Effect of cold chain breaks on the ripening and quality of 'Hass' avocados

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ABSTRACT

This paper deals with the second year's results of a three year study aimed at quantifying the respiration and softening rates of avocado fruit of increasing maturity stored at different storage temperature regimes. During the first year, baseline data was gathered regarding the relationships between, respectively, fruit maturity, storage temperature and storage period on the one hand and the respiration and softening rates of 'Hass' avocado fruit on the other. During the second season, the previous year's trials were repeated and controlled atmosphere and SmartFresh treatments were also introduced. The effect that temperature breaks of varying magnitude have on the quality of the fruit was also determined. Interestingly, the most important defect brought about by the temperature breaks was a drastic increase in pathological disorders. During the third and final year, the study will be extended so as to include the most important green skin cultivars exported from South Africa.

INTRODUCTION

This report deals with the second year's results of the current post-harvest innovation programme (PHI) project. The project is conducted over a three-year period. During the first year, the respiration and firmness of 'Hass' avocados of increasing maturity, stored at different temperatures, were measured over a 50-day period (Lemmer *et al.*, 2009). During the second (current) year, the effect that storage temperature breaks have on the quality and ripening of the fruit was determined.

MATERIALS AND METHODS

The trials were conducted during 2009 and consisted of 79 treatments performed at three moisture content (MC) levels (75, 70 and 65%). The treatments included at the MC 75% and 70% levels are shown in **Table 1**. Five storage temperature settings (4, 5, 6, 7 and 8°C) were used. In the case of the four highest temperature settings, both regular atmosphere (RA) and SmartFresh (SF) as well as controlled atmosphere (CA) treatments were included. In case of the 4ºC setting, only RA and SF treatments were included. The reason for this was that only four experimental CA channels were available. In the case of the 6ºC storage temperature setting, twelve temperature break permutations were also included. The breaks were performed on either day 5 or day 20 and were 5, 10 or 20 hours in duration. In the case of the MC 65% trials, an additional four treatments were included (**Table 2**): the atmospheres of the four CA treatments were broken on day 20 and the fruit were stored under RA conditions for the last ten days.

During storage, the respiration rates of two replicates, consisting of ten boxes of count 16-18 'Hass' fruit each, were measured at four-day intervals. In the case of firmness, readings were taken of 72 fruit per treatment at four-day intervals (RA and SF treatments). In the case of the CA treatments, the atmospheres were broken at ten-day intervals and the firmness measured. After storage, the avocados were ripened at 20ºC and evaluated. Fruit quality parameters included mean no of days to ripen (DTR), grey pulp, stem-end rot and anthracnose.

RESULTS

The respiration rates of the different constant temperature treatments are shown in **Figure 1**. During the first three weeks of storage, the respiration rates of the avocados varied between 5 and 15 mg CO_2/kg/h. The respiration rates of the RA and SF treatments were temperature dependent, with the respiration rates of the SF treatments being slightly lower than that of the corresponding RA treatments. In contrast, the respiration rates of the CA treatments remained at around 5 mg/CO_2/kg/h over the first three weeks of storage, irrespective of the storage temperature. Between days 20 and 24 the respiration rates of all treatments, excluding the continuous CA treatments, started to rise. The RA treatment showed the highest increase in respiration rate and the rate of increase was strictly storage temperature dependent. The respiration rates of the SF fruit did not increase to a similar extent as the RA treatments during the last ten days of storage. Interestingly, the respiration rates of the 20-day CA treatments were similar to those of the corresponding SF treatments during the last ten days of storage (**Figure 1c**).

The firmness results are shown in **Figure 2**. Al-though the sequence reflected the respiration rate results, the configuration did not. For instance, whereas the respiration rates of most treatments remained stable over the first 20 days, the firmness values decreased as from day one. There were also no marked decreases in firmness when the respiration rates went up after day 20. The 30-day CA treatment lost firmness at the slowest rate, followed by the SF, 20-day CA and RA treatments.

The effect that the breaks had on the respiration rates and firmness of the samples are shown in **Figure 3** and **4** (MC 75%), **Figure 5** and **6** (MC 70%) and **Figure 7** and **8** (MC 65%). In general, the effect of the breaks increased in severity as the fruit matured. The increase in respiration rate and the reduction in firmness also became more pronounced as the length of the break increased. In certain cases, a break on day 20 was slightly more harmful than a similar break on day 5. In most cases, the SmartFresh reduced the respiration rate increases and lessened the firmness loss brought about by the breaks.

The mean DTR results of the constant temperature treatments are shown in **Figure 9**. In all cases, the RA ripened at the fastest rate, followed by the Smartfresh and the 30-day CA treatments. In the case of the 65% MC samples, the DTR's of the SF and 20-day CA treatments were almost identical (**Figure 9c**). The reduction in DTR caused by the breaks is shown in **Figure 10**. Generally, the longer the break, the shorter the mean DTR became. The mean DTR's of breaks introduced on day 20 were slightly lower than those of similar length induced on day 5, but the differences were usually not statistically significant. In contrast, the difference between the mean DTR values of the RA and SmartFresh treatments were generally statistically significant.

The grey pulp results are shown in **Figure 11** and **12**. By and large, grey pulp was most prevalent at the highest storage temperatures and most prominent in the most mature fruit (MC 65%). Both CA and SF effectively reduced the incidence of the disorder. However, the temperature breaks did not influence the occurrence of grey pulp.

The stem-end rot results are shown in **Figure 13** and **14**. This pathological disorder was most prominent at the beginning of the season in fruit stored at the higher storage temperatures. It is extremely important to take note of the fact that the temperature breaks caused a significant increase in the incidence of stem-end rot. Breaks introduced on both day 5 and day 20 resulted in an increase in pathology. The longer the

Table 1. Treatments applied at the 75% and 70% moisture content levels to 'Hass' avocados.

Treatment no	Storage temperature (°C)	Storage condition	Break timing (day no)	Break length (hours)
1	4	RA		
2	4	SF		
3	5	RA		
4	5	SF		
5	5	CA		
6	6	RA		
7	6	RA	5	5
8	6	RA	5	10
9	6	RA	5	20
10	6	RA	20	5
11	6	RA	20	10
12	6	RA	20	20
13	6	SF	5	5
14	6	SF	5	10
15	6	SF	5	20
16	6	SF	20	5
17	6	SF	20	10
18	6	SF	20	20
19	6	CA		
20	7	RA		
21	7	SF		
22	7	CA		
23	8	RA		
24	8	SF		
25	8	CA		

Table 2. Treatments applied at the 65% moisture content level to 'Hass' avocados.

