Respiration and softening rates of 'Maluma' and 'Ryan' avocados and the effect that cold chain breaks have on the ripening and quality of these cultivars

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ABSTRACT

This study is the fourth and last of a series aimed at establishing baseline respirational and softening data for South African export avocado fruit. During the 2011 season the respiration and softening rates of 'Maluma' and 'Ryan' were recorded. In this paper the results are compared with similar data generated for 'Hass'. Generally, the respiration rate of 'Maluma' was fairly similar to that recorded for 'Hass' fruit stored at the same temperature, with two exceptions. Upon placing the fruit into cool storage, the respiration rate of 'Maluma' stored at the higher temperature settings remained higher than that of 'Hass' over a one week period. In contrast, during the last 10 days of storage, the respiration rate of 'Maluma' increased at a slower rate than that of 'Hass'. The commercial ramifications of these observations are discussed. With both 'Maluma' and 'Ryan' the ultimate respiration rates (day 30) of fruit stored under controlled atmosphere (CA) or SmartFresh (SF) conditions were comparable with each other but lower than that of avocados stored under regular atmosphere (RA) conditions. At the start of the trial, the firmness of 'Ryan' was quite similar to that of 'Hass'. During storage it decreased at a slightly slower rate than 'Hass'. Upon placing 'Maluma' avocados into cool storage, the firmness of the fruit was lower than that of 'Hass'. However, during the 30 day storage period the firmness of the two cultivars reduced at more or less the same rate. As was the case with 'Hass', 'Fuerte' and 'Pinkerton', CA and SF significantly reduced firmness loss during storage in both 'Ryan' and 'Maluma'. A SF application also significantly reduced the negative effect of a temperature break. The incidences of both stem-end rot and anthracnose were significantly higher in 'Maluma' and 'Ryan' than in 'Hass', especially at the higher storage temperatures. However, when stored under CA or SF conditions, the incidences of the disorders were significantly lower in both cultivars. As was previously reported, the breaks considerably increased the incidences of the disorders while a SF application resisted the development of spoilage. The empirical data generated by this project is already being used commercially, for example, to assist the settling of commercial claims. The information is further being used in the laboratory to develop higher storage temperature regimes for chilling injury sensitive cultivars. The data is also being used in studies aimed at refining the ripening profiles of artificially ripened fruit. It is foreseen that the full value of the empirical information will become commercially apparent over the next number of seasons.

INTRODUCTION

This paper deals with the fourth and last trial in a study aimed at establishing baseline respirational and softening data for South African export avocado fruit. During the first year, the respiration and softening rates of 'Hass' fruit were determined at three maturity stages during storage at four temperature settings (Lemmer & Kruger, 2009). During the second year, the study was repeated and temperature breaks of 5, 10 and 20 hours were introduced on respectively day 5 and day 20 of the 30 day storage period. In addition to regular atmosphere (RA), controlled atmosphere (CA) and SmartFresh (SF) were also introduced during this season (Lemmer & Kruger, 2010). During the third season, the research protocol was repeated with the 'Fuerte' and 'Pinkerton' cultivars (Lemmer & Kruger, 2011). During the current (2011) season, a similar research approach was followed with the 'Maluma' and 'Ryan' cultivars.

MATERIALS AND METHODS

With both the 'Maluma' and 'Ryan' cultivars, the fruit were harvested upon reaching a moisture content of 70%. The fruit were packed at a commercial packing house in the Nelspruit area before being shipped to the ARC-ITSC post-harvest laboratories where the treatments listed in Table 1 were applied. The techniques involved are similar to those described by Lemmer and Kruger (2009, 2010 & 2011).

RESULTS AND DISCUSSION

The results generated in the study are shown in Figures 1 to 12. For each parameter, the 'Maluma' and 'Ryan' results are compared to information previously generated for 'Hass' fruit of similar maturity.

The respiration rates of 'Maluma' and 'Ryan' are compared to that of 'Hass' in Figure 1. Generally, the respiration rates of 'Maluma' were fairly similar to those recorded for 'Hass' fruit stored at the same temperature, while that of 'Ryan' was lower. There were, however, two important differences between 'Hass' and 'Maluma'. Directly after placing the fruit into cold storage, the respiration rate of 'Maluma' was higher than that of 'Hass', especially at the higher storage temperatures. When stored at 8°C, the respiration rate of 'Maluma' only decreased to the 'Hass' level after one week of storage. Under commercial conditions it is recommended that 'Maluma' avocado fruit be placed into storage as soon as possible after harvest. The present results provide a physiological justification for this practice. The next important difference observed was that, during the last 10 days of storage, the respiration rate of 'Maluma' increased at a slower rate than that of 'Hass', especially at the higher storage temperatures. This implies that if placed into cold storage without unnecessary delay, 'Maluma' fruit should not be more susceptible to soft landings than 'Hass'.

The results recorded in terms of the effect that CA and SF had in comparison with RA, were similar to that reported for the previous three cultivars. With both 'Maluma' and 'Ryan' the ultimate respiration rate (day 30) of the CA and SF fruit were comparable and lower than that of the fruit stored under RA conditions.

The firmness readings are plotted in Figure 2. At the start of the trial, the firmness of 'Ryan' was quite similar to that of 'Hass'. During storage it decreased at a slightly slower rate than 'Hass'. Upon placing 'Maluma' avocados into cool storage, the firmness of the fruit was lower than that of 'Hass'. However, during the 30 day storage period the firmness of the two cultivars reduced at more or less the same rate. As was the case with 'Hass', 'Fuerte' and 'Pinkerton', CA and SF significantly reduced firmness loss during storage in both 'Ryan' and 'Maluma'.

Table 1. Treatments applied to 'Maluma' and 'Ryan' avocado fruit (MC 70%) during the 2011 season.

