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

D Lemmer and FJ Kruger

Postharvest Technologies Division,
Agricultural Research Council – Institute for Tropical and Subtropical Crops
Private Bag X11208, Nelspruit 1200, South Africa
E-mail: fransk@arc.agric.za

ABSTRACT

This paper deals with the third year's results of a four year study aimed at quantifying the respiration and softening rates of South African avocado fruit 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. During the third (current) year, the study was extended to the 'Fuerte' and 'Pinkerton' cultivars. The results revealed that, during the first two weeks of storage, the respiration rates of 'Fuerte' and 'Pinkerton' avocado fruit (MC 70%) is comparable to that of 'Hass' of similar maturity. During the third week of storage, the respiration rate of 'Pinkerton' started to increase. With 'Hass' and 'Fuerte', this only happened during the fourth week. However, the magnitude of the increase was smaller in 'Pinkerton' than in 'Hass' and 'Fuerte', especially at the higher storage temperatures. In terms of firmness, 'Fuerte' and 'Pinkerton' softened at more or less the same rate, except at the highest storage temperature (8°C), where 'Fuerte' softened at a considerable faster rate than 'Pinkerton'. Both cultivars softened at a faster rate than that recorded for 'Hass', though the readings may have been confounded by differences in rind texture. As was the case with 'Hass', the most important defect brought about by the temperature breaks in 'Fuerte' and 'Pinkerton' was a significant increase in pathological problems. In the case of 'Fuerte', the breaks also caused a significant increase in grey pulp. A SmartFresh application successfully reduced the grey pulp and, in certain cases, also the incidence of the pathological problems.

UITTREKSEL

Hierdie artikel handel oor die derde jaar se resultate van 'n vier jaar lange studie wat dit ten doel stel om die respirasie- en rypwordingtempo's van Suid-Afrikaanse uitvoer-avokado's wat teen verskillende temperature opgeberg word te kwantifiseer. Gedurende die eerste jaar is basiese inligting betreffende die verwantskappe tussen vrugvolwassenheid, opbergingstemperatuur, opbergingsperiode en die respirasietempo en rypwordingstempo vir 'Hass' avokadovrugte bepaal. Gedurende die tweede seisoen is die vorige jaar se proewe herhaal en die invloed van SmartFresh-behandelings en opberging onder beheerde atmosfeer is ook bepaal. Die invloed wat temperatuuronderbrekings van wisselende omvang op die rypwording en gehalte van die vrugte het, is ook bepaal. Gedurende die derde (huidige) seisoen is die studie uitgebrei om 'Fuerte'- en 'Pinkerton'-kultivars in te sluit. Die resultate het getoon dat die respirasietempo's van die drie kultivars vergelykbaar is tydens die eerste twee weke van opberging. Gedurende die derde week het 'Pinkerton' se respirasietempo begin toeneem terwyl dié van 'Hass' en 'Fuerte' eers tydens die vierde week begin styg het. Die grootte van die toename was egter minder by 'Pinkerton' as by 'Hass' en 'Fuerte', veral teen die hoër opbergingstemperature. In terme van vrugfermte het 'Fuerte' en 'Pinkerton' tydens opberging nagenoeg teen dieselfde tempo versag, behalwe teen die hoogste opbergingstemperatuur (8°C), waar 'Fuerte' teen 'n vinniger tempo as 'Pinkerton' versag het. Beide laasgenoemde kultivars het teen 'n vinniger tempo versag as 'Hass', maar die lesings is heel moontlik verwarrend beïnvloed deur skiltekstuur. Soos die geval by 'Hass' was, het die temperatuuronderbrekings betekenisvolle toenames in patologiese probleme by 'Fuerte' en 'Pinkerton' veroorsaak. In 'Fuerte' se geval het die onderbrekings ook 'n betekeninsvolle toename in gryspulp veroorsaak. Die SmartFresh-behandeling het die gryspulp effektief verminder, asook die voorkoms van patologiese probleme.

INTRODUCTION

This report deals with the third year's results of the current Postharvest Innovation Programme (PHI) project. The project is conducted over a four 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 storage period (Lemmer *et al*., 2009). During the second year, the effect that storage temperature breaks have on the quality and ripening of the 'Hass' fruit was determined (Lemmer & Kruger, 2010). During the current study, the investigation was extended to include two of the most important green skin cultivars ('Fuerte' and 'Pinkerton') exported from South Africa. During the fourth year (2011) the 'Maluma' and 'Ryan' cultivars will be included.

MATERIALS AND METHODS

Both the 'Fuerte' and 'Pinkerton' trials were performed at a moisture content (MC) level of 70%. Each trial consisted of 21 treatments (**Table 1**). Three storage temperature settings (5, 6, and 8°C) were used. Regular atmosphere (RA), SmartFresh (SF) and controlled atmosphere (CA) treatments were included. In the case of the 6°C storage temperature setting, twelve temperature breaks (20°C) were also included. The breaks were 5, 10 or 20 hours in duration and were performed on either day 5 or day 20. The CA treatments were broken on day 20 and the fruit were stored under RA conditions for the last ten days in order to simulate commercial conditions.