Treatment no	Storage temperature (°C)	Storage condition	Break timing (day no)	Break length (hours)
1	4	RA		
2	4	SF		
3	5	RA		
4	5	SF		
5	5	CA 20 days		
6	5	CA 30 days		
7	6	RA		
8	6	RA	5	5
9	6	RA	5	10
10	6	RA	5	20
11	6	RA	20	5
12	6	RA	20	10
13	6	RA	20	20
14	6	SF	5	5
15	6	SF	5	10
16	6	SF	5	20
17	6	SF	20	5
18	6	SF	20	10
19	6	SF	20	20
20	6	CA 20 days		
21	6	CA 30 days		
22	7	RA		
23	7	SF		
24	7	CA 20 days		
25	7	CA 30 days		
26	8	RA		
27	8	SF		
28	8	CA 20 days		
29	8	CA 30 days		

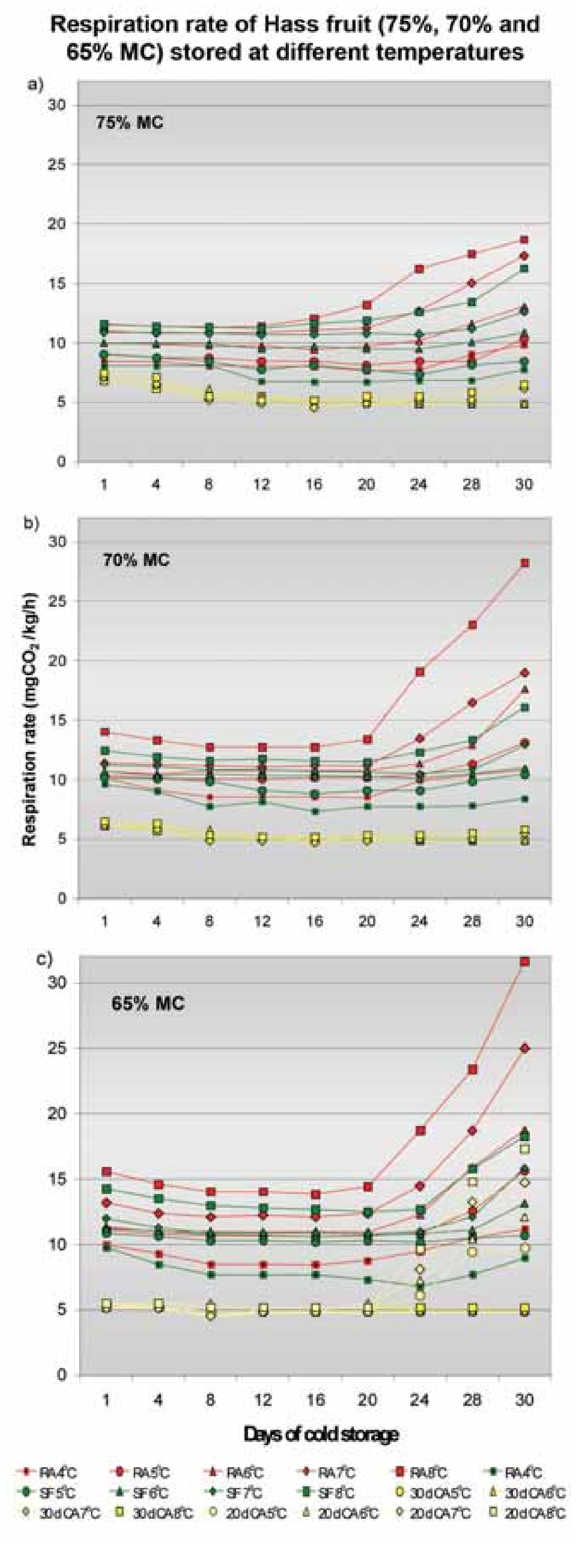

Figure 1. Respiration rates of 'Hass' fruit stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

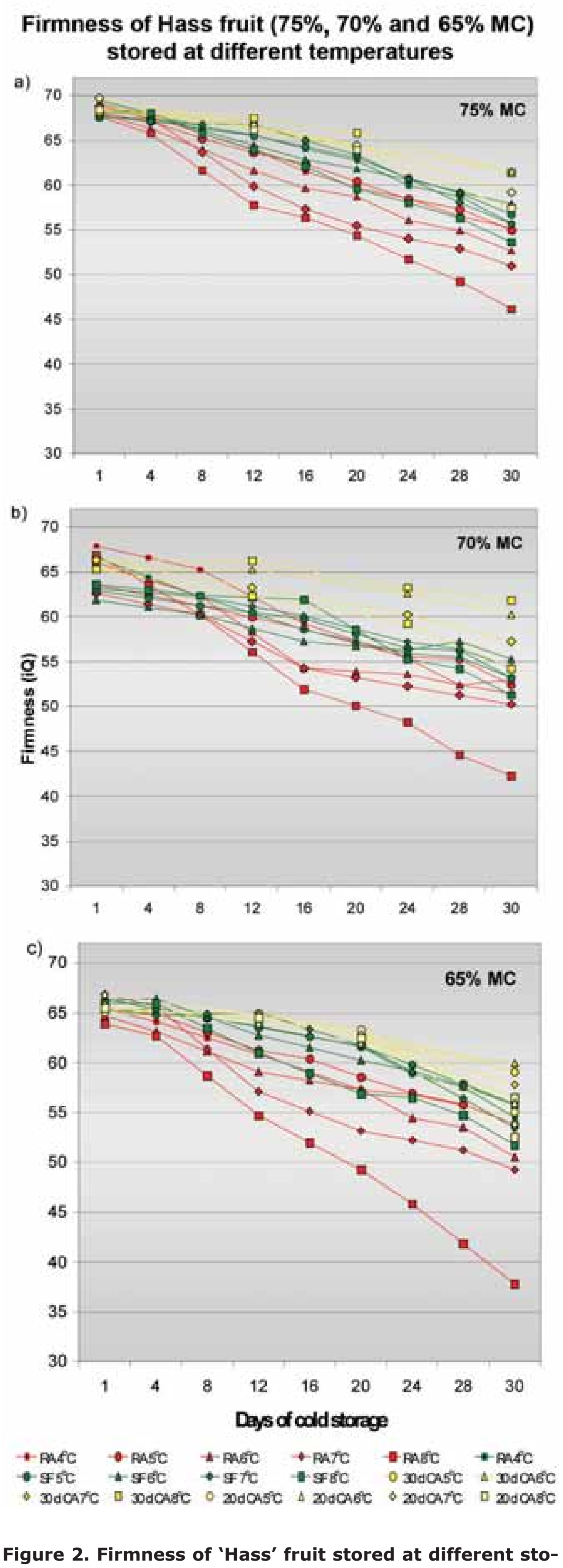

Figure 2. Firmness of 'Hass' fruit stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

