

INFLUENCE OF TIME OF DAY OF HARVEST ON 'HASS' AVOCADO RIPE FRUIT QUALITY

T.A. Elmsly, A.J. Mandemaker, E.M. Dixon,
 D.B. Smith and J. Dixon
 Avocado Industry Council Ltd., P.O. Box 13267,
 Tauranga 3110
 Corresponding author: tonielmsly@nzavocado.co.nz

ABSTRACT

In New Zealand during the main harvest period 'Hass' avocado fruit is potentially being harvested throughout the day from dawn to dusk. The time of day the fruit are harvested could affect the ripening time and the incidence and severity of ripe rots. To determine the effect that the time of day the fruit were harvested has on ripe fruit quality, fruit were harvested at different times in a day over two harvest seasons and evaluated for ripening times and the levels of ripe rots. In 2003, time of day of harvest had no effect on the incidence and severity of fuzzy patches, stem end rot, brown patches (body rots), the incidence of sound fruit and total weight loss during storage. Between orchards the time of day of harvest had a different effect on the incidence of ripe rots. In 2005, the incidence and severity of stem end rot on fruit harvested at dawn or the mid afternoon were not different but tended to be less in the fruit harvested in the mid afternoon. There was a reduction in the severity of body rots from dawn to the mid afternoon. There was a consistent trend across orchards for the incidence of sound fruit to be greater by about 20% in the fruit harvested in the mid afternoon compared to the fruit harvested at dawn. The fruit harvested in the mid afternoon tended to ripen slightly faster than the fruit harvested at dawn. Harvesting avocado fruit at different times of the day can influence the incidence of sound fruit. The effect of the time when the fruit were harvested on ripe rots could be inconsistent from orchard to orchard implying that other orchard factors are more important than the

time of day the fruit were harvested. Avocado fruit harvested in November are of lower maturity than fruit harvested in January and have fewer ripe rots. The time of year when the fruit are harvested may be more important than the time of day when the fruit are harvested in setting the inherent risk of developing ripe rots. The reason for the different results between years may have been related to the general water status of the fruit at harvest. At the time of harvest in January 2005 the soil was drier than in November 2003. Even in dry soil conditions, avocado fruit at dawn will contain the greatest amount of water for the day and be at their most turgid. Avocado fruit at dawn are likely to be susceptible to handling damage at harvest in a similar manner to fruit harvested after rain and therefore at a higher risk of fungal infection than the fruit harvested in the mid afternoon. This may explain why there was an effect on fruit quality of the time of day of harvest in 2005 and not in 2003.

Keywords: *body rot, ripening time, stem end rot, weight loss*

INTRODUCTION

In New Zealand the main harvest period of 'Hass' avocado fruit is from August to April with the fruit potentially being harvested throughout the day from dawn to dusk before transport to a packing house. A major determinate of New Zealand avocado fruit quality is the incidence and severity of ripe rots that develop during ripening once the fruit are in the market (Dixon, 2001). The weight loss of the fruit during the initial stages of ripening after harvest influences ripening time which in turn affects the development of ripe rots (Yearsley *et al.*, 2002a, 2002b; Lallu *et al.*, 2003). Pick to pack times longer than 24 hours have been shown to increase ripe rots (Dixon *et al.*, 2005), in part, due to increased weight loss before storage (Lallu *et al.*, 2004). The initial weight loss of avocado fruit immediately after harvest may be influenced by the fruit water status (Bower, 1984) when harvested with fruit at dawn most likely to have the greatest water content and fruit harvested mid afternoon the lowest water content (Schroeder, 1958). The time

of day the fruit are harvested could affect the ripening time of avocado fruit (Bower *et al.*, 1982) and subsequently the incidence and severity of ripe rots where dew on the fruit at dawn could result in a greater viable fungal inoculum load being present than at a warmer, drier period of the day. There are important implications in the interpretation of the treatment effects found in postharvest research if ripe fruit quality varies according to the time of day of harvest. The potential is for research results to reflect more the time when the fruit were harvested rather than to describe genuine treatment effects. Should the time of day when fruit are harvested be important for fruit quality, experimenters and commercial harvesting operations would need to be aware of the implications that harvest times during the day may have on fruit quality. With fruit harvested at certain times having a greater risk of developing ripe rots there is also the potential to avoid high risk harvest periods. To determine the effect that the time of day the fruit were harvested has on ripe fruit quality, fruit were harvested at different times within a day over two harvest seasons and evaluated for ripening times and the levels of ripe rots.

