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The effect of heat shock treatments followed by a quarantine cold treatment on avocado fruit quality

T. Grové, M.S. De Beer & W.P. Steyn
Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit 1200

OPSOMMING

Die Suid Afrikaanse avokadobedryf wend pogings aan am met Hass vrugte foegang tot markte in die VSA te verkry. Aangesien vrugtevlieë avocado's in Suid Afrika aanval, is dit belangrik om 'n no-oes kwaranfyn behandeling te ontwikkel wat vrugte vry van vrugtevlieë maak. In hierdie sfudie is voorlopige navorsing gedoen met hitteskok behandelings vir koue bestandheid in kwaranfyn koue bebandelings. Hass vrugte is getoefs maar ander kultivars soos Fuerte, Pinkerton, Edranol en Ryan is ook ingesluit. Die warmwater hitteskok behandelings het daaruit bestaan dat vrugte in 'n warmwater bad von 46°C vir 5 minute geplaas word. Daarna is vrugte met waks behandel. Die kontrole vrugte is daarna direk in koelopberging by 6.5°C (±0.5) vir 28 dae geplaas. Die vrugfe wat die hitteskok behandeling ontvang het, is vir 2 uur by die heersende temperatuur geplaas en daarna vir 28 dae by 2°C gestoor. Na hierdie stoor periode is die vrugte by kamertemperatuur gehou vir ongeveer 1 week en daarna geëvalueer. Hass was die kultivar wat die meeste pofensiaal getoon hef vir hitteskok behandelings gevolg deur kwarantyn koue behandelings.

ABSTRACT

The South African avocado industry is striving to gain access to the USA markets with Hass fruit. Since fruit flies attack avocados in South Africa, it is important to develop a post-harvest quarantine treatment to free fruit from fruit flies. Therefore, in this study preliminary research was done with hot water heat shock treatments for cold tolerance in quarantine cold treatments. Hass fruit were tested but other cultivars such as Fuerte, Pinkerton, Edranol and Ryan were also included. The hot water heat shock treatment consisted of immersing the fruit in a water bath of 46°C for 5 minutes. Thereafter the fruit were treated with wax. Control fruit were immediately placed in cold storage at 6.5°C (±0.5) for 28 days, while the heat shock treated fruit were left for 2 hours at ambient temperature before storage at 2°C for 28 days. After storage the fruit were kept at room temperature for approximately 1 week and then evaluated. Hass was the cultivar

that showed the most potential for heat shock treatments followed by quarantine cold treatments.

INTRODUCTION

The Mediterranean fruit fly *Ceratitis capitata* (Wiedemann), the Natal fruit fly *Ceratitis rosa* Karsch and the Marula fruit fly *Ceratitis cosyra* (Walker) are known to be present in South African avocado orchards (Grové *et a*l., 1998). However, the avocado is not considered to be a good host for fruit fly development (Brink *et al.,* 1997). De Villiers and Van den Berg (1987) state that under normal orchard practices no larval development takes place in avocado fruit. According to Du Toit and De Villiers (1990) fruit fly larvae do not develop in the fruit of commercial avocado cultivars. Although the avocado is not a suitable host, fruit flies can develop to maturity in the fruit under certain conditions (Brink *et al.*, 1997).

Experiments conducted in Hawaii by Armstrong *et al.* (1983) and Armstrong (1991) have indicated that Sharwil avocados are non-hosts for the development of fruit flies. In 1990, the infestation-free quarantine procedure for Sharwil avocados grown in Kona, Hawaii, was approved based on the assumption that fruits on trees are not hosts of fruit flies. However, Sharwil avocado fruit was found to be a host for tephritid fruit flies when the trees are under drought conditions (Liquido et al., 1995). Therefore, avocados have been banned for further export from Hawaii to the USA mainland until a quarantine treatment is approved by the Animal and Plant Health Inspection Services (APHIS).

Thus, for the exploitation of new markets by the South African avocado industry, it is therefore essential to develop a post-harvest quarantine treatment. Cold treatments are used to disinfest horticultural products from tephritid fruit flies before entering export marketing channels (Armstrong, 1983). Prolonged storage temperatures below 4-6°C tend to induce chilling injury in most avocado cultivars. Heat treatments can be used to reduce chilling injury. Research on heat treatments on South African avocados has been conducted in order to reduce chilling injury and post-harvest decay and to enhance storage life (Bard & Kaiser, 1996; Donkin & Wolstenholme, 1995; Kritzinger & Kruger, 1997; Weller *et al*., 1997). Heat shock treatments for cold tolerance in quarantine treatments have been evaluated on Sharwil avocados in Hawaii (Sanxter, 1994; Nishijima *et al*., 1995) and on Hass avocados in Australia.