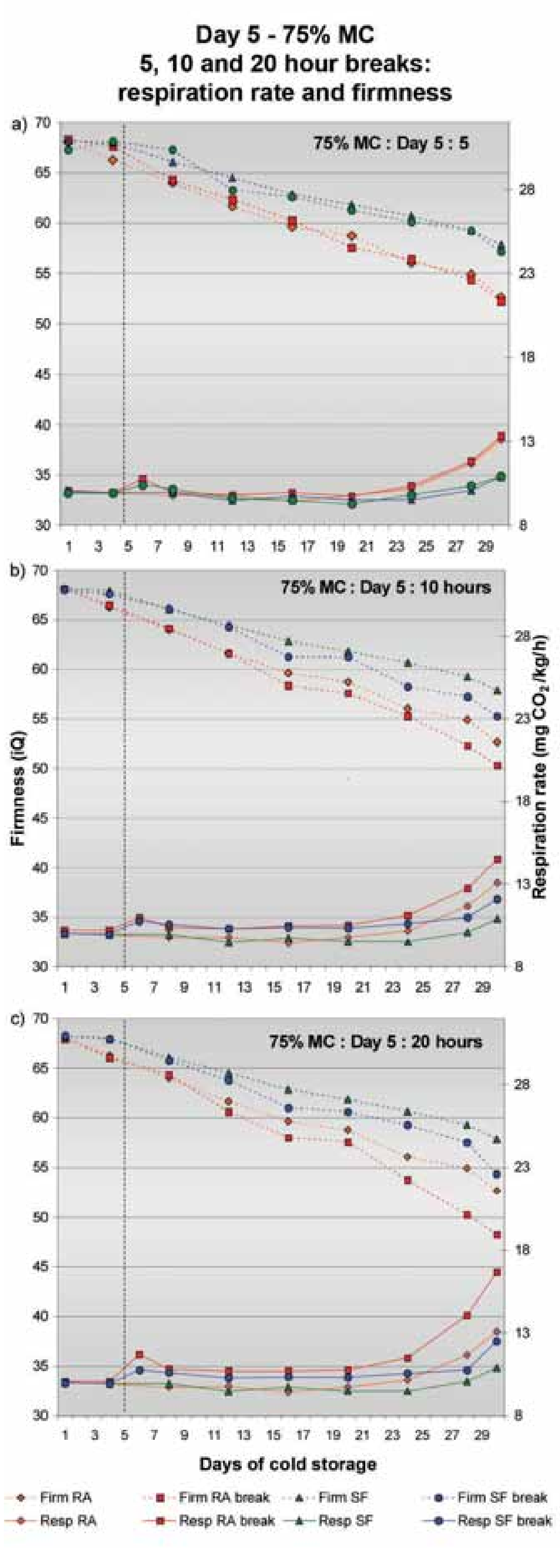

Figure 3. Respiration rate and firmness of 'Hass' fruit at a moisture content of 75% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 5.

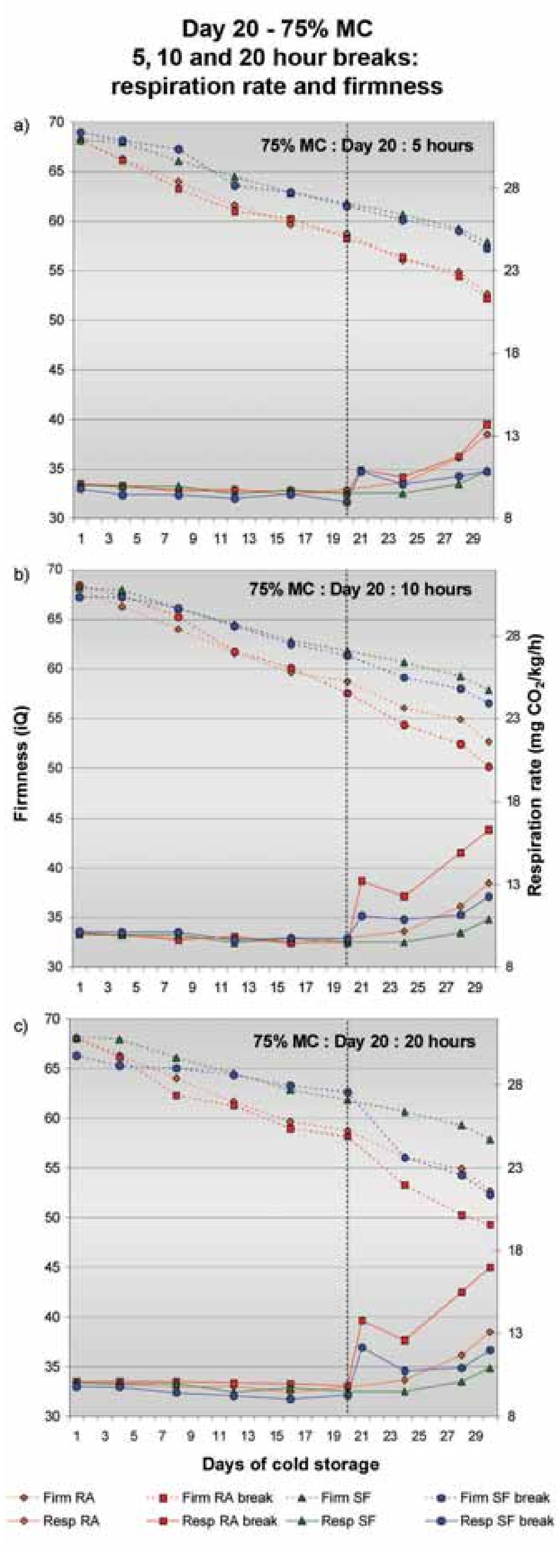

Figure 4. Respiration rate and firmness of 'Hass' fruit at a moisture content of 75% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 20.

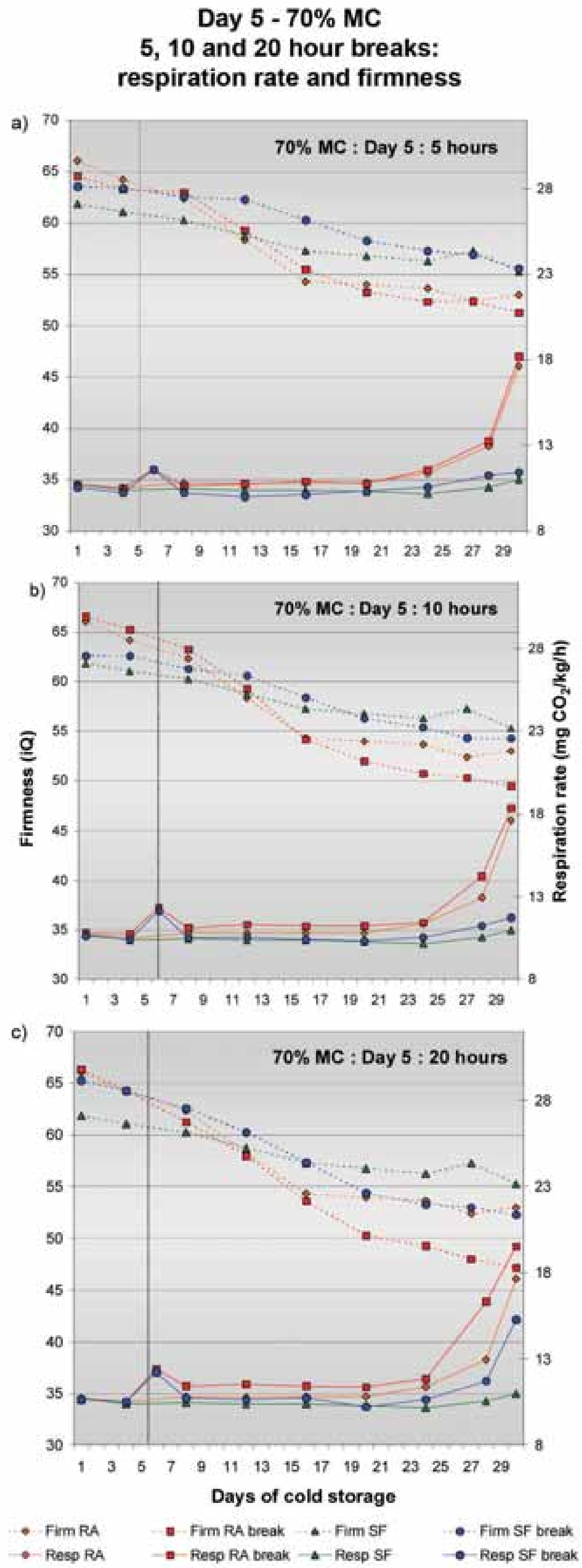

Figure 5. Respiration rate and firmness of 'Hass' fruit at a moisture content of 70% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 5.

