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Further Evaluation of Hot Water / Air Heatshock Treatment of South African Avocados

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ABSTRACT

Heat shock treatments have been proposed by researchers in other avocado producing countries as a method to reduce chilling injury in fruit. This may enable the export of fruit at lower storage temperatures. Preliminary studies conducted by us indicated specific trends, but were not consistent with published reports on the matter. During the 1997 season the experiments were continued, using refined methodology. The outcome was, however, consistent with our previous results. Hass proved to be unresponsive to the treatment while a measure of success was obtained with Fuerte and Edranol. The technique further proved to be unnecessary in Ryan while certain encouraging trends were observed in Pinkerton. As a number of factors, e.g. maturity fluctuations within a sample, influence the effectiveness of the technique it is at this stage suggested that packing houses refrain from using the method. The procedure will be incorporated in a comprehensive post-harvest study aimed at addresing the ailments encountered with especially Pinkerton during the last two seasons.

UITTREKSEL

Hitteskok behandeling word in ander avokado produseren.de lande voorgeslel as 'n metode om koueskade by avokado's te bekamp. Dit verbeter die vrugte se kans om teen laer temperature na die buiteland versend te word. Voorlopige proewe wat ons in 1996 uitgevoer het, het egter resultate opgelewer wat nie ooreenstem met gepubliseerde verslae van ander lande nie. Gedurende die 1997-seisoen is die proewe voortgesit, maar met verfynde metodiek. Die resultate was egter ooreenstemmend met die vorige jaar se bevindings. Hass het nie op die behandeling gereageer nie, maar 'n mate van sukses is wel met Fuerte en Edranol behaal. Die tegniek is onnodig bevind by Ryan, maar belowende tendense is by Pinkerton waargeneem. Aangesien 'n reeks faktore die effektiwiteit van die tegniek beinvloed. bv. vrug volwassenheid wat fluktueer in dieselfde monster, word daar aanbeveel dat pakhuise nie poog om die tegniek toe te pas nie. Die metode sal die kömende seisoen in 'n omvattende Pinkerton Studie program gemkorporeer word met die doel om die probieme wat met die kultivar gedurende die afgelope twee seisoene ondervind is. aan te spreek.

INTRODUCTION

Lower storage temperatures reduce the ripening rate of fruit, resulting in physiological and market related benefits. In addition, it may act as disinfestation treatment for certain insects. Unfortunately, the lower the temperature, the more chilling injury is induced, especially in a subtropical fruit such as the avocado.

Heatshock is a treatment which has been investigated as a possible tool to reduce chilling injury in avocados. Hot water heatshock treatments were found to be highly effective in reducing chilling injury in New Zealand Hass (Woolf *et al,* 1996) but less effective with Fuerte. However, the preliminary results we obtained during the 1996 season (Kritzinger *et al.,* 1997) indicated that hot water heatshock (HWHS) treatments convey a measure of protection to South African Fuerte but none to Hass. In Fuerte it was found to work best when applied between 40°-42°C for 20-30 minutes. The technique, however, was found only to be effective when applied within a specific maturity range.

In addition to the above, HWHS experiments were also conducted with Pinkerton, Ryan and Edranol. Minimal chilling injury was induced with untreated Pinkerton and Ryan when stored at 2°C. On the other hand, Edranol benefited from the technique. The technique further worked best when applied under specific conditions. Prewaxing of the fruit before the heat treatment was found to render the fruit more tolerant to temperature related damage. Temperature conditioning of fruit before exposure to chilling inducing temperatures also seemed to be beneficial.

During the 1997 season the experiments were refined in a number of ways. The temperature and time intervals between the treatments were firstly narrowed to fall within the most effective ranges identified during the previous year. Chilling inducing regimes which were 2°-4°C lower than the commercial regime but which followed the same stepping pattern were also implemented. The potential of pretreating the fruit to induce reduced sensitivity to heat damage, was also investigated. Hot air treatments were used in addition to water treatments in certain of these trials.

MATERIALS AND METHODS

A total of twenty trials were conducted during the 1997 season. Eight trails using Fuerte, five with Hass, two each with Pinkerton and Edranol and three with the Ryan cultivar were conducted respectively. The fruit originated from four locations, namely Burgershall (research station), Kiepersol (Koeltehof & Koos van Heerden, Levubu (research station) and Barberton (Michael van Schalkwyk). Standard procedures were used to prepare the fruit for treatment, namely, a wash with 0.5% HTH solution to remove sooty mould, followed by a rinse in water and a Stafresh 1:1 coating. The various storage regimes employed, are depicted in Figure 1.