During storage, the respiration rates of two replicates, consisting of ten boxes of count 18 fruit each, were measured at four day intervals. In the case of firmness, readings were taken of 72 fruit per treatment. With the RA and SF treatments, the measurements were taken at four day intervals, while the CA treatments were broken at ten day intervals and the firmness measured. After storage, the avocados were ripened at 20°C and evaluated. Fruit quality parameters included the mean number of days to ripen (DTR) and the incidences of grey pulp, stem-end rot and anthracnose.

RESULTS AND DISCUSSION

The respiration rates of the constant temperature treatments are shown in **Figure 1**. During the first three weeks of storage, the respiration rates of 'Fuerte' varied between 5 and 15 mg/CO_2/kg/h. This was similar to that recorded for 'Hass' during the previous year. In the case of 'Pinkerton' the measurements varied between 5 and 13 mg/CO_2/kg/h during the first two weeks. The respiration rates of the RA and SF treatments were temperature dependent, with the respiration rates of the SF treatments being slightly lower than those of the corresponding RA treatments.

In the case of 'Fuerte', the respiration rates of the RA and SF treatments started to increase between

Table 1. Treatments applied to 'Fuerte' and 'Pinkerton' avocado fruit (MC 70%) during the 2010 season.

Treat no	Moist (%)	Storage temp °C	Storage condition	Break (day)	Break 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	

days 20 and 24. In the case of 'Pinkerton', the rise in respiration rate started between days 16 and 20, but the rise was less drastic compared to that of 'Fuerte' (Figure 1), especially at the higher storage temperatures. This observation supports the current recommendation to export the 'Pinkerton' cultivar at 8°C in order to prevent chilling injury.

In contrast with the RA and SF treatments, the respiration rates of the CA treatments remained at around 5 mg/CO_2/kg/h over the first 20 days of storage, irrespective of the storage temperature. After breaking the CA on day 20, the respiration rates of the CA treatments increased and the readings were comparable to that of the SF treatments by day 30.

Whereas the respiration rates of most treatments remained stable over the first 2-3 weeks, the firmness values steadily decreased as from day one (**Figure 2**). In both 'Fuerte' and 'Pinkerton', the initial firmness values were lower than that recorded for 'Hass' during the previous season. However, this may possibly be due to rind texture differences between the cultivars.

There was no corresponding acceleration in firmness loss during the period that the respiration rate of most treatments started to increase (between days 16 and 24). The CA and SF treatments lost firmness at the slowest rate followed by the RA treatments. At 8°C, firmness loss was significantly slower in 'Pinkerton' than in 'Fuerte'. This observation also supports the current recommendation to export 'Pinkerton' at 8°C in order to prevent chilling injury.

The influence that the breaks had on the respiration rates and firmness of the samples, are shown in **Figure 3** - **6**. In both 'Fuerte' and 'Pinkerton', the

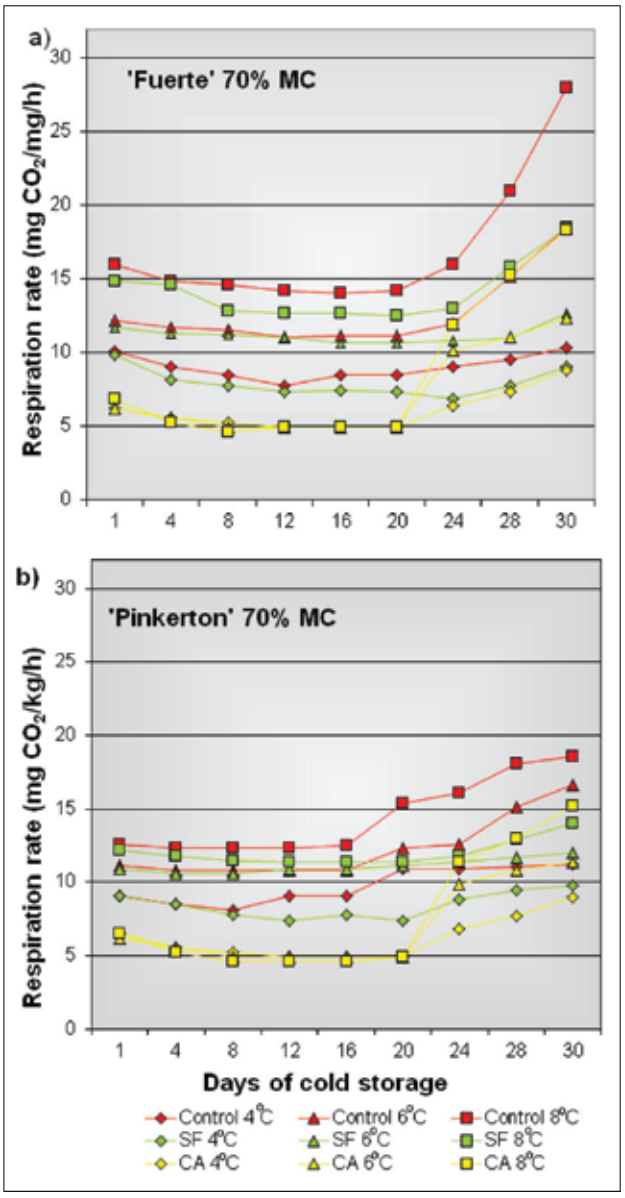

Figure 1. Respiration rates of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit stored at different storage temperature settings.