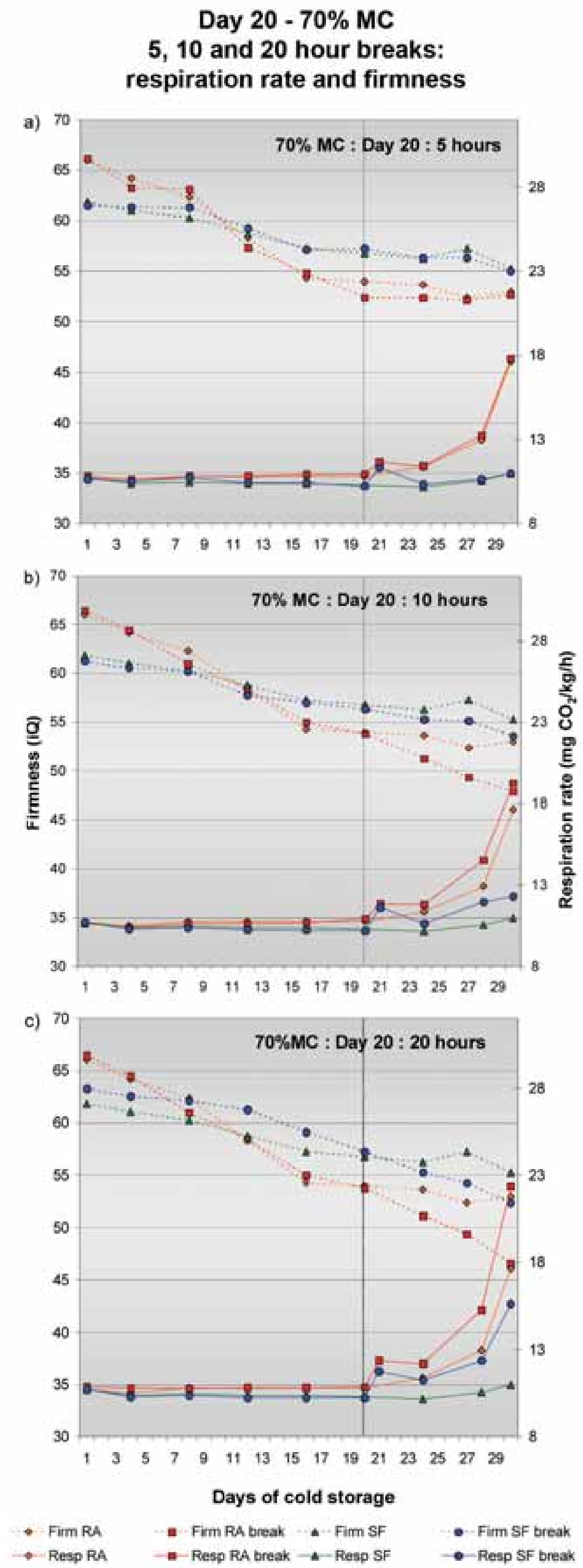

Figure 6. Respiration rate and firmness of 'Hass' fruit at a moisture content of 70% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 20.

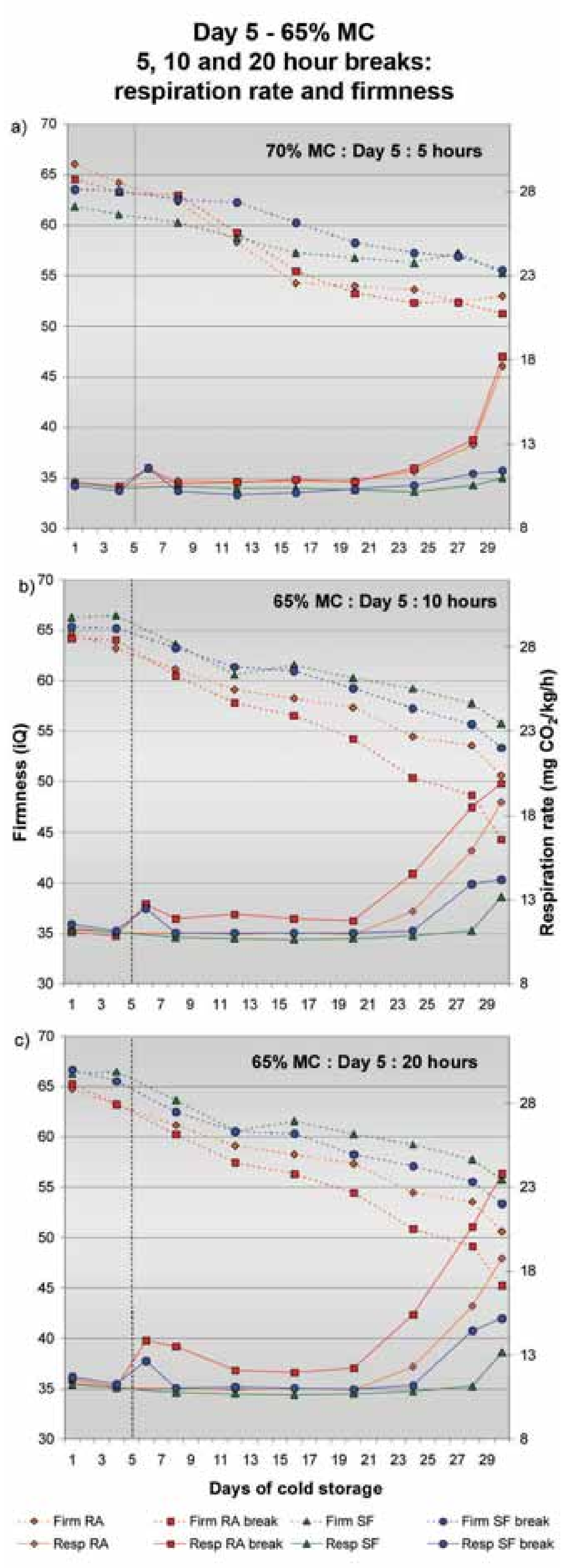

Figure 7. Respiration rate and firmness of 'Hass' fruit at a moisture content of 65% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 5.