The trials were structured as follows:

Fuerte

1.Hot Water Heatshock Treatments (HWHST): 40, 41, 42, 43°C for 22, 24, 26, 28 minutes. Storage temperature (ST) step 5½- 4°C.

2.HWHST: 40, 41, 42, 43°C for 22, 24, 26, 28 minutes ST step 5½-4°C.

3.HWHST: 39, 40, 41, 42°C for 20, 22, 24, 26 minutes. ST steps 5°, 3°C and 2½-1°C.

4.HWHST + PT (pre-treatment): 30°C for 1h, 40°C for 26 minutes, and 42°C for 24 minutes. ST steps 4°C and 2°C.

5.Hot Air Heatshock Treatment (HAHST): 38°C for 3, 6, 10h; 40°C for ½h; ST 2°C.

6.Hot Air Heatshock Treatment (HAHST): 38°C for 3, 6, 10h; 40°C for ½h; ST 2°C.

7.HAHST: 36, 38, 40°C for ½*,* 3, 6, 10, 12h; ST step 4°C and 2°C.

Hass

1. HWHST: 40, 41, 42, 43°C for 22, 24, 26, 28 minutes; ST steps 5½-4°C and 7½-5½°*C.*

2. HWHST: 40, 41, 42, 43°C for 22, 24, 26, 28 minutes; ST steps 5½ -4°C and 7½-5½ °C.

3. HWHST: 40° for 24, 26, 28min., 41° for 24, 26, 28 min; 42°C for 22, 24 min; 43°C for 20, 22, 33 minutes; ST steps 3½-2°C.

4. HAHST: 38°C for 6, 9, 24h; 40°C for ½h; St 2°C.

5. HAHST: 38°C for 3, 6, 10h; 40°c for ½h*;* ST 2°C.

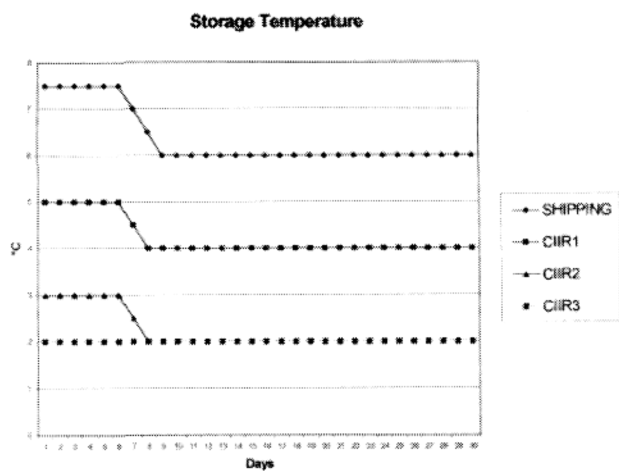

Figure 1: Example of the storage temperature regimes used to induce chilling injury. The shipping temperature regime used at the time was simulated. In addition, chilling injury inducing regimes (CIIR) which were between 2°C and 4°C lower than the shipping regime were employed. In most cases a sample of fruit was also stored at a constant 2°C

Pinkerton

1. HWHST: 39°C for 12, 15, 18 min; 40°C for 15, 18, 20 min; 42°C for 18, 20, 22 min; 43°C for 12, 15, 18 min; ST steps 5- 3½°*C.*

2. PT1 (HAHST), PT2 (HAHST) + HWHST: 38°C for 10h; 20°C for 4h; 39, 40, 42 and

43°C for 15 min; ST 2°C.

Ryan

1. HWST: 40° for 18, 20, 22, 25 min; 41° for 18, 22, 25 min; 42°C for 15, 18, 22min; 43°C for 15, 18, 22 min; ST step 5½-2½°C and 2°C.

2. HAHST: 36, 38, 40°C for 9, 10, 11h; ST 3½- 2°C, 5 4°C and 2°C.

Edranol

1. HWHST: 39°C for 22, 28, 30 min; 40°C for 20, 22, 25 min; 41 °C for 15, 18, 20 min; 42°C for 8, 10, 15 min; St 5-4°C, 3-2°C and 2°C.