Treatment no	Moisture %	Storage temp ºC	Storage condition	Break (day)	Brake period (hours)
1	70	4	RA	No break	
2	70	4	SF	No break	
3	70	4	CA	No break	
4	70	6	RA	No break	
5	70	6	SF	No break	
6	70	6	CA	No break	
7	70	6	RA	5	5
8	70	6	RA	5	10
9	70	6	RA	5	20
10	70	6	RA	20	5
11	70	6	RA	20	10
12	70	6	RA	20	20
13	70	6	SF	5	5
14	70	6	SF	5	10
15	70	6	SF	5	20
16	70	6	SF	20	5
17	70	6	SF	20	10
18	70	6	SF	20	20
19	70	8	RA	No break	
20	70	8	SF	No break	
21	70	8	CA	No break	

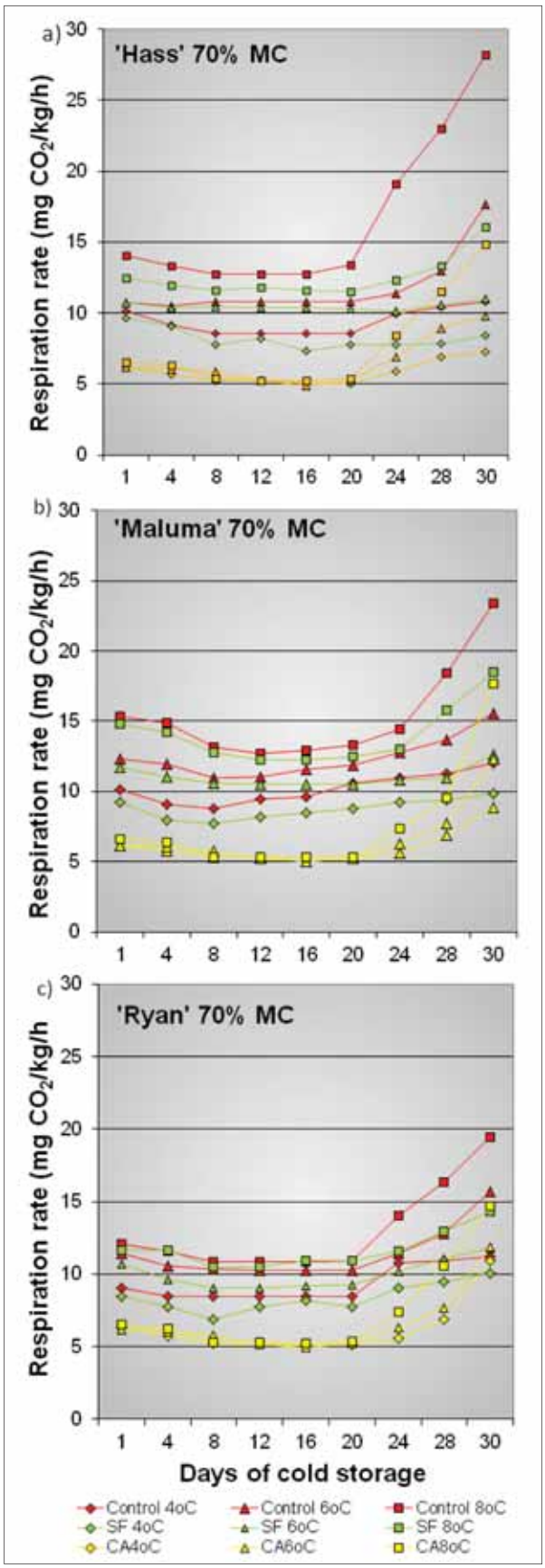

Figure 1. Respiration rates of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit stored at different storage temperature settings.

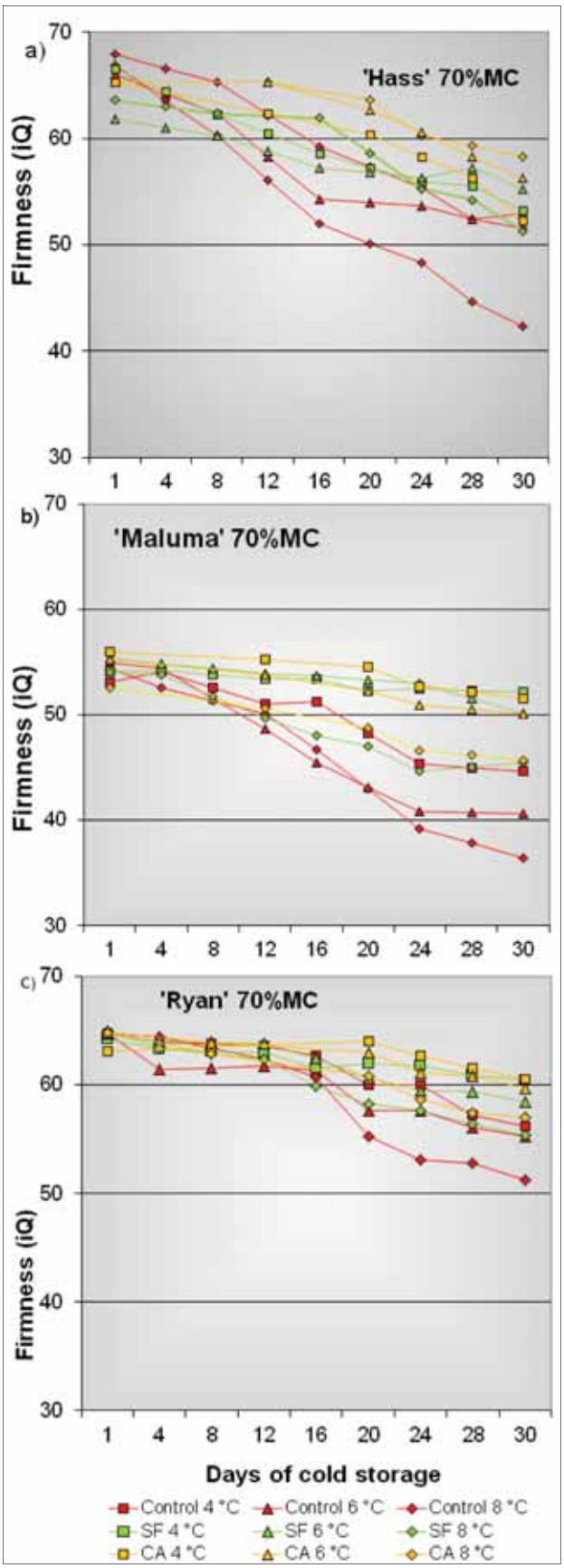

Figure 2. Firmness of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit stored at different storage temperature settings