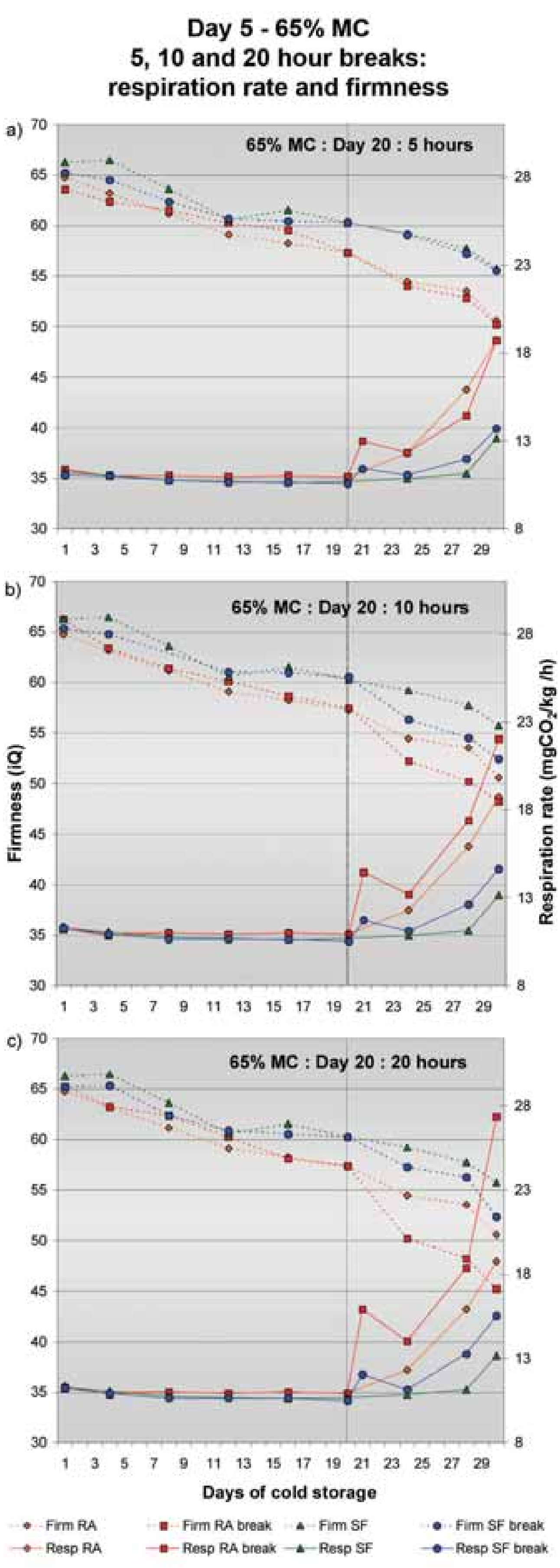

Figure 8. Respiration rate and firmness of 'Hass' fruit at a moisture content of 65% stored at 6ºC subjected to: a) 5 hour, b) 10 hour, c) 20 hour temperature breaks on day 20.

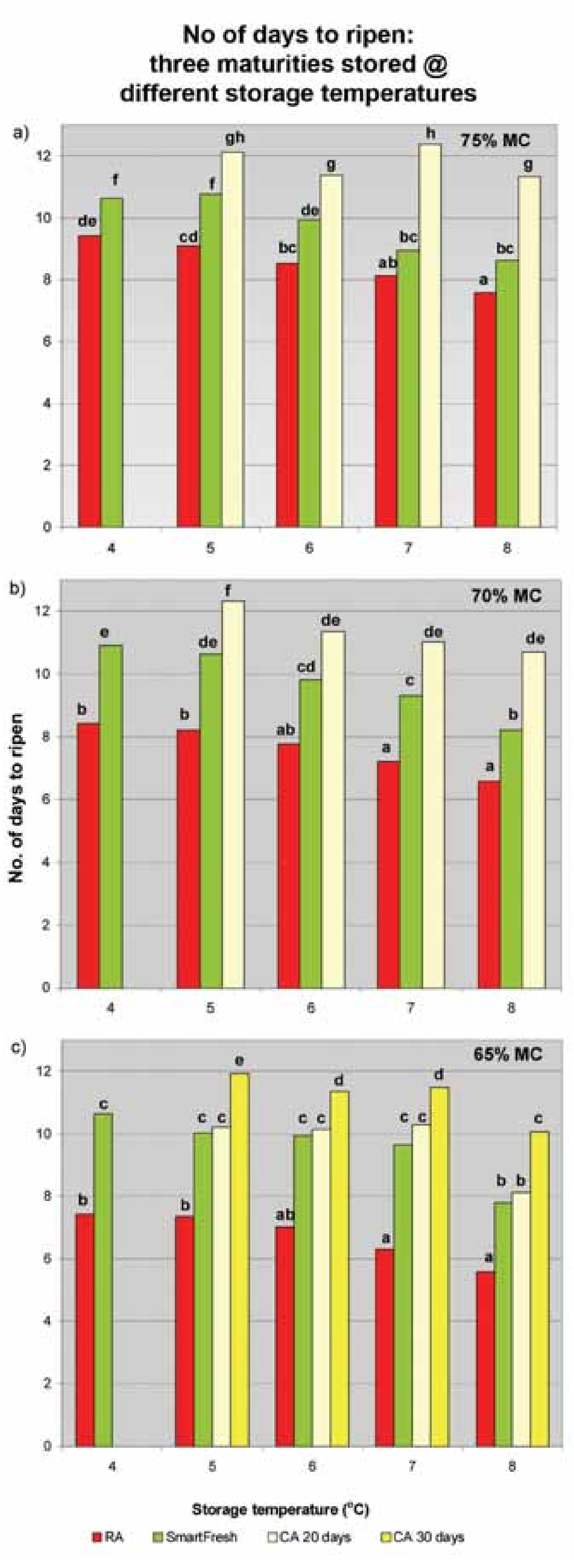

Figure 9. Mean number of day to ripen 'Hass' fruit stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