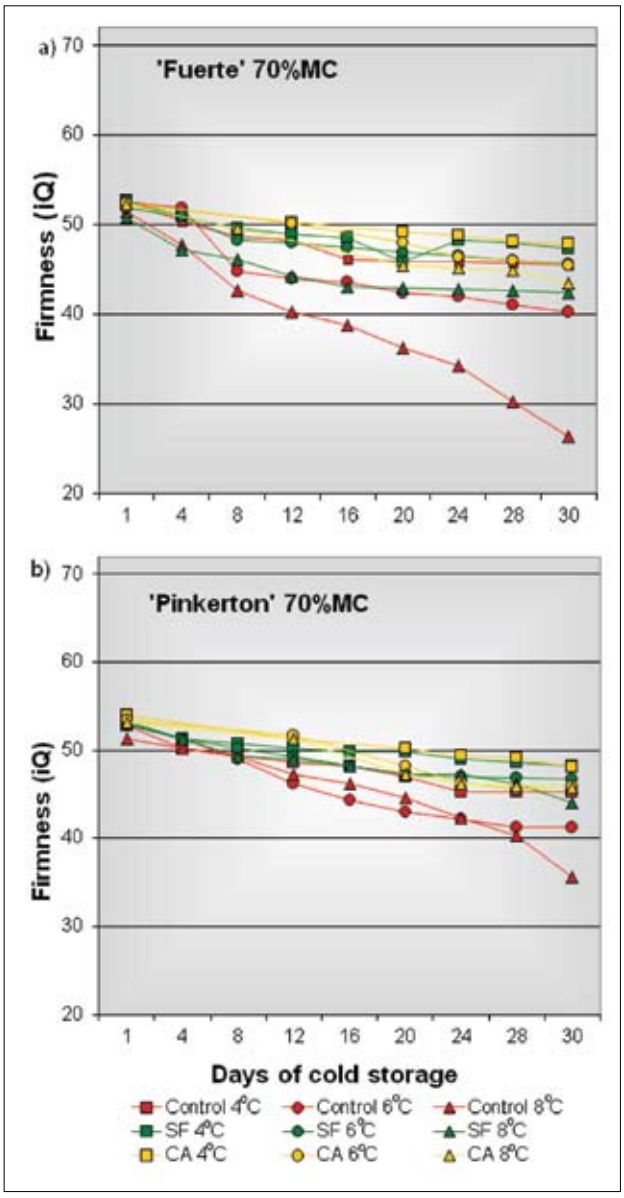

Figure 2. Firmness of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit stored at different storage temperature settings.