In order to visibly portray the differential effect that temperature breaks had on 'Maluma' and 'Ryan', only the 20 hour breaks are shown in Figure 3 (break induced on day 5) and Figure 4 (break induced on day 20). From the figures it is clear that the breaks (on both day 5 and day 20) had a more pronounced effect on 'Maluma' than on 'Hass' and 'Ryan'. However, it is also evident that in the case of 'Maluma', a SF application significantly reduced the negative effect of the break. This again corroborates the current industry recommendation regarding the benefits of treating 'Maluma' with SF.

The mean number of days required to ripen the fruit (mDTR) is shown in Figure 5. Whereas 'Hass' fruit stored under CA took longer to ripen than the SF treated fruit stored at similar temperatures, this was not the case with 'Maluma' and 'Ryan'. With the latter two cultivars the CA and SF treatments gave similar mDTR results.

The effect that temperature breaks had on the mDTR of the three cultivars is shown in Figure 6. Although it was shown in Figure 6 that a simulated cold chain break caused a higher rate of firmness loss in 'Maluma' than in 'Hass', the mDTR values did not reflect this. The higher end-of-storage respiration rate recorded for 'Hass' (Figure 1) may possibly provide an explanation for this, in that the observed trend would have been further amplified during the shelf life phase at 20°C.

Not only did 'Ryan' take significantly longer to ripen than the other two cultivars, the effect that the cold chain breaks had were less drastic and the nett effect of the SF treatments were slightly greater. This probably ties in with the lower respiration rate results reported in Figures 1, 3 and 4.

The grey pulp results of the three cultivars are shown in respectively Figure 7 (no temperature breaks) and Figure 8 (temperature breaks). Interestingly no grey pulp was recorded in the fruit of the 'Maluma' cultivar. In the case of 'Hass', a low incidence (less than 5%) was recorded for fruit stored at 8°C. 'Ryan' fruit stored at 4°C had no grey pulp while the 6 and 8°C treatments had around 10% grey pulp. Unlike the previous results recorded for 'Fuerte' (Lemmer & Kruger, 2011), the temperature breaks did not cause an increase in grey pulp. The SF application again very effectively controlled grey pulp and not one of the SF treatments had the disorder.

The stem-end rot results are shown in Figure 9. The incidence of this disorder was significantly higher in 'Maluma' and 'Ryan' than in 'Hass', especially at the higher storage temperatures. When stored under CA or SF conditions, the incidences of the disorder were significantly lower in both cultivars. The effect that cold chain breaks had on the disorder is shown in Figure 10. As was previously noticed (Lemmer & Kruger, 2010; Lemmer & Kruger, 2011), the breaks significantly increased the incidence of the disorder while a SF application made it less prevalent.

The anthracnose results are shown in Figures 11 and 12. The trends were fairly similar to that re-

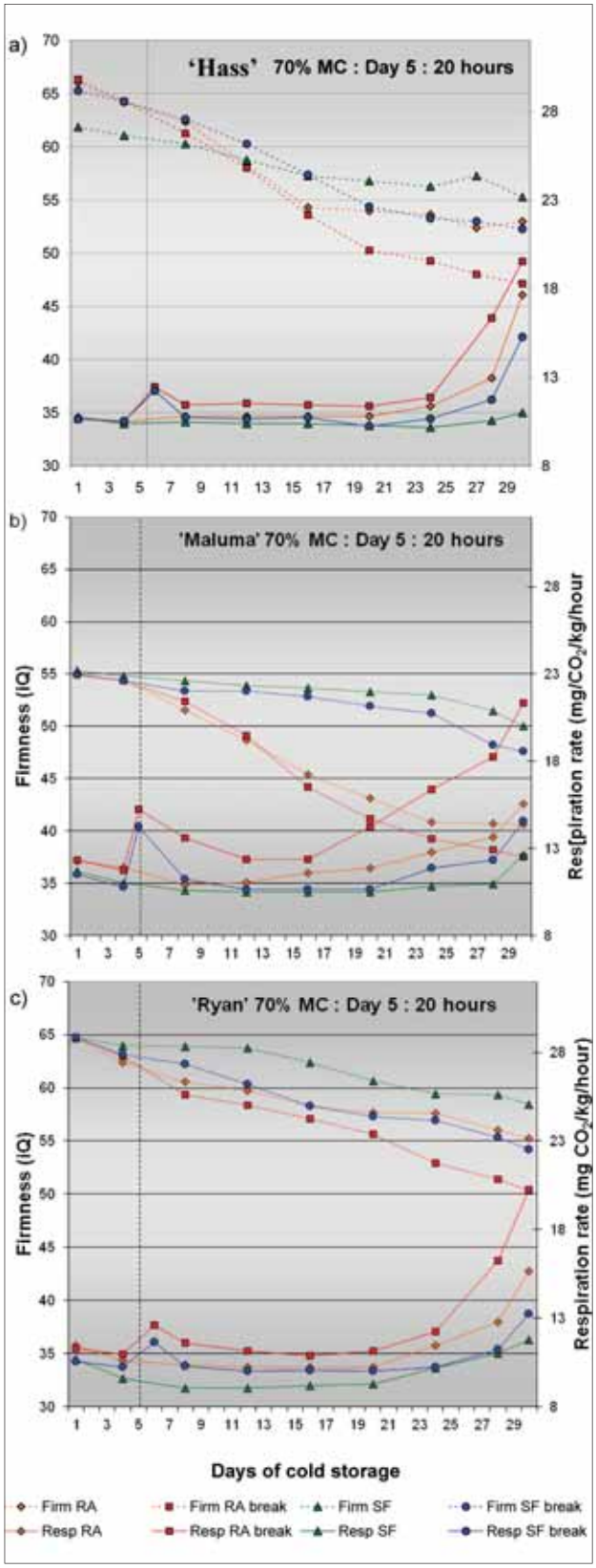

Figure 3. Respiration rate and firmness of 'Hass', 'Maluma' and 'Ryan' fruit at a moisture content of 70% stored at 6°C subjected to a 20 hour temperature break on day 5.