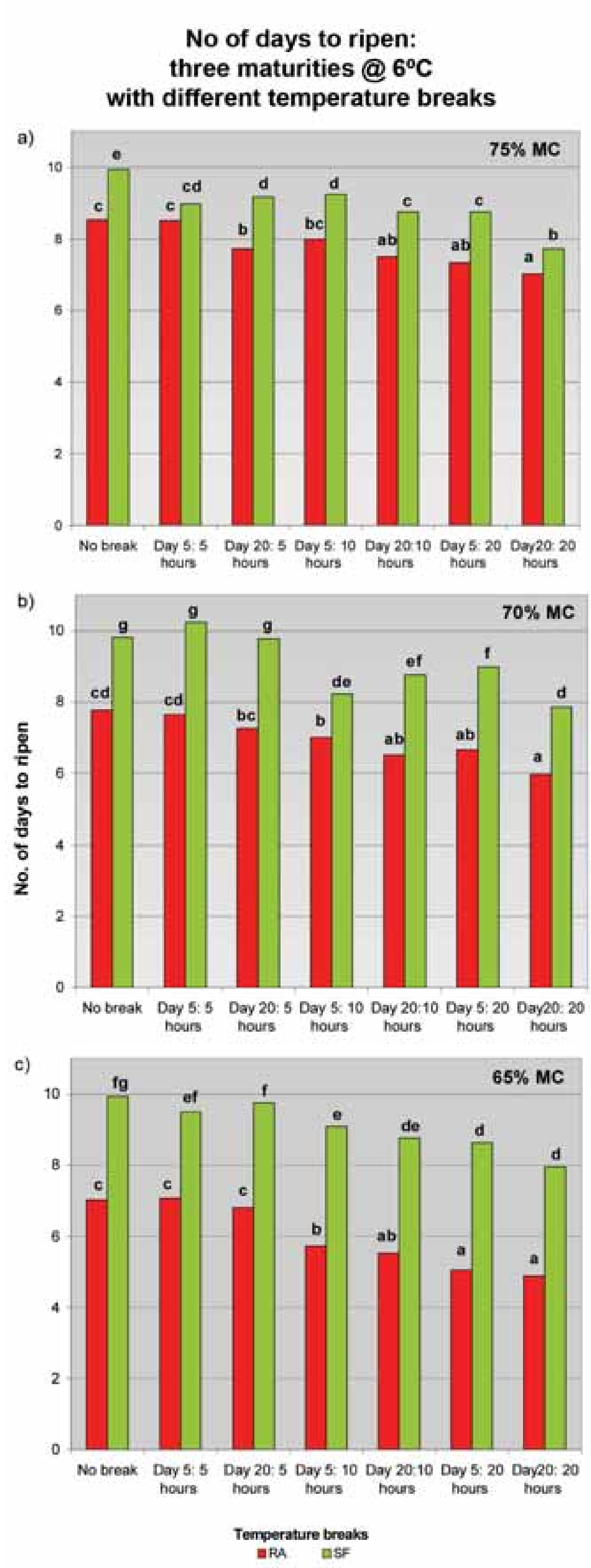

Figure 10. Mean number of day to ripen 'Hass' fruit stored at 6ºC when subjected to different temperature breaks: a) 75% MC, b) 70% MC, c) 65% MC.

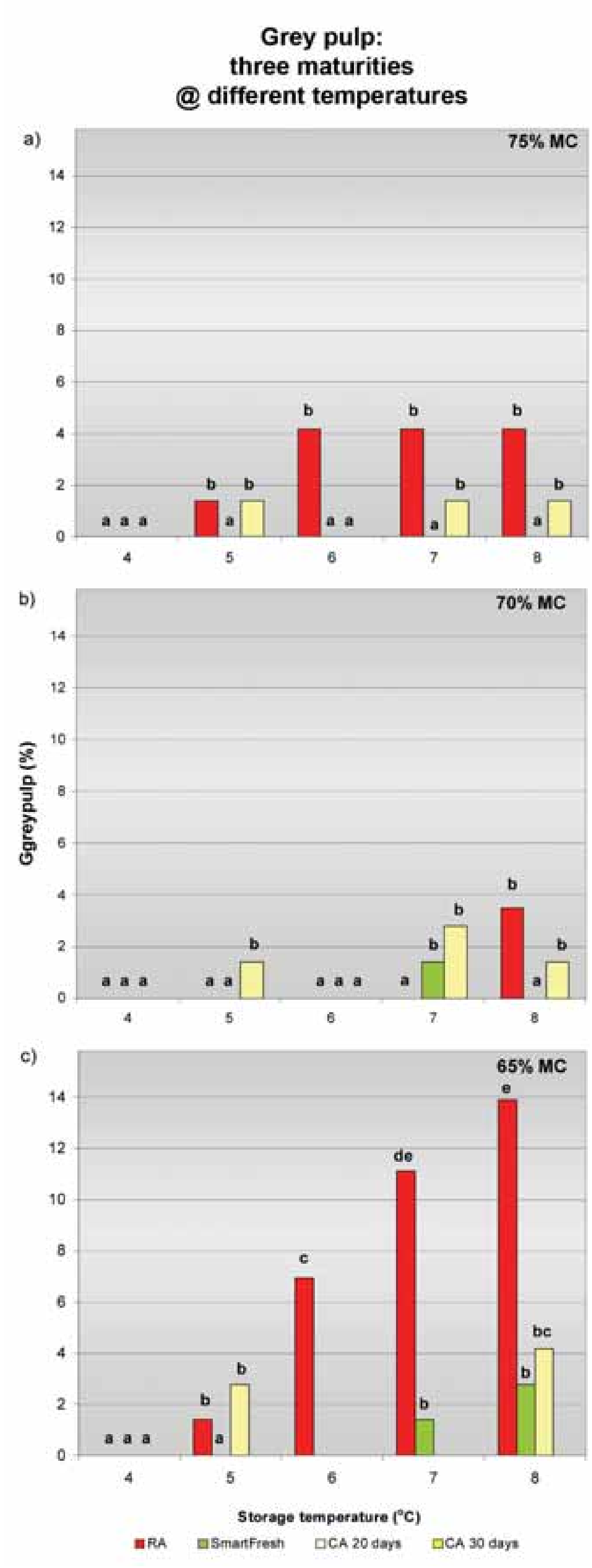

Figure 11. Percentage of 'Hass' fruit with grey pulp when stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

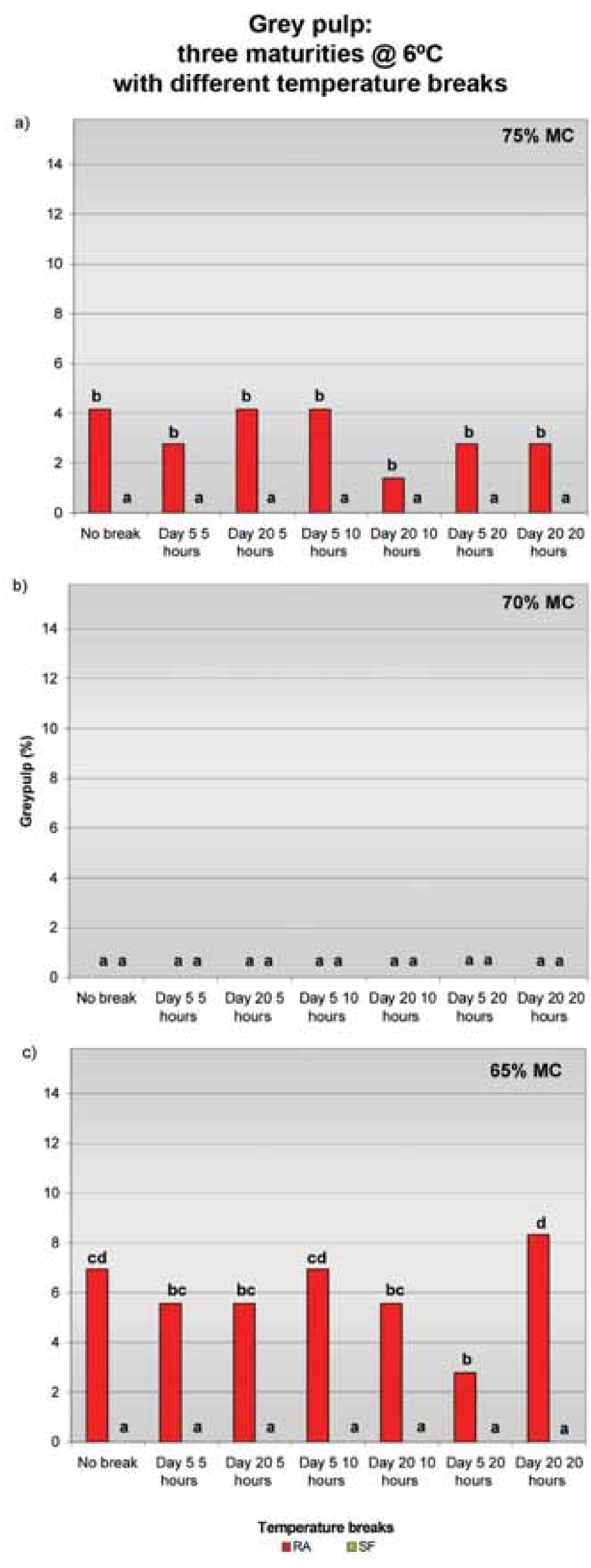

Figure 12. Percentage of 'Hass' fruit with grey pulp stored at 6ºC when subjected to different temperature breaks: a) 75% MC, b) 70% MC, c) 65% MC.

