 0.3	6.3 ± 0.4	6.3 ± 0.3	5.6 ± 0.1	5.5 ± 0.1	5.5 ± 0.1	4.1 ± 0.2
		5.5	4.2 ± 0.1	3.5 ± 0.1	4.2 ± 0.4	3.5 ± 0.1	3.5 ± 0.1	6.1 ± 0.4	3.5 ± 0.1	2.5 ± 0.1
	Control	1.5	7.2 ± 0.2	7.1 ± 0.2	6.1 ± 0.3	6.0 ± 0.2	5.5 ± 0.1	5.5 ± 0.1	5.4 ± 0.1	3.9 ± 0.2
		5.5	4.3 ± 0.1	3.5 ± 0.1	3.3 ± 0.1	3.5 ± 0.1	3.5 ± 0.1	5.4 ± 0.1	3.5 ± 0.1	2.5 ± 0.1
2	Heat	1.5	7.3 ± 0.3	6.7 ± 0.4	5.5 ± 0.3	5.9 ± 0.2	5.3 ± 0.1	5.4 ± 0.1	5.6 ± 0.1	3.9 ± 0.2
		5.5	4.3 ± 0.2	3.5 ± 0.1	3.4 ± 0.1	3.3 ± 0.1	3.5 ± 0.1	5.5 ± 0.1	3.5 ± 0.1	2.6 ± 0.2
	Control	1.5	7.3 ± 0.3	6.3 ± 0.3	5.4 ± 0.1	5.9 ± 0.2	5.3 ± 0.1	5.5 ± 0.1	5.7 ± 0.1	4.0 ± 0.2
		5.5	4.3 ± 0.2	3.6 ± 0.1	3.7 ± 0.3	3.5 ± 0.1	3.6 ± 0.1	5.5 ± 0.1	3.5 ± 0.1	2.7 ± 0.2
3	Heat	1.5	7.2 ± 0.4	6.7 ± 0.3	5.4 ± 0.3	5.9 ± 0.2	5.3 ± 0.1	5.5 ± 0.1	5.4 ± 0.1	-
		5.5	4.8 ± 0.2	3.7 ± 0.1	3.5 ± 0.1	3.5 ± 0.1	3.6 ± 0.1	5.5 ± 0.1	3.5 ± 0.1	-
	Control	1.5	7.1 ± 0.3	6.1 ± 0.2	5.6 ± 0.1	5.9 ± 0.2	5.3 ± 0.1	5.4 ± 0.1	5.7 ± 0.1	-
		5.5	4.5 ± 0.2	3.5 ± 0.1	3.4 ± 0.1	3.5 ± 0.1	3.5 ± 0.1	5.2 ± 0.1	3.5 ± 0.2	-

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