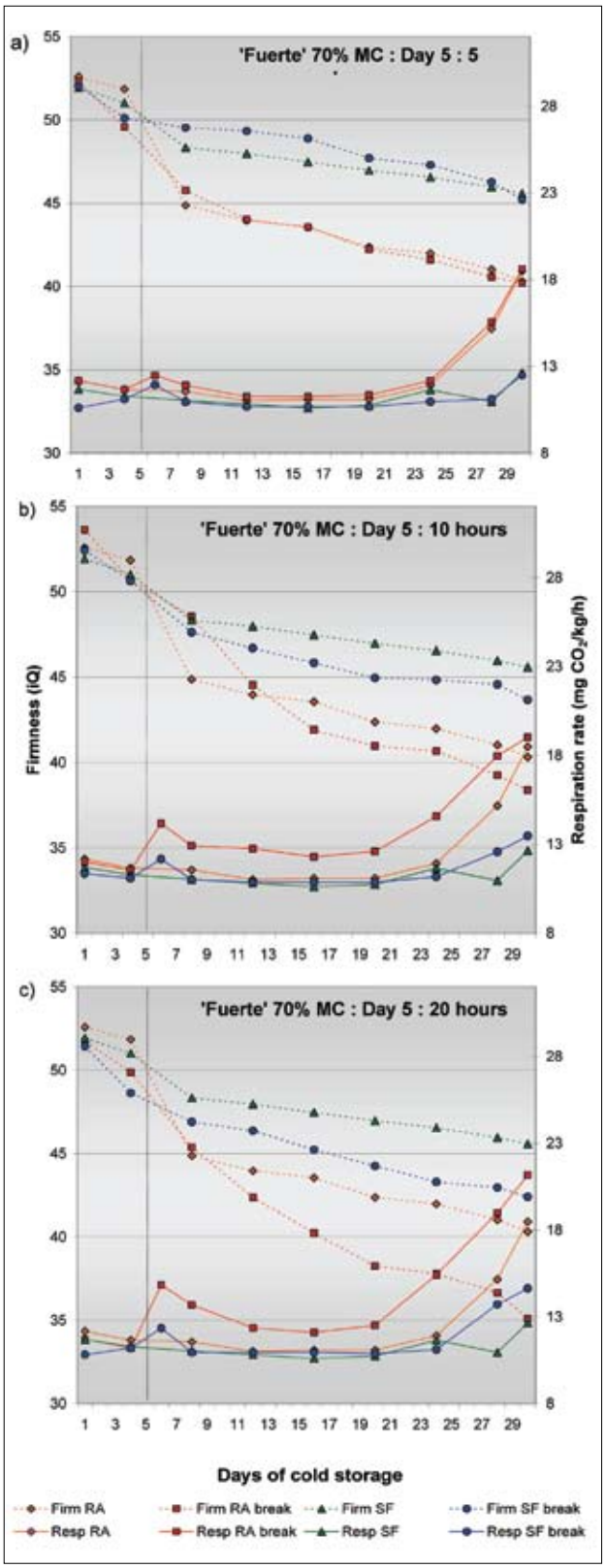

Figure 3. Respiration rates and firmness readings of 'Fuerte' avocado fruit stored at 6°C subjected to 5 hour (a), 10 hour (b) and 20 hour (c) temperature breaks on day 5.

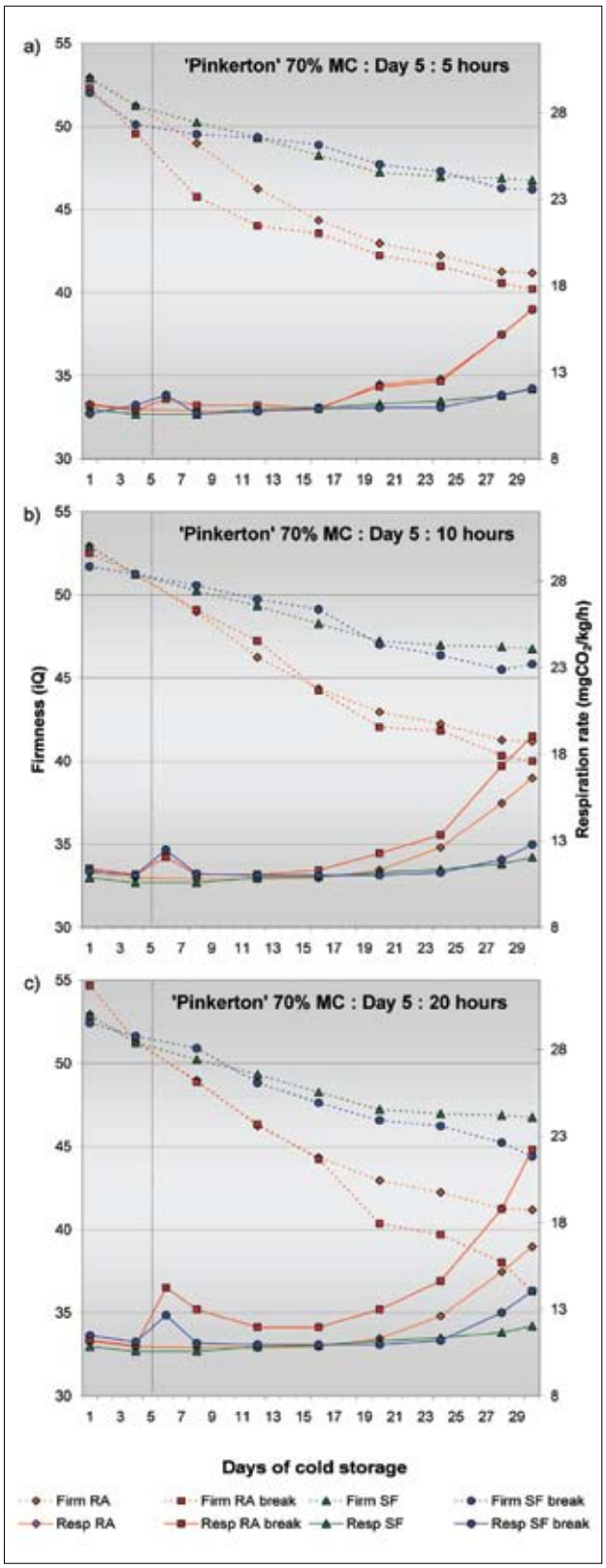

Figure 4. Respiration rates and firmness readings of 'Pinkerton' avocado fruit stored at 6°C subjected to 5 hour (a), 10 hour (b) and 20 hour (c) temperature breaks on day 5.