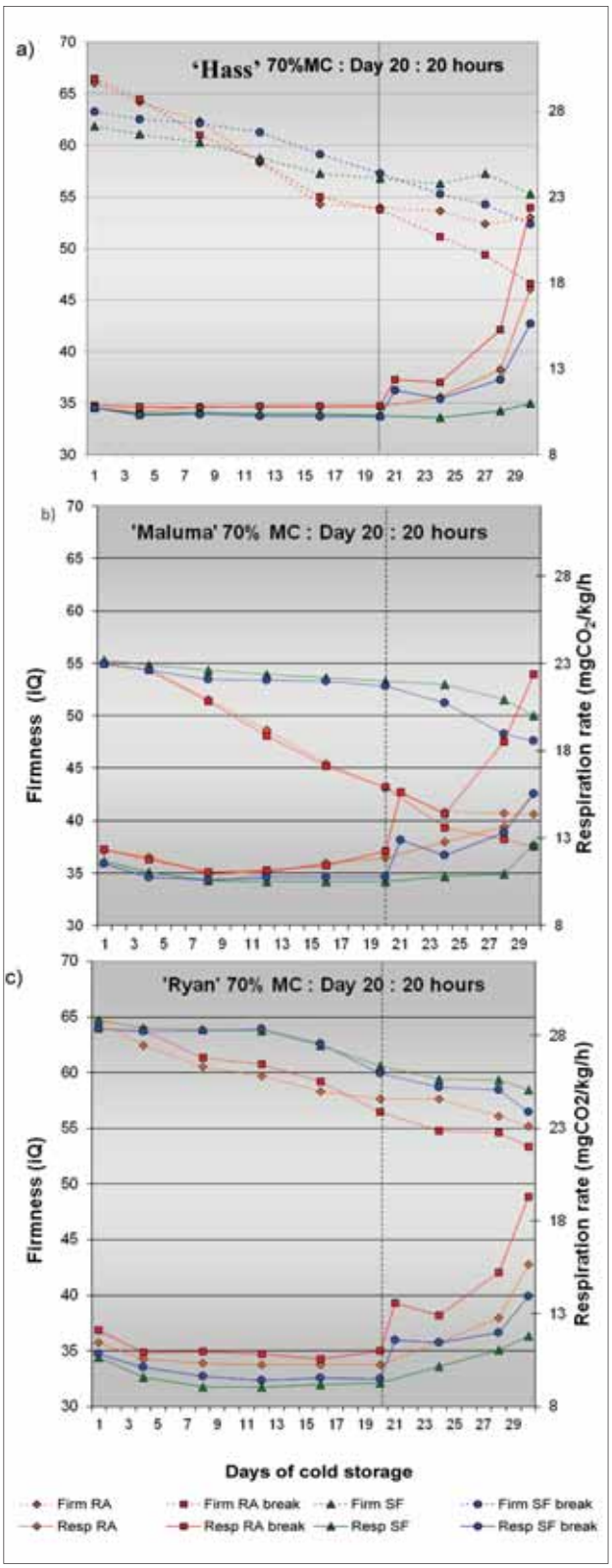

Figure 4. Respiration rate and firmness of 'Hass', 'Maluma' and 'Ryan' fruit at a moisture content of 70% stored at 6°C subjected to a 20 hour temperature break on day 20.