MATERIALS AND METHODS

One thousand and five hundred 'Hass' avocado fruit were harvested from 3 orchards in the Western Bay of Plenty, New Zealand (37°S, 176°E) on the 11/11/2003 to 12/11/2003. Five replicates, consisting 20 fruit in a single layer tray, were harvested at dawn, mid-morning, midday, mid-afternoon and dusk. A second trial harvested 306 fruit from 4 orchards in the Western Bay of Plenty. Four replicates, consisting of 12 - 20 fruit in a single layer tray, were harvested at dawn or mid-afternoon on 26/1/2005 to 27/1/2005. In both trials, fruit were harvested directly into trays and were ungraded. Fruit were stored for 28 days from harvest at 4°C ± 0.5°C, RH 85% ± 5%. Fruit were ripened at 20°C ± 1°C, RH 65% ± 5%. Once the fruit reached at least a minimum eating softness, determined by hand feel equivalent to a firmometer measurement of 85 with a 300g weight, the fruit

were assessed for external and internal fruit quality disorders according to the Avocado Industry Council Fruit Assessment Manual (Dixon, 2003).

Fruit dry matter content at harvest was measured using a 20 fruit sample from each orchard, using the peel method described by Mandemaker (2004). Fruit dry matter content for trial one was: Orchard A, 32.1%, orchard B, 29.0% and orchard C, 29.2%. Trial two: orchard D was 35.2%, orchard E, 37.0%, orchard F 34.2% and orchard G 33.7%.

Results were analysed by One Way ANOVA using Tukeys' family error rate of 5% using MINITAB version 13.31.

RESULTS

Trial 1

The amount of ripe rots was low with more than 95% of fruit being sound at the 5% disorder threshold level (Table 1). Time of day of harvest had no effect on the incidence and severity of fuzzy patches, stem end rot, brown patches (body rots), the incidence of sound fruit and total weight loss during storage. Fruit harvested at dawn took longer to ripen than fruit harvested at mid morning, midday, mid afternoon and dusk; however the difference is only 7.2 hours.

The time of day of harvest had a different effect on the incidence of ripe rots between each orchard. In orchard A, the incidence of brown patches increased from one harvest to the next as the day progressed. For orchard B the incidence of brown patches increased to be at maximum at midday and mid-afternoon and then declined at dusk. The fruit harvested from orchard C had the greatest incidence of brown patches at dawn after which the incidence of brown patches declined to be low for the rest of the day. Overall there was no consistent trend between orchards in the incidence of brown patches with time of day of harvest (Figure 1).

Table 1. Incidence and severity of stem end rot, brown patches, fuzzy patches and sound fruit, time to ripen and weight loss of 'Hass' avocado fruit harvested at different times of the day on 11-12/11/2003, stored for 28 days at 4°C ± 0.5°C, 85% ± 5% RH then ripened at 20°C ± 1°C, 65% ± 5% RH.