2. HAST: 36, 38, 40°C for ½, 3, 6, 10, 12h; ST steps 3-2°C, 5-4°C and 2°C.

RESULTS AND DISCUSSION

The results obtained with Fuerte are listed in table 1 and representative grid layouts are shown in figures 2 and 3. Although the choice of temperature and time combinations was based on the most promising combinations identified last year, the results were essentially similar to those attained during the previous season. In 3 of the 7 experiments, significant differences were noticed between the control and one of the treatments. Two of these experiments (1 and 3), were HWHS treatments and in both the exposure time was 24 minutes. The effective temperature was found to be between 40 and 42°C. The third was a HAHST treatment where the best temperature again was found to be 40°C but applied for 6 hours.

The effect of fruit maturity on the resistance of Fuerte to chilling injury and ultimately on the effectiveness of HWHST was mentioned by Kritzinger and Kruger (1997). It was found that the technique was ineffective at the beginning of the season but more effective during the middle of the season. Towards the end of the season it was difficult to induce chilling injury. The continuous lowering of step-down temperature regimes applied in the present study allowed for more consistency with regard to the induction of chilling injury, but the effectiveness of the heatshock techniques remained erratic. In conclusion it would therefore seem that, although a measure of success was attainable with Fuerte, the lack of repeatability of the results was such that the technique was regarded as inappropriate for use in a packinghouse.

Table 1 : Chilling injury induced in Fuerte fruit which were subjected to the heat treatment regimes described in the text and stored at the temperature regimes indicated in the table.

Trial no.	*Storage Temperature*	*Best Combination*	*% C.I. Best*	*% C.I. Control*
1	5½° - 4°C	42°C for 24 min	10,3	33,3
2	5½° - 4°C	40°C for 26 min	18,4	26,8
3	6° - 5°C 4°-3°C 2½° - 1°C	- 40°C for 26 min 40°C for 24 min	- 2,5 3,3	4,3 7,0 29,3
4	5° - 4°C 2°C	PT+42° for 24 min 40°C for 26 min	0 20	8 27
5	2°C	38°C for 10h	59,4	62,4
6	2°C	38°C for 10h	29	31
7	5°-4°C 2°C	40°C for ½h 40°C for 6h	0 3,4	0 31

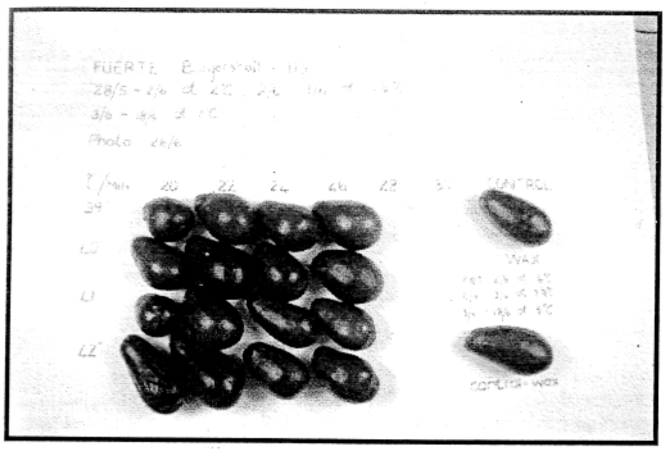

Figure 3. Grid layout of Fuerte as for the above except that the storage temperature regime was considerably more severe (2 to 1,5 to 1°C). The chilling injury induced in fruit which were treated for 22 minutes or less was subsequently considerably more severe than in figure 2 while the fruit treated for 24-26 minutes showed relatively little chilling injury. The top control represents the fruit stored at the shipping regime used for Fuerte of the specific maturity stage, namely, 6 to 5,5 to 5°C.

The results obtained with Hass are exhibited in table 2. The results were consistent with our previous results in that the technique was found to be totally ineffective. Great care was taken to accurately control the treatment temperatures and chilling inducing regimes. We were, however, not able to reproduce the favourable results attained by Woolf *et al* (1996) with New Zealand Hass.