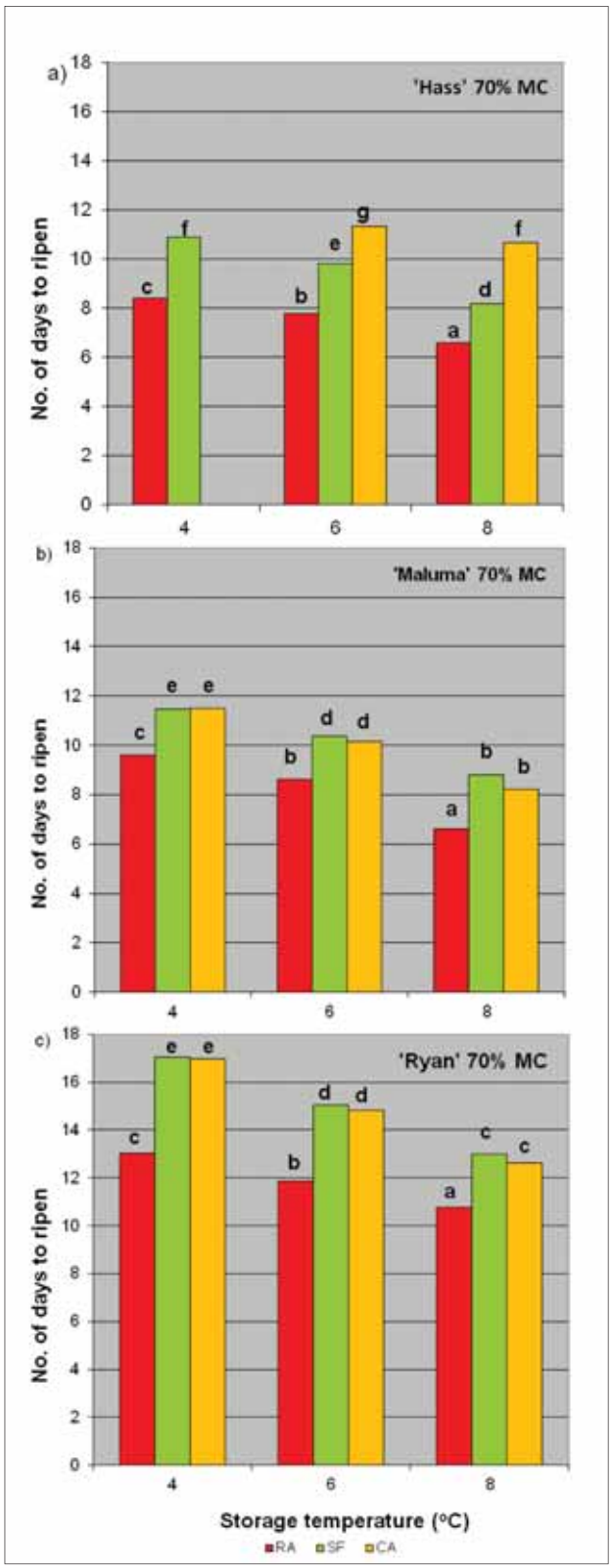

Figure 5. Mean number of days to ripen 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit stored at different storage temperature settings.

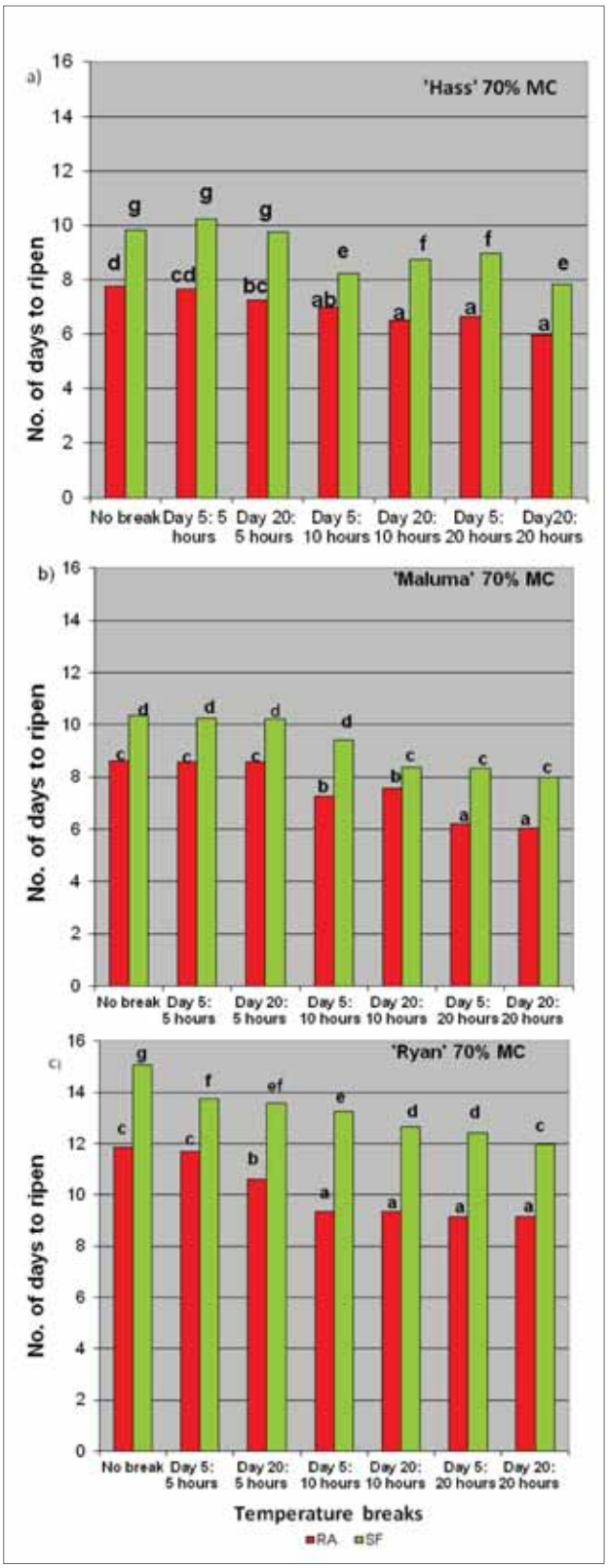

Figure 6. Mean number of days to ripen 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit stored at 6°C and subjected to different cold chain breaks.