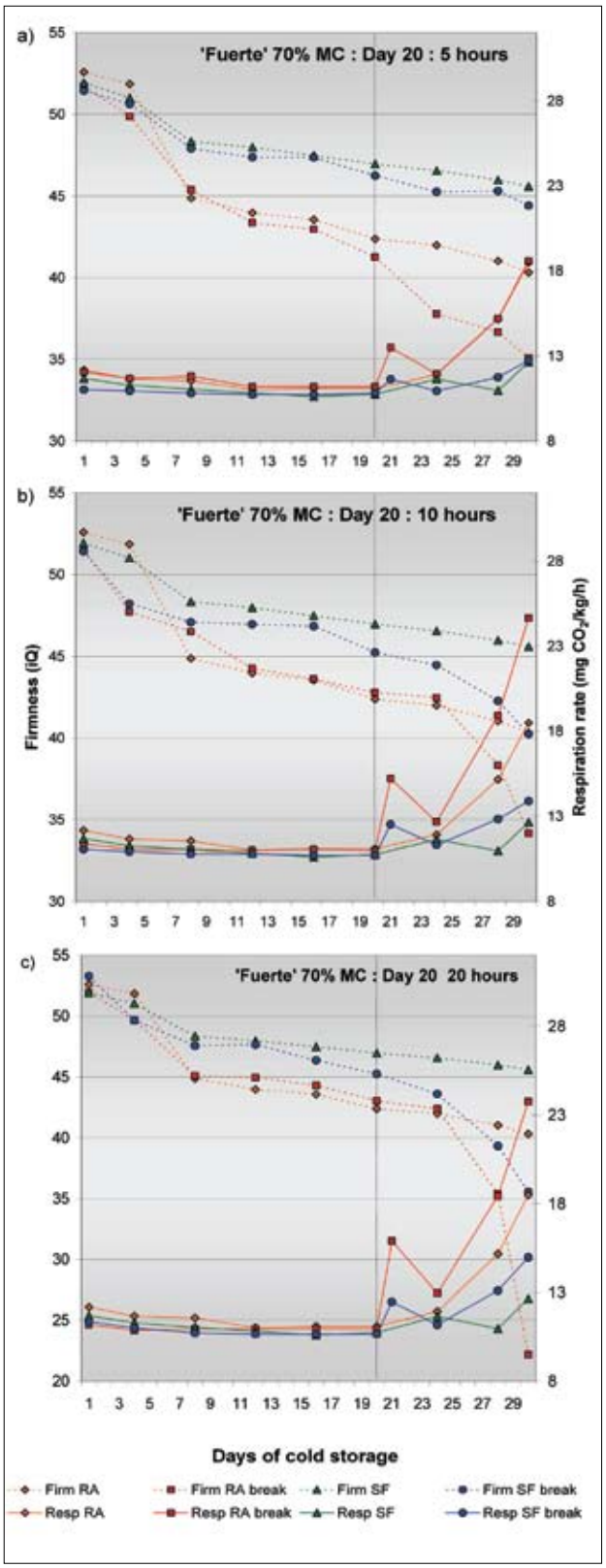

Figure 5. Respiration rates and firmness readings of 'Fuerte' avocado fruit stored at 6°C subjected to 5 hour (a), 10 hour (b) and 20 hour (c) temperature breaks on day 20.