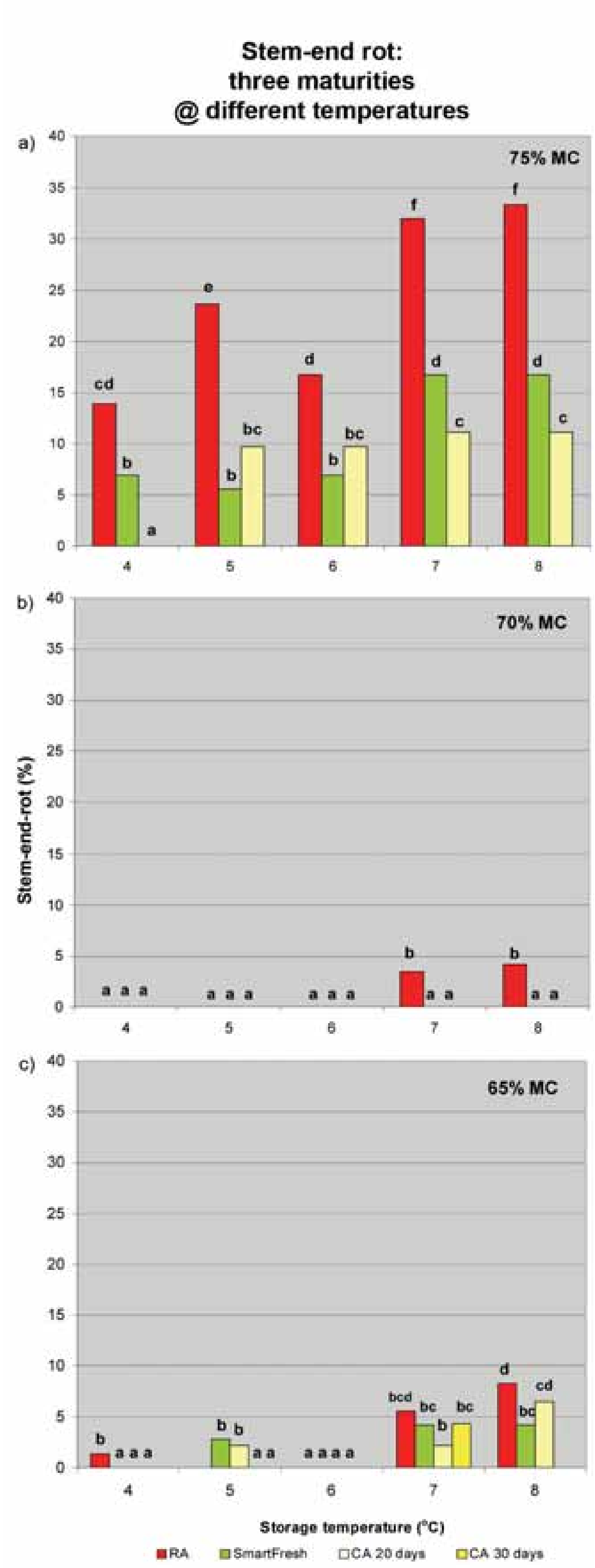

Figure 13. Percentage of 'Hass' fruit with stem-end rot when stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

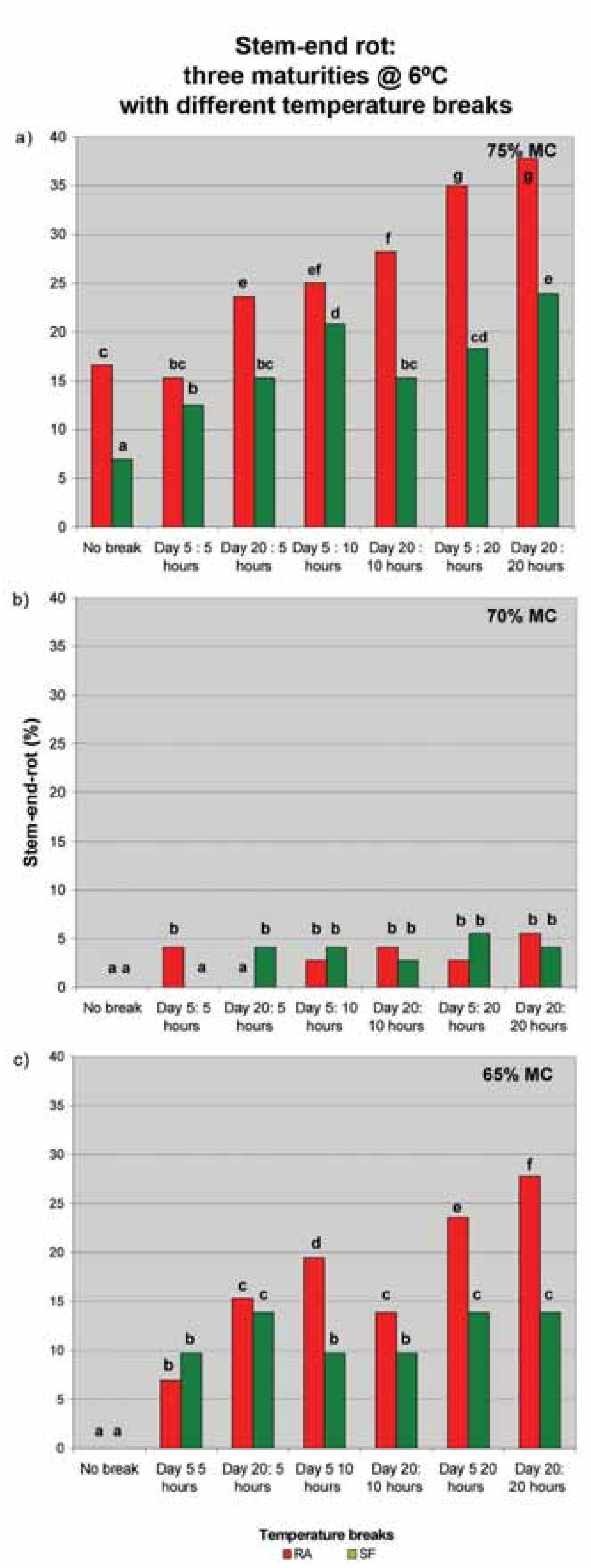

Figure 14. Percentage of 'Hass' fruit with stem-end rot stored at 6ºC when subjected to different temperature breaks: a) 75% MC, b) 70% MC, c) 65% MC.