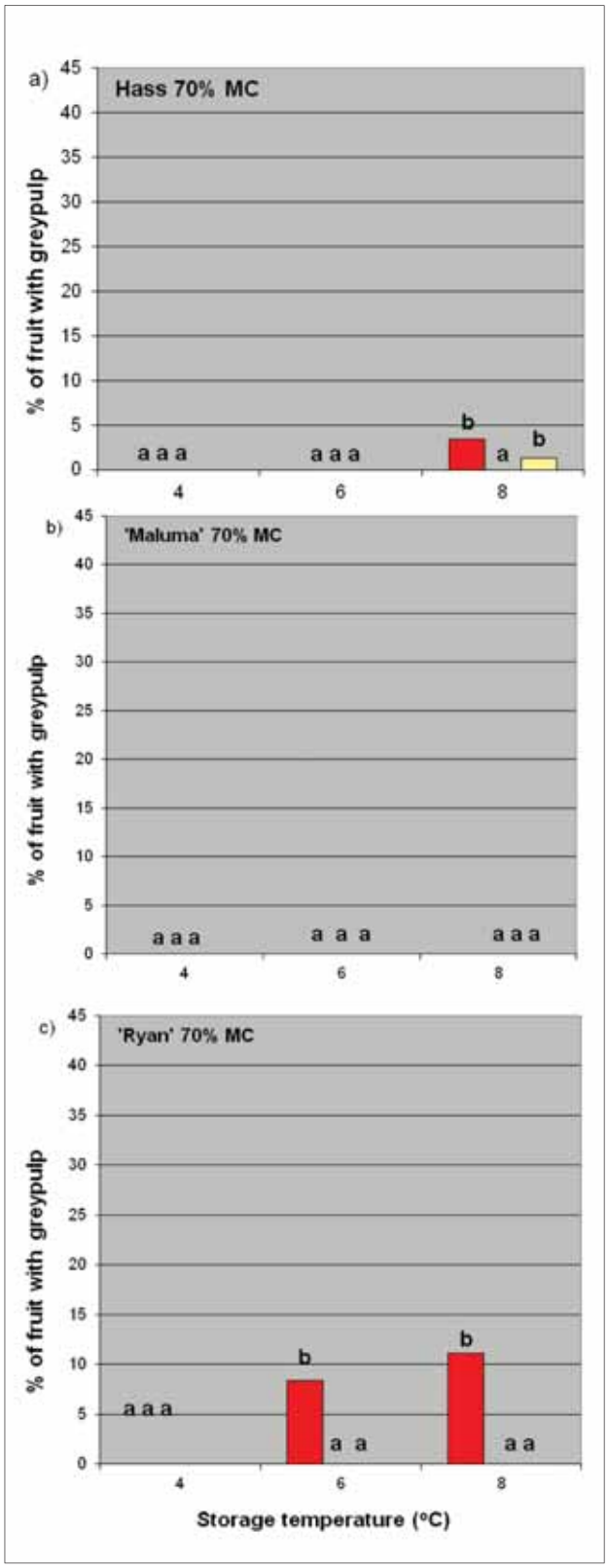

Figure 7. Percentage of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit with grey pulp stored at different storage temperature settings.

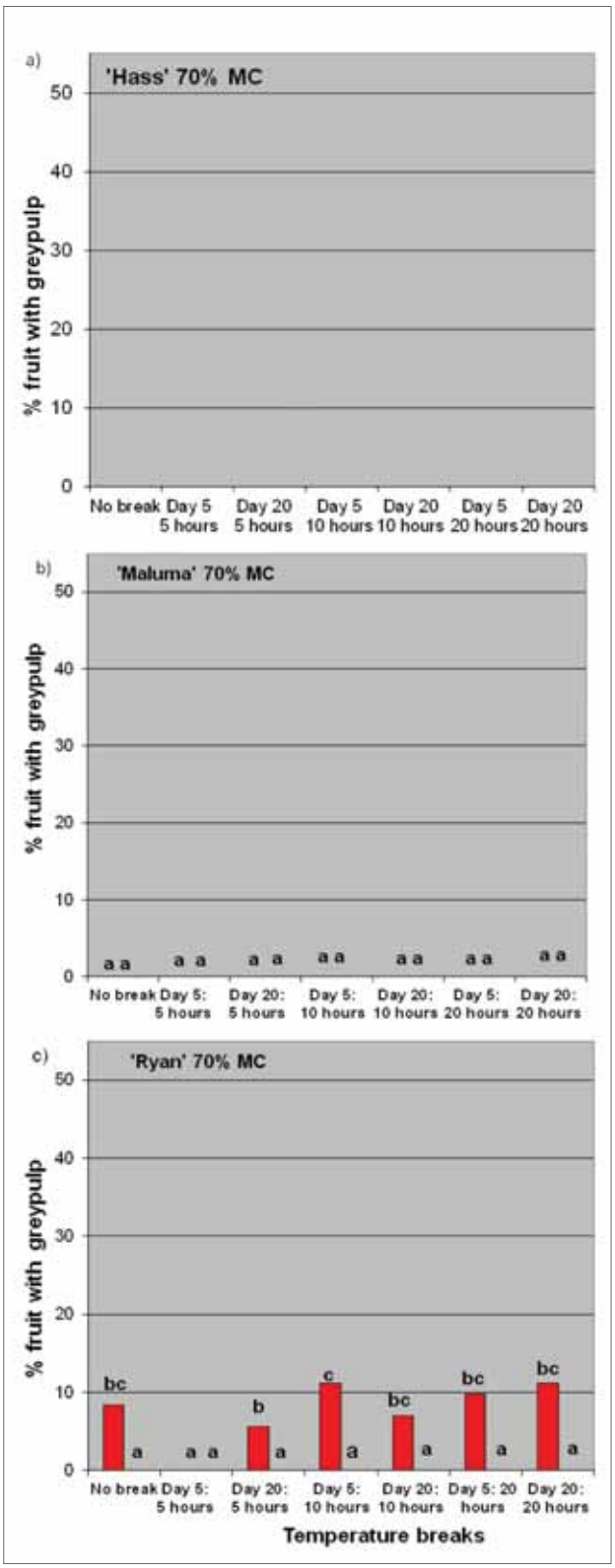

Figure 8. Percentage 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) fruit with grey pulp after being stored at 6°C and subjected to different cold chain breaks.