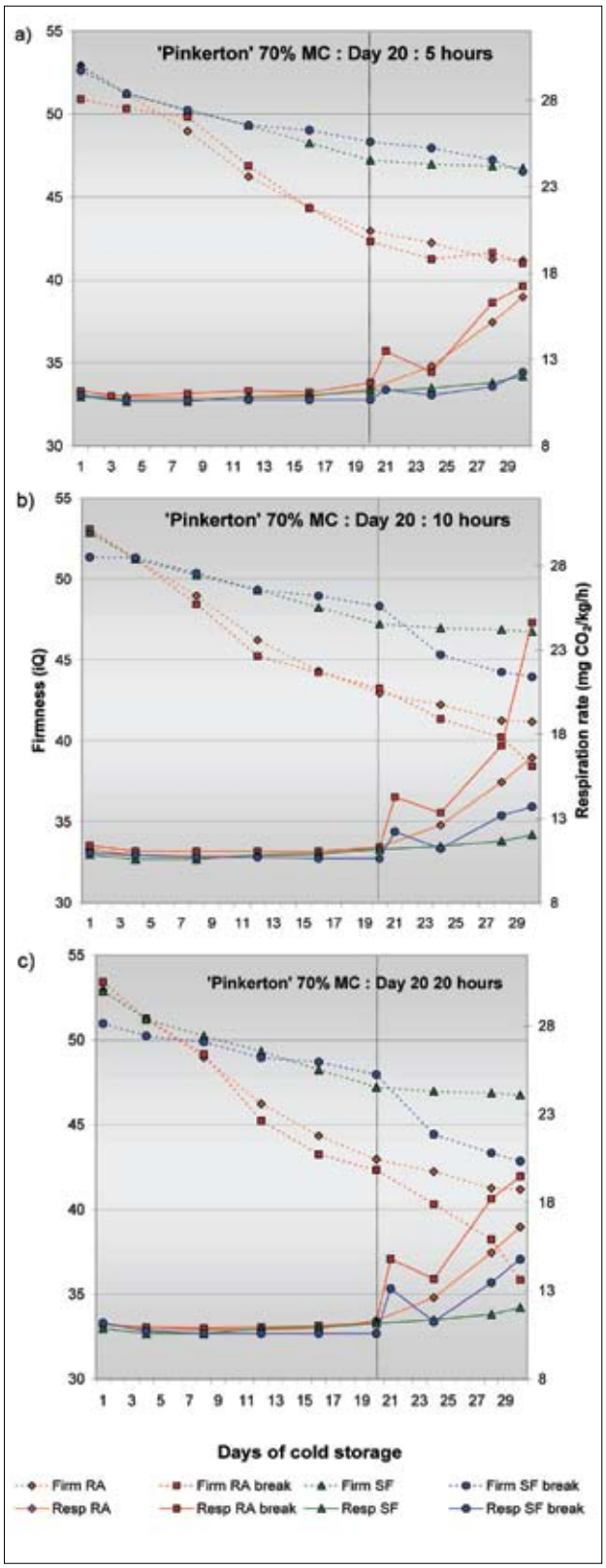

Figure 6. Respiration rates and firmness readings of 'Pinkerton' avocado fruit stored at 6°C subjected to 5 hour (a), 10 hour (b) and 20 hour (c) temperature breaks on day 20.

increase in respiration rate and the reduction in firmness became more pronounced as the length of the break increased. Of the two cultivars, 'Pinkerton' seemed to be least affected by the breaks. In certain cases, a break on day 20 was slightly more detrimental than a similar break on day 5. In most cases, the SF application reduced the increase in respiration rate and lessened the firmness reduction associated with the breaks.

The mean DTR results of the constant temperature treatments are shown in **Figure 7**. In all cases, the RA ripened at the fastest rate followed by the SF and the CA treatments. This was more or less the same for both 'Fuerte' and 'Pinkerton'. The reduction in DTR caused by the breaks is shown in **Figure 8**. Generally, the longer the break, the shorter the mean DTR became. In most cases, the mean DTR's of the treatments subjected to breaks on day 20 were slightly lower than breaks of similar length induced on day 5. The differences between the mean DTR values of the RA and SF treatments were generally statistically significant.

The grey pulp results are shown in **Figure 9** and **10**. In the case of 'Fuerte', stored under RA, grey pulp was most prominent at the highest storage temperatures (Figure 9). Both CA and SF effectively reduced the incidence of the disorder. 'Pinkerton' did not show any grey pulp. The temperature breaks seemed to increase the occurrence of grey pulp in 'Fuerte', especially with the longer breaks (Figure 10).

The stem-end rot results are shown in **Figure 11** and **12**. The incidence of this pathological disorder was higher in 'Fuerte' than in 'Pinkerton', especially at 8°C. At this temperature, the incidence of the

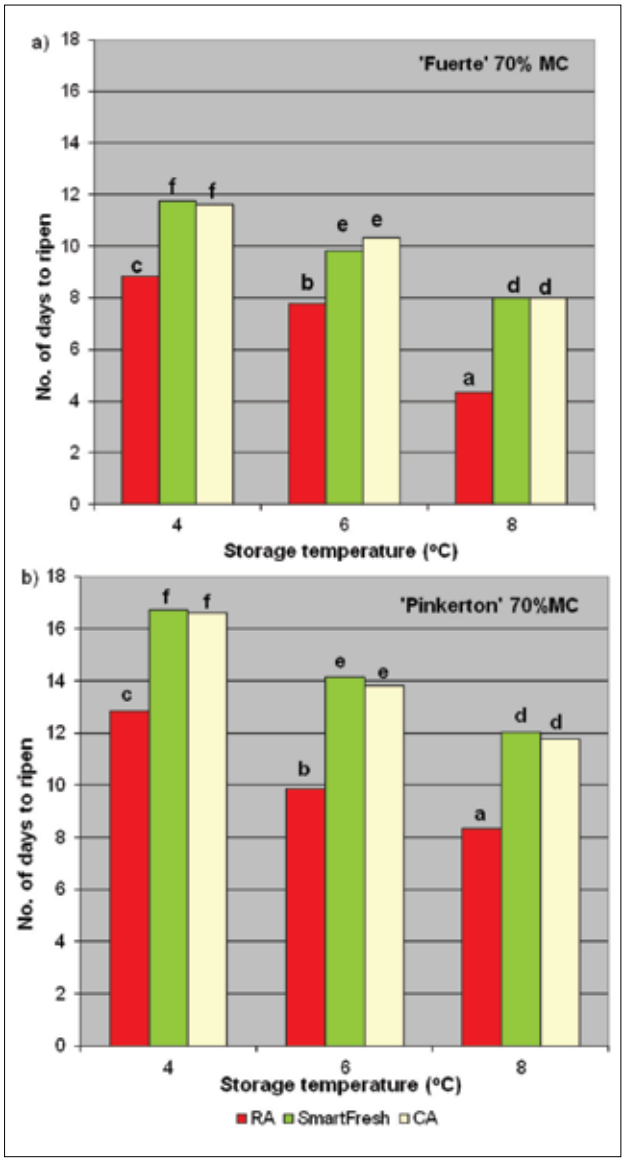

Figure 7. Mean number of days to ripen 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit stored at different storage temperature settings.