The South African avocado industry is striving to gain access to the US markets with Hass fruit. Therefore, in this study preliminary research was done with hot water heat shock treatments for cold tolerance in quarantine cold treatments. Hass fruit as well as other cultivars such as Fuerte, Pinkerton, Edranol and Ryan were tested.

MATERIALS & METHODS

Five cultivars obtained from different production areas throughout the 1998 season were used (Table 1). Fruit were transported by car from the various production areas to the ITSC at Nelspruit. The moisture content of the samples was determined. Fruit were washed with a 0.5% hypochlorite solution to remove sooty blotch and thereafter rinsed

with water. Approximately ten fruit in each experiment served as a control, while the remaining fruit received a heat shock treatment (Table 1). The hot water heat shock treatment consisted of dipping the fruit in a water bath of 46°C for 5 minutes. Thereafter the fruit were treated with a natural wax emulsion, Stafresh (1:1). Control fruit were placed in cold storage at 6.5°C (±0.5) for 28 days immediately after waxing, while the heat shock treated fruit were left for 2 hours at ambient temperature before storage at 2°C for 28 days. After storage the fruit were kept at room temperature for approximately 1 week and then evaluated. The date on which each experiment was evaluated is given in Table 1.

Table 1. Cultivars from different localities used in the experiments

Cultivar	Location	Treatment Number of fruit	Control Number of fruit	Treatment Date	Evaluation Date
Fuerte	Burgershall	43	9	7 April	12 May
Fuerte	Burgershall	49	11	17 April	21 May
Hass	Levubu	62	20	20 April	22 May
Hass	Nelspruit	35	10	22 April	26 May
Pinkerton	Burgershall	40	10	6 May	10 June
Hass	Burgershall	40	10	6 May	10 June
Hass	Nelspruit	35	10	11 May	17 June
Hass	Nelspruit	35	9	28 May	9 July
Edranol	Nelspruit	85	19	3 June	9 July
Edranol	Burgershall	35	10	18 June	22 July
Hass	Burgershall	20	10	23 July	1 September
Ryan	Burgershall	42	18	30 July	4 September

Table 2. Effect of heat shock treatment followed by low storage temperature on Fuerte fruit quality

FUERTE		
Burgershall 7 April 1998 (Moisture content of the fruit 72.25%)		
Parameters	Heat shock treated fruit	Control fruit
Chilling injury	27.50	33.75
Lenticel damage	22.62	27.86
Stem end rot	11.71	26.33
Anthracnose	29.17	63.33
Firmness	35.42	33.67
Browning	0.05	0
Grey pulp	0.12	0.22
Burgershall 14 April 1998 (Moisture content of the fruit 70.58%)		
Chilling injury	8.12	5.55
Lenticel damage	1.02	2.73
Stem end rot	0	0
Anthracnose	0	0
Firmness	50.37	45.73
Browning	0	0
Grey pulp	0	0

Table 3. Effect of heat shock treatment followed by low storage temperature on Hass fruit quality

HASS		
Levubu 20 April 1998 (Moisture content of the fruit 72.09%)		
Parameters	Heat shcok treated fruit	Control fruit
Chilling injury	4.11	0.55
Lenticel damage	3.68	1.15
Stem end rot	0	0
Anthracnose	0	
Firmness	74.03	61.90
Browning	0	0
Grey pulp	0	0
Nelspruit 22 April		
Chilling injury	0	0
Lenticel damage	0.54	0.9
Stem end rot	0	0
Anthracnose	0	0
Firmness	61.94	59.90
Browning	0.09	0
Grey pulp	0.	0
Nelspruit 11 May (Moisture content of the fruit 71.65%)		
Chilling injury	0.23	0
Lenticel damage	0.31	0.50
Stem end rot	0	0
Anthracnose	0	0
Firmness	58.63	51.80
Browning	0.09	0
Grey pulp	0	0
Nelspruit 28 May (Moisture content of the fruit 71.13%)		
Chilling injury	0	0
Lenticel damage	0.17	0
Stem end rot	0	0
Anthracnose	0	0
Firmness	59.97	50.33
Browning	0	0
Grey pulp	0	0

The important parameters evaluated were:

1. Chilling injury
   The percentage of skin affected by chilling injury.
2. Lenticel damage
   The percentage of the skin affected by lenticel damage.
3. Stem end rot
   The percentage of fruit pulp affected by stem end rot.
4. Anthracnose
   The percentage fruit skin affected by anthracnose.
5. Fruit firmness
   Fruit firmness was measured with a hand-held densimeter. Two measurements were obtained from each fruit. The readings ranged from 100 (hard) to 0 (soft).
6. Internal physiological disorders like browning of pulp and grey pulp were annotated. Browning of the pulp was evaluated on a scale of 0-3 and grey pulp on a scale of 0-5.