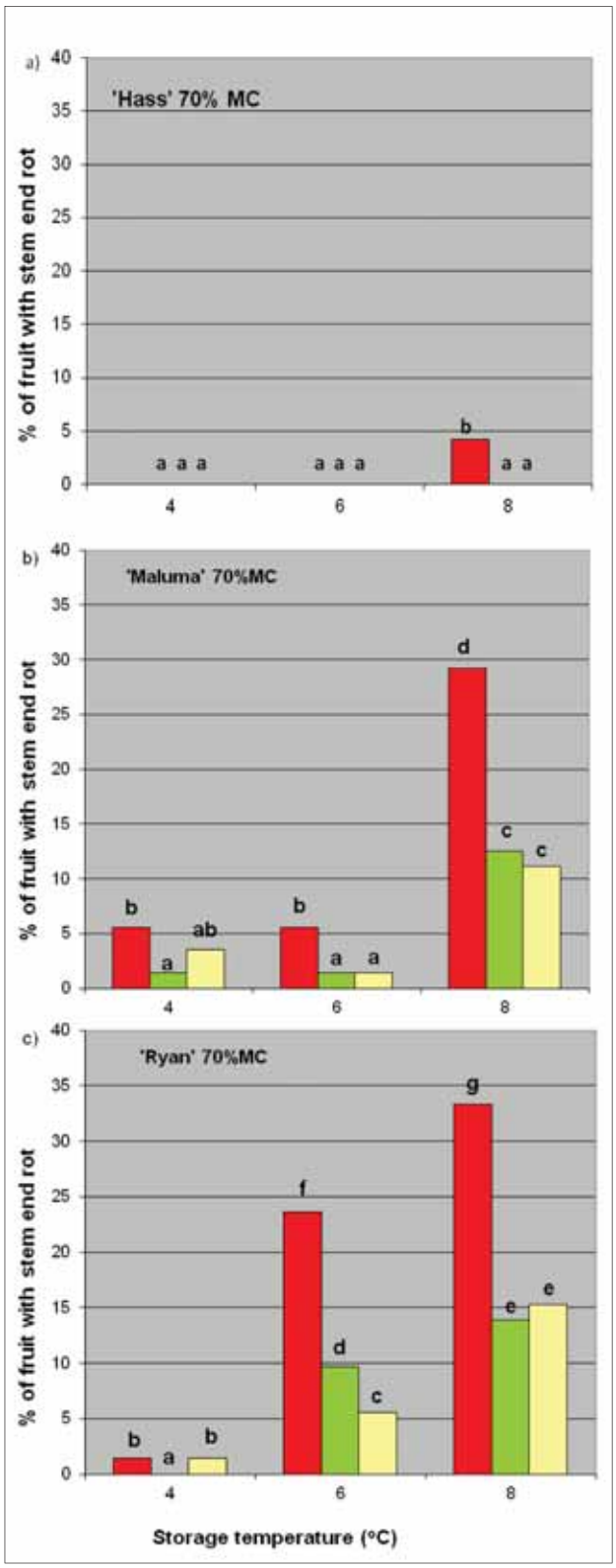

Figure 9. Percentage of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit with stem-end rot after storage at different storage temperature settings.

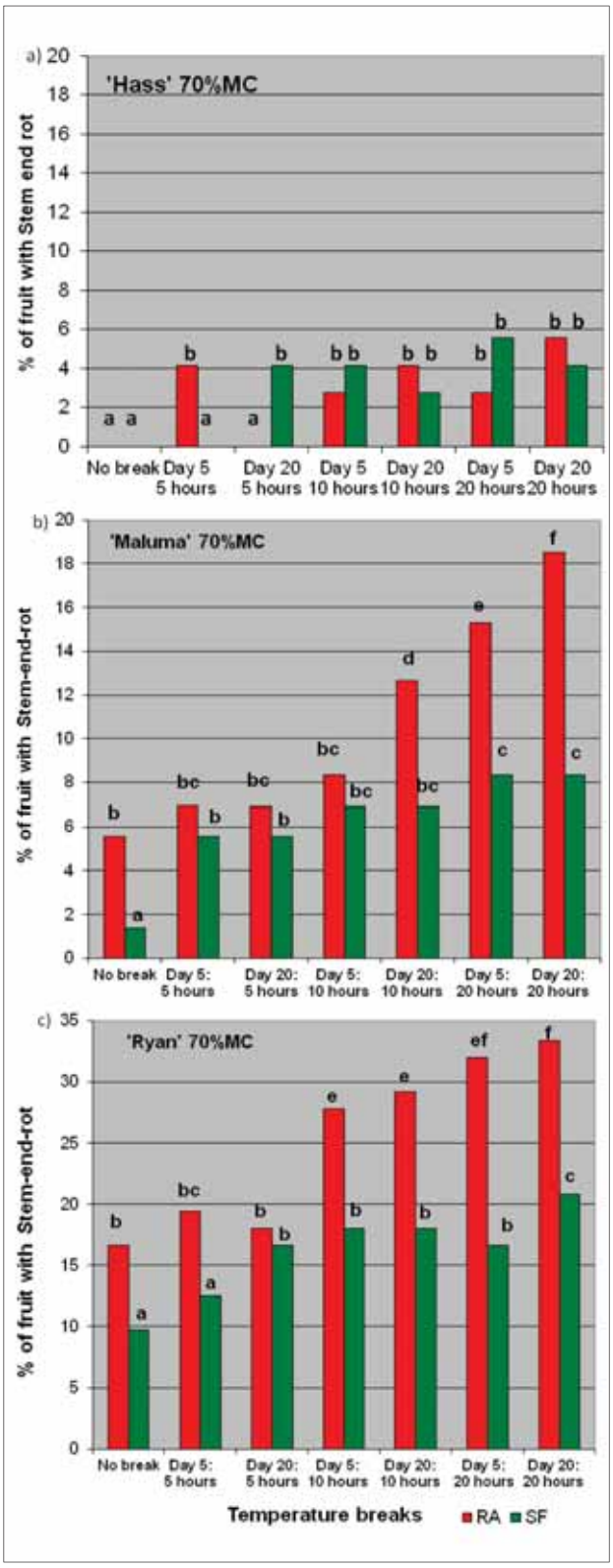

Figure 10. Percentage of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit with stem-end rot after being stored at 6°C and subjected to different cold chain breaks.