Time of harvest	Stem end rot		Brown patches		Sound fruit	Fuzzy patches		Time to ripen Days	Weight loss ³ %
	Inc% ¹	Sev% ²	Inc%	Sev%	Inc%	Inc%	Sev%		
Dawn	2.7	0.1	10.0	0.2	97.3	1.7	0.02	4.9a ⁴	3.5
Mid AM	5.3	0.1	8.0	0.1	98.0	1.7	0.03	4.5b	3.4
Midday	4.0	0.1	13.3	0.3	95.7	2.7	0.05	4.6b	3.6
Mid PM	4.0	0.1	13.0	0.3	97.3	2.3	0.02	4.6b	3.5
Dusk	4.3	0.1	13.3	0.3	96.3	1.3	0.01	4.6b	3.5

¹Incidence, ²Severity, ³Mass loss in storage, ⁴Values in the same column with the same letter are not significantly different according to a one-way analysis of variance where $p = 0.05$.

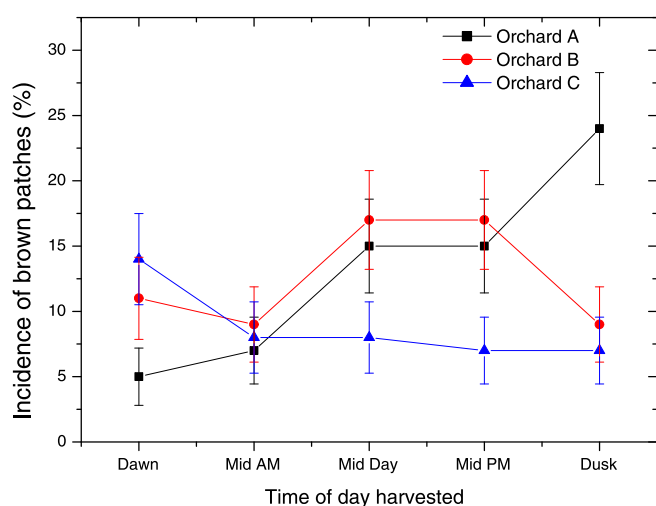


Figure 1. Average incidence of brown patches at different times of the day when harvested on 'Hass' avocado fruit from 3 orchards in the Bay of Plenty. Vertical bars represent the standard error of the mean.

Trial 2

The incidence and severity of stem end rot on fruit harvested at dawn or the mid-afternoon was not significantly different but showed a trend to be less in the fruit harvested in the mid-afternoon (Table 2). There was no consistent effect of harvesting at different times of the day on the incidence of body rots with only the fruit from orchard D having a reduced incidence of body rots (Table 2). There was a consistent trend for the severity of body rots to be decreased in the mid-afternoon compared to dawn. Overall there was a significant reduction in the severity of body rots from dawn to the mid-afternoon. There was a consistent trend across the orchards for the incidence of sound fruit to be greater by about 20% in the fruit harvested in the mid-afternoon compared to the fruit harvested at dawn. The fruit harvested in the mid-afternoon tended to ripen slightly faster than the fruit harvested at dawn.

Table 2. Incidence and severity of stem end rot, brown patches, sound fruit and time to ripen of 'Hass' avocado fruit harvested at different times of the day on 26-27/1/2005, stored for 28 days at 4°C ± 0.5°C, 85% ± 5% RH then ripened at 20°C ± 1°C, 65% ± 5% RH.

Orchard	Time of harvest	Stem end rot		Body rots	Sound fruit		Time to ripen	
		Inc% ¹	Sev% ²	Inc%	Sev%	Inc%	Days	
D	Dawn	20.0	0.5	80.0a	4.4	80.0	4.3	
	Mid pm	10.0	0.2	50.0b	2.0	95.0	3.8	
E	Dawn	75.0	3.2	90.0	41.1a ³	15.0	4.4	
	Mid pm	58.3	2.4	100.0	19.5b	41.7	4.0	
F	Dawn	15.0	0.9	55.0	8.7	70.0	4.6	
	Mid pm	15.0	0.4	60.0	1.9	90.0	3.9	
G	Dawn	0.0	0.0	10.0	0.2	0.0	3.2	
	Mid pm	0.0	0.0	15.0	0.2	0.0	3.0	
Mean	Dawn	25.0	1.1	58.8	13.6a	66.2a	4.1	
	Mid pm	16.7	0.5	51.4	4.4b	86.1b	3.6	

¹Incidence, ²Severity, ³Values in the same column with the same letter are not significantly different according to a one-way analysis of variance where $p = 0.05$.