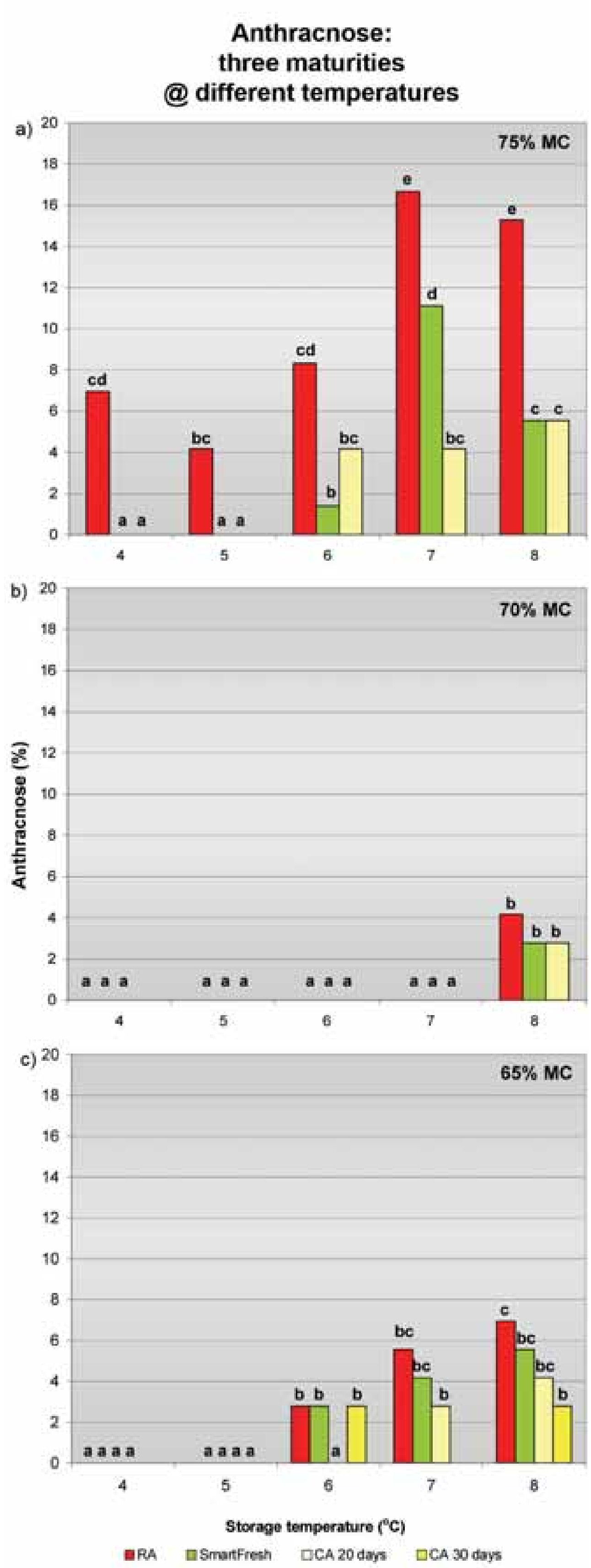

Figure 15. Percentage of 'Hass' fruit with anthracnose when stored at different storage temperature settings: a) 75% MC, b) 70% MC, c) 65% MC.

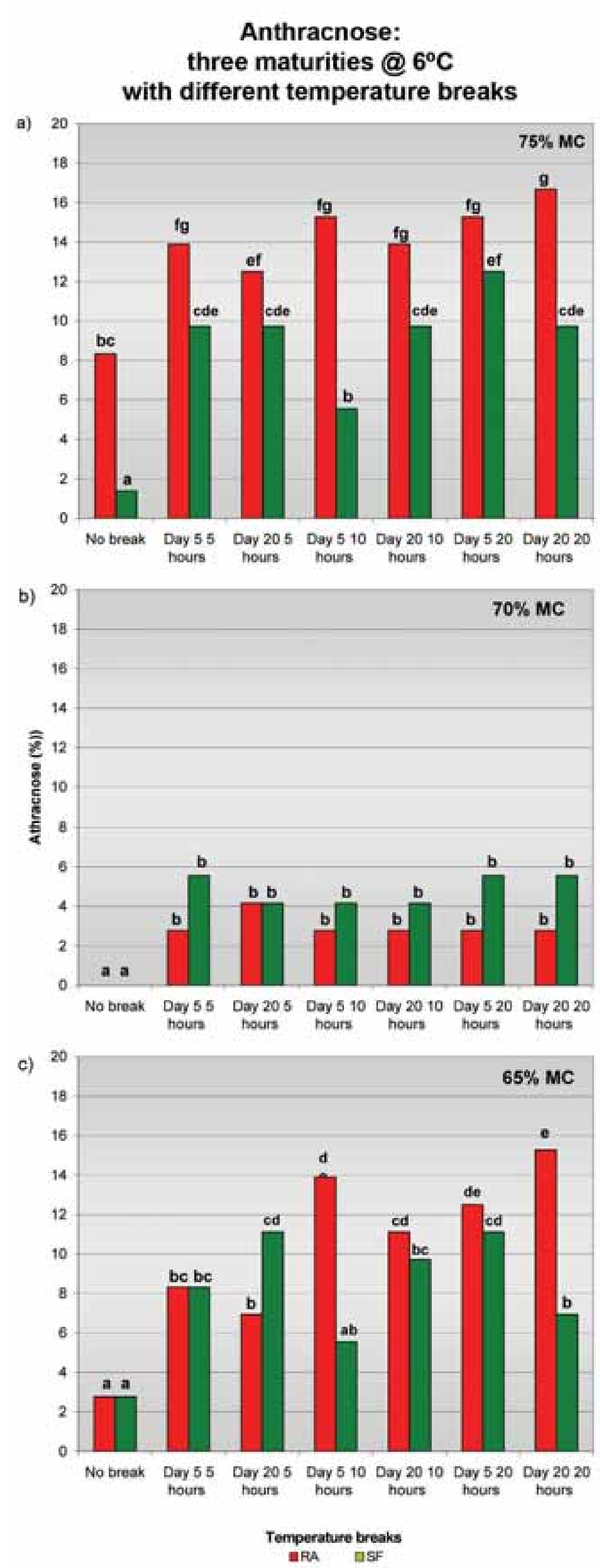

Figure 16. Percentage of 'Hass' fruit with anthracnose stored at 6°C when subjected to different temperature breaks: a) 75% MC, b) 70% MC, c) 65% MC.

break, the worst the pathology became. In certain cases the SF treatments significantly reduced the incidence of stem-end rot.

The anthracnose results are shown in **Figure 15** and **16**. It more or less followed a similar pattern to stem-end rot, though the increase in pathology brought about by the breaks was less severe than with stem-end rot.

CONCLUSIONS

The current study has clearly demonstrated the importance of storing South African export avocados under uninterrupted low temperature CA or SF conditions. The most important result generated concerns the pathology induced by temperature breaks. This is a facet that is seriously underrated by the industry. It will, therefore, be interesting to perform a commercial survey regarding this aspect during coming seasons.

During the 2010 season, the trials conducted during 2008 and 2009 will be repeated with the most important green skin cultivars. A comprehensive report will be submitted after the third year's research has been completed.

ACKNOWLEDGEMENTS

The authors would like to thank the Postharvest Innovation Programme for financial support.

LITERATURE CITED

LEMMER, D., MALUMANE, T.R. & KRUGER, F.J. 2009. Quantification of the respiration and softening rates of South African avocados of increasing maturity stored at different temperatures. *South African Avocado Growers' Association Yearbook*, 32: 32-35.