The results obtained in the two Edranol trials are shown in table 3. A number of interesting deductions could be made. The fruit used in the two trials were of similar maturity (approximately 70%). Also the experiments were done on two consecutive days (27 and 28 August) and the fruit were kept in the same cold rooms. Yet, the percentage of chilling injury induced in the controls was higher in the HWHST trail than in the HAHST. The fruit used in the former trial originated from the Kiepersol area where the temperatures fluctuate less than in the area Kaapsehoop from which the fruit for the second trial, were obtained. The importance of lower orchard temperatures in conditioning fruit against chilling injury, as shown by Swarts (1982) has therefore again come to the fore in our experiments.

Although the percentage chilling injury induced differed between the two trials, the order was identical in that the more severe storage regimes induced the highest percentage of chilling injury .Furthermore both the water and air treatments further appeared to confer a measure of protection against chilling injury.

The results obtained with Ryan are shown in table 4 and a representative layout is exhibited in figure 4. As may be deduced from the data, relatively little chilling injury was observed in the controls. In one case where 13.5% chilling injury was induced, the hot water treatment at 43°C for 22 minutes apparently bestowed a measure of protection, as the mean percentage chilling injury recorded, was 2%.

The results obtained in the two experiments conducted with Pinkerton are listed in table 5. No chilling injury was induced in the first experiment. The second experiment consisted of a HAHT pretreatment followed by a HWHT and storage at 2°C. This treatment conferred a high measure of protection to the fruit as the mean chilling injury recorded in the control fruit was 30.9% while none of the treated fruit exhibited symptoms.

Table 2:Chilling injury induced in Hass fruit which were sub-jected to the heat treatment regimes described in the text and stored at the temperature regimes indicated in the table.

Trial no.	*Storage Temperature*	*Best Combination*	*% C.I. Best*	*% C.I. Control*
1	5½° - 4°C 7½°-5½°C	40°C for 24 min -	2,7 -	8,6 2,6
2	5½° - 4°C 7½°-5½°C	42°C for 24 min -	4,1 -	7,8 3,4
3	3½° - 2°C	43°C for 22 min	1,5	1,0
4	2°C	38°C for 24 h	52,8	2,3
5	2°C	38°C for 6h	36,3	30

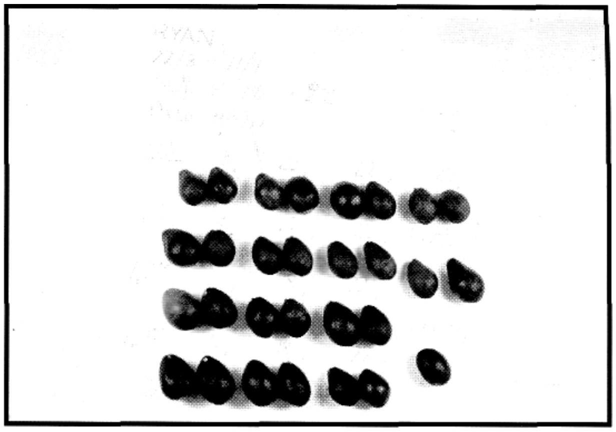

Figure 4.Ryan fruit which were hot water heat treated and then subjected to one of two storage regimes. In the matrix the fruit are packed in pairs. The fruit on the left were kept at a 5 to 3,5 to 3 to 2,5°C regime while the fruit on the right was kept at a constant temperature of 2°C. The median fruit from each permutation was used in the layout and it is clear that the fruit kept at 2°C sustained more chilling injury than the fruit kept at the higher step-down regime. The fruit in the bottom right hand corner is the control fruit which sustained the most chilling injury.

Table 3. Chilling injury induced in Edranol fruit which were subjected to the heat treatment regimes described in the text and stored at the temperature regimes indicated in the table.

Trial no.	*Storage Temperature*	*Best Combination*	*% C.I. Best*	*% C.I. Control*
1	5°- 4°C	38°C for 3h	0	5
	3°-2°C	36°C for ½h	0	4,5
	2°C	36°C for 10h	0	10
2	5°- 4°C	42°C for 8min.	0	23,1
	3°-2°C	40°C for 22min.	0	15
	2°C	42°C for 15min.	17,5	30

Table 4:Chilling injury induced in Ryan fruit which were subjected to the heat treatment regimes described in the text and stored at the temperature regimes indicated in the table.

Trial no.	*Storage Temperature*	*Best Combination*	*% C.I. Best*	*% C.I. Control*
1	5½°-2½°C	40°C for 22min.	0	5
	2°C	43°C for 22min.	2,0	13,3
2	5°- 4°C	-	-	0
	3½°-2½°C	38°C for 11h	1,0	2,5
	2°C	38°C for 9h	0	0

Table 5:Chilling injury induced in Pinkerton fruit which were subjected to the heat treatment regimes described in the text and stored at the temperature regimes indicated in the table.