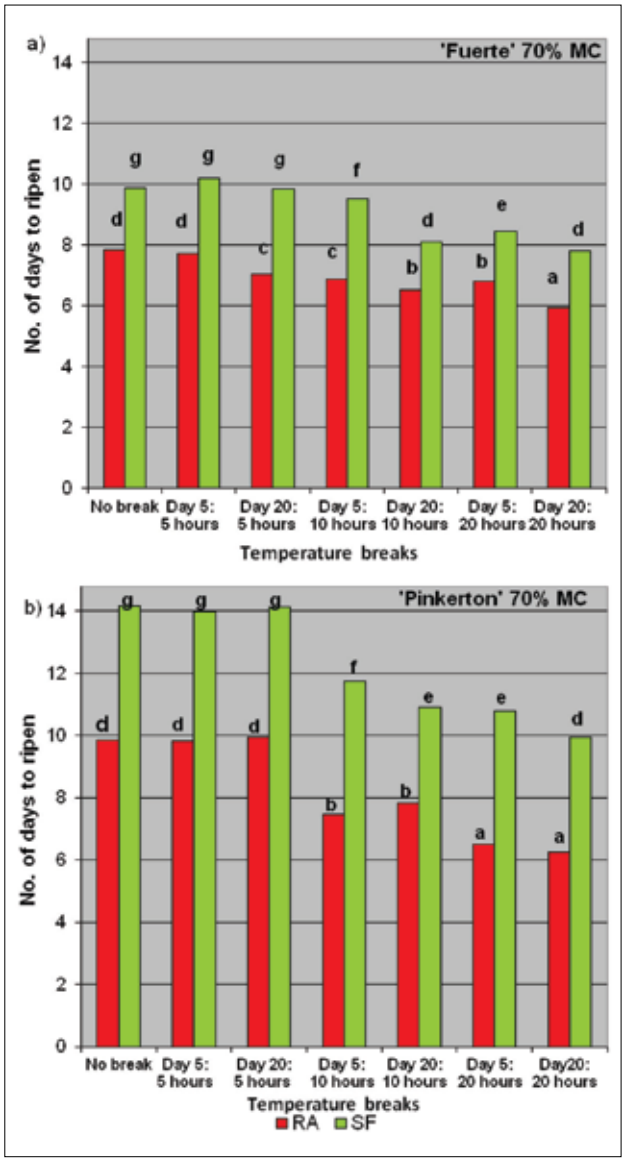

Figure 8. Mean number of days to ripen 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit stored at 6°C and subjected to different cold chain breaks.

disorder was reduced by the SF and CA treatments (Figure 11). The temperature breaks caused a significant increase in the incidence of stem-end rot in 'Fuerte' and to a lesser extent in 'Pinkerton' (Figure 12). Breaks introduced on both day 5 and day 20 resulted in an increase in stem-end rot. The longer the break, the worse the pathological problems became. In certain cases the SF treatments reduced the incidence of stem-end rot in 'Fuerte'.

The anthracnose results are shown in **Figure 13** and **14**. It more or less followed a similar pattern to stem-end rot. The anthracnose infections brought about by the breaks were higher in 'Fuerte' than in 'Pinkerton' (Figure 14). The longer the break, the worse this specific problem became. The SF treatment reduced the incidence of anthracnose in 'Fuerte' fruit subjected to a temperature break.

CONCLUSION

The results generated for the 'Fuerte' and 'Pinkerton' cultivars are in line with those previously recorded for 'Hass'. The respiration and firmness results provide an explanation regarding the rationale behind the current storage temperature recommendations for 'Pinkerton'. It further clearly demonstrates the negative effect that cold chain breaks have on the storage potential of the two cultivars. Similarly induced pathological problems were also recorded for 'Hass'. However, the grey pulp that was induced in 'Fuerte' by, especially, the longer breaks, is a novel observation.