DISCUSSION

Harvesting avocado fruit at different times of the day may have an influence on the incidence and severity of ripe rots and the incidence of sound fruit if the fruit are harvested at dawn compared to the mid-afternoon. The effect of the time when the fruit were harvested on ripe rots was inconsistent from orchard to orchard implying that other orchard factors are also important in determining the amount of ripe rots on the fruit. The other orchard factors may include the general fungal inoculum load in an orchard, the time since rain, the soil moisture content of the soil and how the fruit are handled from the orchard to the packhouse.

The fruit harvested at dawn in 2005 had a greater incidence and severity of ripe rots in contrast to the fruit harvested in 2003 where the ripe rots were similar at each harvest time. The reason for the differences between the years is not known but

could have been related to the general water status of the fruit at harvest in each year. Typical soil moisture matrix potential readings from tensiometers were about -20kPa in November 2003 and less than -50kPa in January 2005. These differences in the soil moisture matrix potential may explain why there was no difference in fruit quality in 2003 compared to the fruit quality in 2005. Fruit at dawn are expected to contain the greatest amount of water, be the most turgid, and gradually lose water during the day as the temperature rises and the overall water loss from the trees increase (Schroeder, 1958). By mid-afternoon it is anticipated that the trees will have lost water due to transpiration and a short term decrease in water potential occurs. Water is thought to be drawn out of the fruit into the rest of the tree during this period (Schroeder, 1958). Once the stomata in the leaves close in the mid-afternoon as a water conservation measure the water potential of the tree begins to recover and during the night the tree will usually

fully recover the water lost during the previous day. When the soil is dry, as is typical in January and February on non-irrigated orchards in the Western Bay of Plenty, the tree could draw water from the fruit to keep the leaves well supplied with water. To confirm if the fruit have a lower fruit water status in the mid-afternoon requires further study.

Growth studies on avocado fruit in California have also indicated that the fruit shrink in diameter during the day and recover during the night where the fruit grow slightly and start the next day slightly bigger (Schroeder, 1958). The recovery of fruit size during the night is thought to result in fruit that are fully hydrated at dawn. Avocado fruit with high water content could be susceptible to handling damage at harvest as was found with fruit harvested after rain (Everett *et al.*, 2001; Pak, 2003) and therefore at a higher risk of fungal infection than the fruit harvested in the mid-afternoon. A greater susceptibility to handling damage may explain why the fruit harvested at dawn in 2005 tended to develop more ripe rots than the fruit harvested in the mid-afternoon. The results of this study indicate that 'Hass' avocado fruit harvested at or near dawn should be treated as high risk fruit in a similar manner to the fruit harvested after rain. The time of year when the fruit are harvested may be more important than the time of day when the fruit are harvested in setting the inherent risk of developing ripe rots. Avocado fruit harvested in November compared to fruit harvested in January typically develop fewer ripe rots (Dixon *et al.*, 2003).

Harvesting avocado fruit in the mid-afternoon compared to harvesting at dawn can potentially increase the incidence of sound fruit in some years on some orchards. The inconsistent results for each year and between orchards suggest that there are other orchard factors that are more important in the development of ripe rots than the time of day the fruit were harvested. However, for research trials noting the time of day the fruit were harvested should be considered good experimental practice.

CONCLUSIONS

The time of day of harvest showed a consistent trend for the fruit harvested in the mid afternoon to have fewer ripe rots and more sound fruit. The effect of harvesting at different times of the day was not great but may on some orchards increase the incidence of sound fruit by up to 20%. There are other pre-harvest and post harvest factors such as the fungal inoculum load, the time since rain, pick to pack times and rough post harvest handling that will also have a negative impact on fruit quality. Harvesting the fruit only in the mid afternoon can potentially reduce the incidence and severity of ripe rots in some years on some orchards. Other orchard factors, such as fruit maturity, may be more important in determining the amount of ripe rots than the time of day the fruit were harvested.