RESULTS AND DISCUSSION

Both samples of heat shock treated Fuerte fruit from Burgershall showed chilling injury (Table 2). The sample with the lower moisture content showed less chilling injury. Heat shock treated Hass fruit displayed less chilling injury than Fuerte and in some cases none occurred (Tables 3 and 4). Pinkerton, Edranol and Ryan heat shock treated fruit showed chilling injury (Tables 5, 6 and 7). When chilling injury was high the percentage

lenticel damage was also high. Heat shock treated fruit displayed less stem end rot than control fruit (Tables 2, 5 and 7). Heat shock treated fruit were firmer than control fruit. A very low number of fruit was affected by browning and grey pulp.

Table 4. Effect of heat shock treatment followed by low storage temperature on Hass fruit quality

HASS		
Burgershall 6 May (Moisture content of the fruit 72.82%)		
Parameters	Heat shock treated fruit	Control fruit
Chilling injury	3	1.10
Lenticel damage	1.78	1.50
Stem end rot	0	0
Anthracnose	0	0
Firmness	60.73	63.90
Browning	0.03	0
Grey pulp	0	0
Burgershall 23 June (Moisture content of the fruit 67.83%)		
Chilling injury	1.5	1.70
Lenticel damage	2.7	2.70
Stem end rot	0	0.90
Anthracnose	0	0.30
Firmness	53.40	49.30
Browning	0	0
Grey pulp	0.10	0

Table 5. Effect of heat shock treatment followed by low storage temperature on Pinkerton fruit quality

PINKERTON		
Burgershall 6 May 1998		
Parameters	Heat shock treated fruit	Control fruit
Chilling injury	14.88	3.5
Lenticel damage	0	3.2
Stem end rot	0.50	30
Anthracnose	10.88	0
Firmness	55.78	44.50
Browning	0.63	0.90
Grey pulp	0.08	0

Table 6. Effect of heat shock treatment followed by low storage temperature on Edranol fruit quality

EDRANOL		
Burgershall 3 June 1998 (Moisture content of the fruit 74.00%)		
Parameters	Heat shock treated fruit	Control fruit
Chilling injury	32.89	27.68
Lenticel damage	1.25	0
Stem end rot	0	0
Anthracnose	0.12	0
Firmness	56.73	54.00
Browning	0	0
Grey pulp	0	0
Burgershall 18 June 1998 (Moisture content of the fruit 70.84%)		
Chilling injury	23.43	8.89
Lenticel damage	2.34	0
Stem end rot	0	0.11
Anthracnose	6	41.67
Firmness	57.31	51.78
Browning	0	0.11
Grey pulp	0.13	0

These results indicate that as the moisture content of the fruit dropped, chilling injury tended to be less. Kritzinger and Kruger (1997) found that in the beginning of the season hot water treatments reduced chilling injury, but it was not possible to eliminate it. Towards the end of the season chilling injury was preventable, but also in control fruit

very little injury occurred. Therefore, the effectiveness of hot water heat shock treatments is markedly influenced by fruit maturity.

Table 7. Effect of heat shock treatment followed by low storage temperature on Ryan fruit quality

RYAN		
Burgershall 30 June 1998		
Parameters	Heat shock treated fruit	Control fruit
Chilling injury	1.9	7.78
Lenticel damage	19.29	9.67
Stem end rot	0	1.28
Anthracnose	1.81	19.78
Firmness	54.21	51.17
Browning	0	0
Grey pulp	0.04	0.11

Heat shock treatments followed by lower storage temperatures showed potential in increasing the post-harvest life of avocado fruit. This is reflected in higher densimeter readings, indicating that fruit will arrive in a firmer condition than with conventional treatments.

Hass was the cultivar that showed the most potential for heat shock treatments followed by quarantine cold treatments. In the future lower storage temperatures may be used to reach quarantine security. Further trials using this treatment would have to be done for an entire season to confirm the results.

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