Trial no.	*Storage Temperature*	*Best Combination*	*% C.I. Best*	*% C.I. Best*
1	5°-3½°C	39°C for 15 min..	0	0
2	2°C	38°C for 10h+ 20°C for 4h 43°C for 15 min.	0	30,9

Table 6:Incidence of grey pulp in control and heat treated Pinkerton fruit stored at two temperature regimes

Storage regime (°C)	*Treatment*	*Mean Score (0-3)**
Step 5-3,5	Controls	0.22a
Step 5-3,5	Treatments#	0.47a
Constant 2	Controls	1.33b
Constant 2	Treatments#	2.15b

The result of all treatments were pooled for these readings
* 0 denotes no internal browning and 3 intense browning
Values in columns followed by the same letter do not differ significantly according to Student's T test (P= 0,05)

Table 7:Incidence of external discolouration other than chilling injury in control and heat treated Pinkerton fruit stored at two temperature regimes.

Storage regime (°C)	*Treatment*	*External discolouration (%)*
Step 5-3,5	Controls	3.33a
Step 5-3,5	Treatments#	5,87a
Constant 2	Treatments#	15.2b
Constant 2	Controls	16.25b

The results of all treatments were pooled for this reading.
Values in columns followed by the same letter do not differ significantly according to Student's T test (P=0,05)

Considering the results obtained in this and last year's studies, the general conclusion reached is that heatshock treatments reduces susceptibility of South African Fuerte, Edranol and Pinkerton to chilling injury. However, the technique was found to be ineffective with South African Hass while Ryan was found to be relatively resistant to chilling injury whether treated or not.

It is recommended that packing houses should not attempt to apply this technique at this stage as the reaction of fruit to the technique varies within a sample. This is probably due to variation with regard to maturity. Ferguson & Woolf (1997) have shown that avocado fruit on the outside of a tree are subjected to higher heat units during the day and are correspondingly less susceptible to chilling injury than those on the inside. The latter authors have shown that the protein profile of the inside fruit differs from the outside and have ascribed the increased resistance to chilling injury to the raising of heatshock proteins in fruit exposed to the sun. On account of our previous heatshock experimental results (Kritzinger & Kruger, 1997) and fruit maturity results (Krugerei *al.,* 1995, Kruger, 1996, Kruger *et al,* 1996(a); Kruger *et al,* 1996(b), Kruger & Claassens, 1997) we are, however, of the opinion that the primary reason for the deviation is variation in fruit maturity. Be that as it may, the variation within a consignment will make it difficult for a packinghouse to apply the technique. Ongoing research into the potential of non destructive electronic firmness checking (Kruger & Rowell, 1997) in order to categorise fruit into maturity classes seems to be the next logical step.

A NOTE ON THE PHYSIOLOGICAL DISORDERS OF PINKERTON

Detailed observations were made during the present study on the incidence of physiological disorders as well as fungal infections causing pathology in fruit. In general, the prevalence of physiological disorders were not influenced by the treatments, except in extreme permutations of the highest temperatures combined with the longest exposure times. In the latter case, severe internal browning of the fruit flesh set in. In light of these results, we have considered it less important to refer to this aspect in detail. However, in view of the physiological problems currently encountered with Pinkerton, we thought it appropriate to refer briefly to the observations made on this cultivar.

The incidence of grey pulp is indicated in table 6. The occurrence of external discolouration other than chilling injury is shown in table 7. The fruit used in the trials were of the same origin and the trails were all conducted within a 24 hour period. From the table it is clear that the HWHT and HAHT did not affect the incidence of the disorders. However, the fruit stored at 2°C had a significantly higher incidence of grey pulp and external discolouration than those stored at the 5-3°C regime. It would therefore seem that temperatures which are not sufficiently low to induce chilling injury may still facilitate discolouration of the fruit.

Preliminary work has been done on appropriate storage temperature regimes for Pinkerton (Schutte, 1994). Further experimentation specifically aimed at establishing the relationship between storage temperature and the incidence of grey pulp and external discolouration is essential. This is to be combined with controlled atmosphere experiments using higher temperature regimes.

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