REFERENCES

- Bower, J.P., van Lelyveld, L.J. and Nel, M.E. (1982). The influence of Fuerte fruit water potential on ripening. *South African Avocado Growers' Association Yearbook* **5**: 36-38.
- Bower, J.P. (1984). Effect of fruit water stress and irrigation regime in the ripening of stored avocado fruit, cultivar; Fuerte. *South African Avocado Growers' Association Yearbook* **7**: 55-56.
- Dixon, J. (2001). Development of fruit quality disorders in New Zealand avocados at out-turn in the USA for the 2000-2001 and 2001-2002 seasons. *New Zealand Avocado Growers' Association Annual Research Report*. **1**: 31-40.
- Dixon, J. (2003). New Zealand Avocado Assessment Manual. Version 3.0 Avocado Industry Council Ltd.
- Dixon, J., Pak, H.A., Smith, D.B., Elmsly, T.A. and Cutting, J.G.M. (2003). New Zealand avocado fruit quality: the impact of storage temperature and maturity. *New Zealand Avocado Growers' Association Annual Research Report*. **3**: 48-53.

Dixon, J., Elmsly, T.A., Smith, D.B. and Pak, H.A. (2005). Increasing pick to pack times increases ripe rots in 'Hass' avocados. *New Zealand Avocado Growers' Association Annual Research Report. 5*: 43-50.

Everett, K.R., Hallett, I.C., Yearsley C., Lallu N., Rees-George, J. and Pak, H.A. (2001). Morphological changes in lenticel structure resulting from inhibition and susceptibility to handling damage. *New Zealand Avocado Growers' Association Annual Research Report. 1*: 47-53.

Lallu, N., Yearsley, C., Punter, M., Billing, D., Francis, K. and Pikadala, P. (2003). Effects of prepacking holding temperatures on shelf life of 'Hass' avocados. *New Zealand Avocado Growers' Association Annual Research Report. 3*: 108-117.

Lallu, N., Punter, M., Haynes, G., Francis, K., Billing, D., Pikadala, P. and Burdon, J. (2004). Role of water loss in ripening of 'Hass' avocados. *New Zealand Avocado Growers' Association Annual Research Report. 4*: 70-79.

Mandemaker, A.J., Pak, H.A., Elmsly, T.A. and Smith, D.B. (2004). Comparison of core and peel sampling methods for dry matter measurement in Hass avocado fruit. *New Zealand Avocado Growers' Association Annual Research Report. 4*: 36-46.

Pak, H.A., Dixon, J., Smith, D.B., Elmsly, T.A. and Cutting, J.G.M. (2003). Impact of rainfall prior to harvest on ripe fruit quality of 'Hass' avocados in New Zealand. *New Zealand Avocado Growers' Association Annual Research Report. 3*: 22-31.

Schroeder, C.A. (1958). Growth and development of the avocado fruit. *California Avocado Society Yearbook* **42**: 114-118.

Yearsley, C., Lallu, N., Burdon, J., Billing, D., Punter, M. and Osman, S. (2002a). Effects of prepacking holding temperatures on shelf-life quality of 'Hass' avocados. *New Zealand Avocado Growers' Association Annual Research Report. 2*: 75-82.

Yearsley, C., Lallu, N., Burdon, J., Billing, D., Punter, M. and Osman, S. (2002b). Effects of airflows during storage or shipping on shelf-life quality of 'Hass' avocados. *New Zealand Avocado Growers' Association Annual Research Report. 2*: 83-91.

ACKNOWLEDGEMENTS

Thanks to Alex Barker, Grahame Body, Dan Cook, Kevin Holley, Hugh Moore, Terry Ridder and Brian Robinson for supplying fruit for this trial. Thanks to New Zealand Kiwifruit Ltd, Katikati, for their assistance with fruit storage.