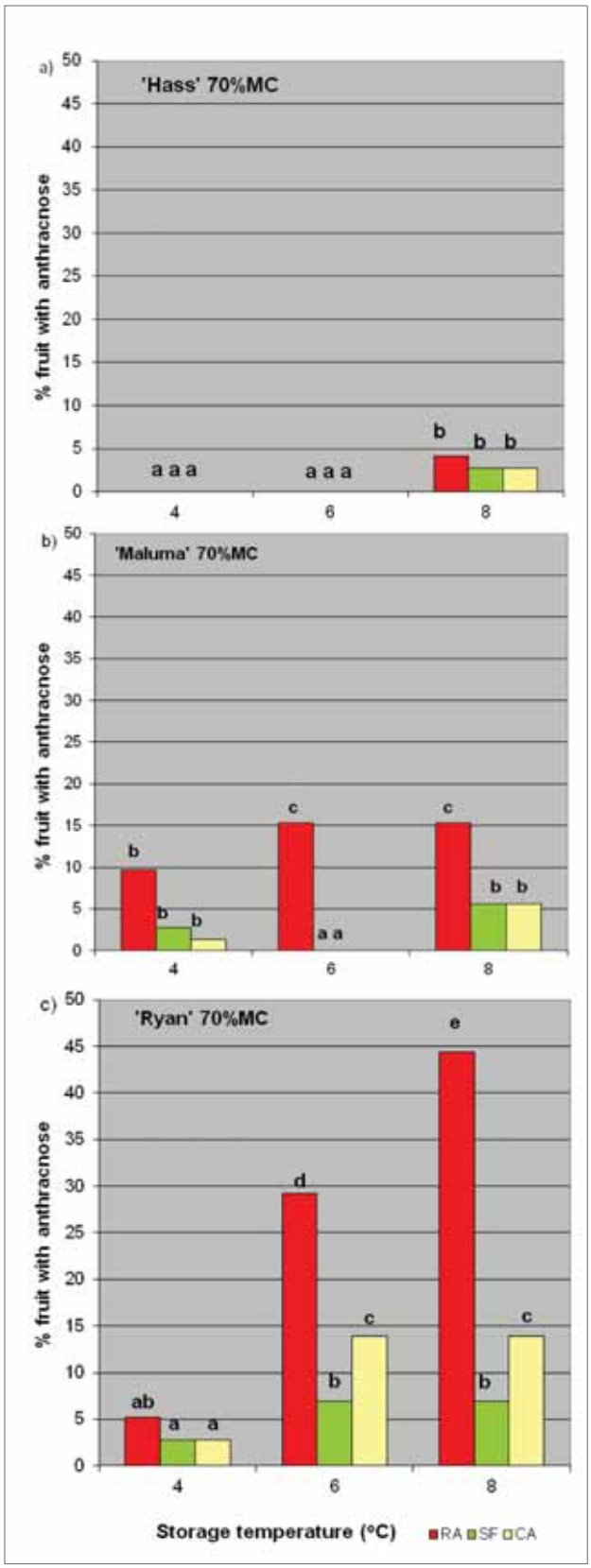

Figure 11. Percentage of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit with anthracnose after storage at different storage temperature settings.

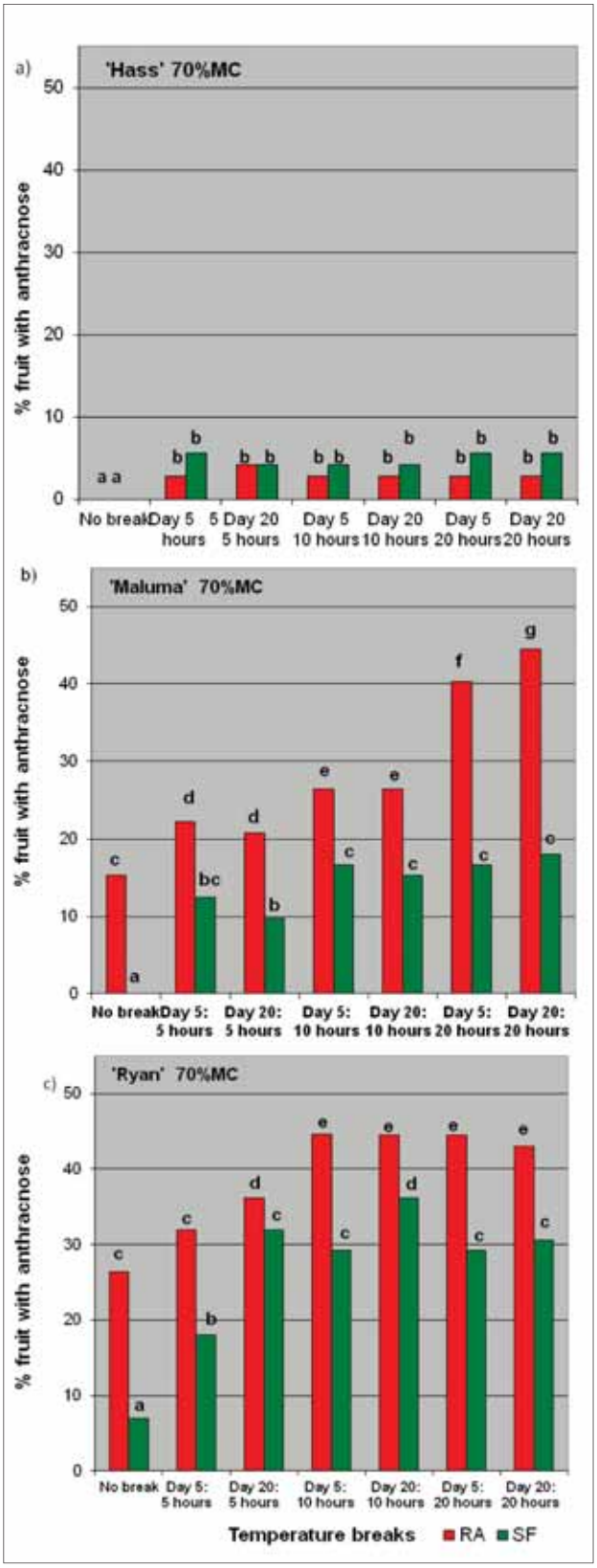

Figure 12. Percentage of 'Hass' (a), 'Maluma' (b) and 'Ryan' (c) avocado fruit with anthracnose after being stored at 6°C and subjected to different cold chain temperature breaks.

corded for stem-end rot in that the incidences were again higher in 'Maluma' and 'Ryan' than in 'Hass', while the breaks increased the disorder and the SF application reduced the pathology.

The empirical data generated by this project is already being used commercially, for example, to assist the settling of commercial claims. The information is further being used in the laboratory to develop higher storage temperature regimes for chilling injury sensitive cultivars. The data is also being used in studies aimed at refining the ripening profiles of artificially ripened fruit. It is foreseen that the full value of the empirical information will become commercially apparent over the next number of seasons.

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