The study reiterated the critical importance of using either CA or SF. It also provided clarification regarding the reasons why pre-packers should not encounter ripening problems when ripening South African SF

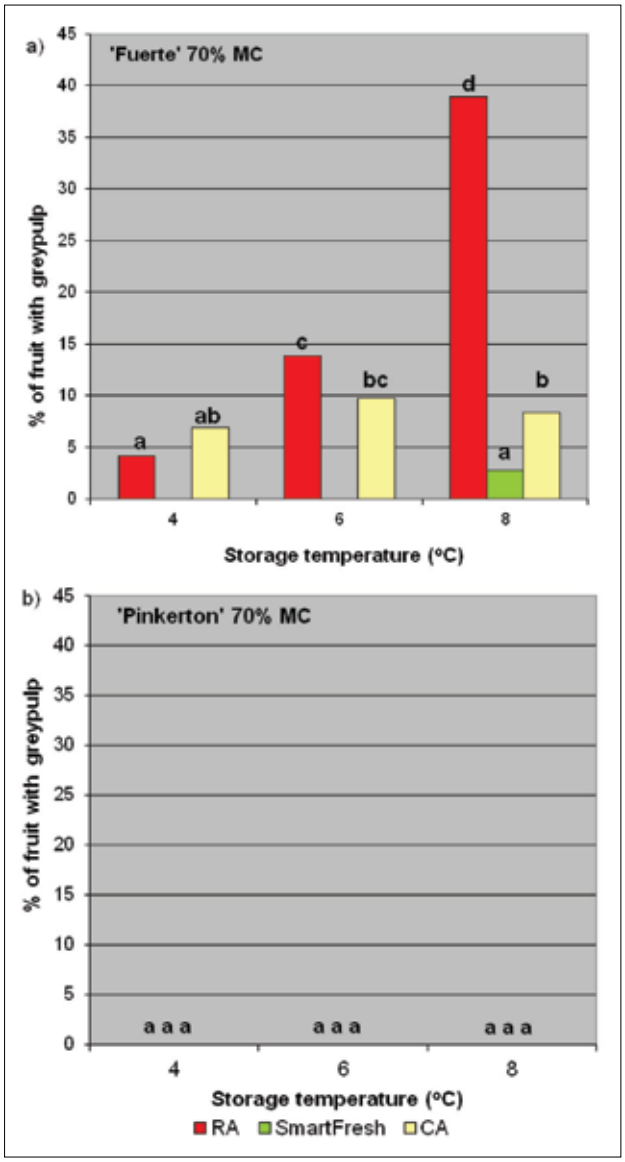

Figure 9. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit with grey pulp stored at different storage temperature settings.

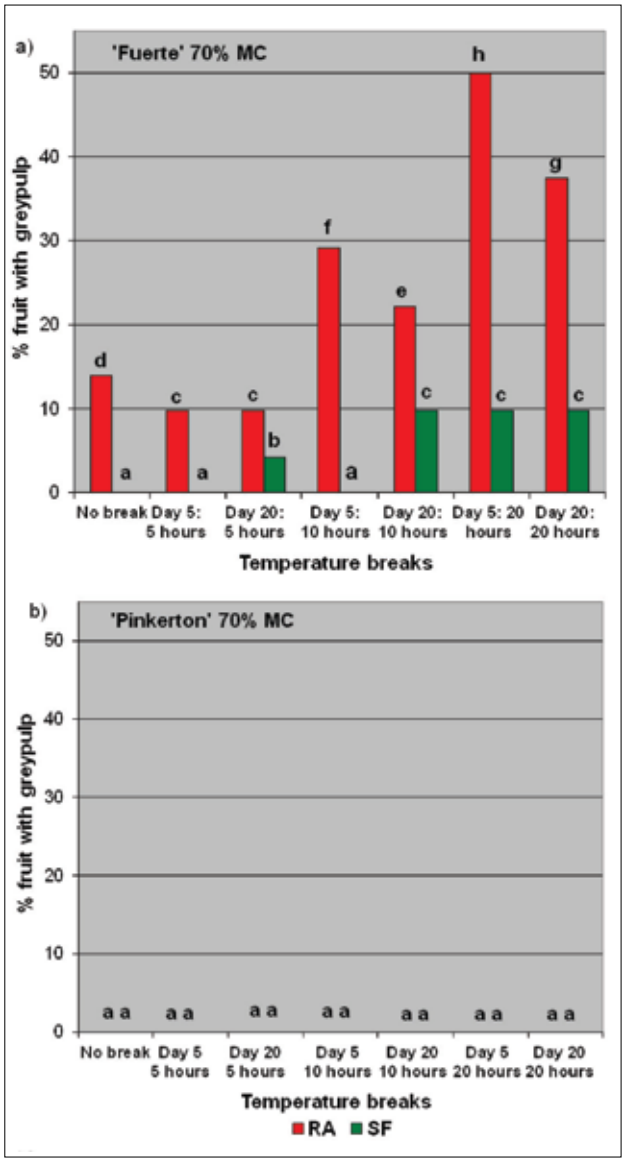

Figure 10. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) fruit with grey pulp after being stored at 6°C and subjected to different cold chain breaks.

avocado fruit stored for periods similar to those used in the present study. The respiration and firmness results are quite useful for upgrading of the currently used step down storage temperature regimes.

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.

LEMMER, D. & KRUGER, F.J. 2010. Effect of cold chain breaks on the ripening and quality of 'Hass' avocados. *South African Avocado Growers' Association Yearbook,* 33: 14-24.

ACKNOWLEDGEMENTS

The authors would like to thank the PHI and Agricultural Research Council for financing the project and various SAAGA members for logistical support.

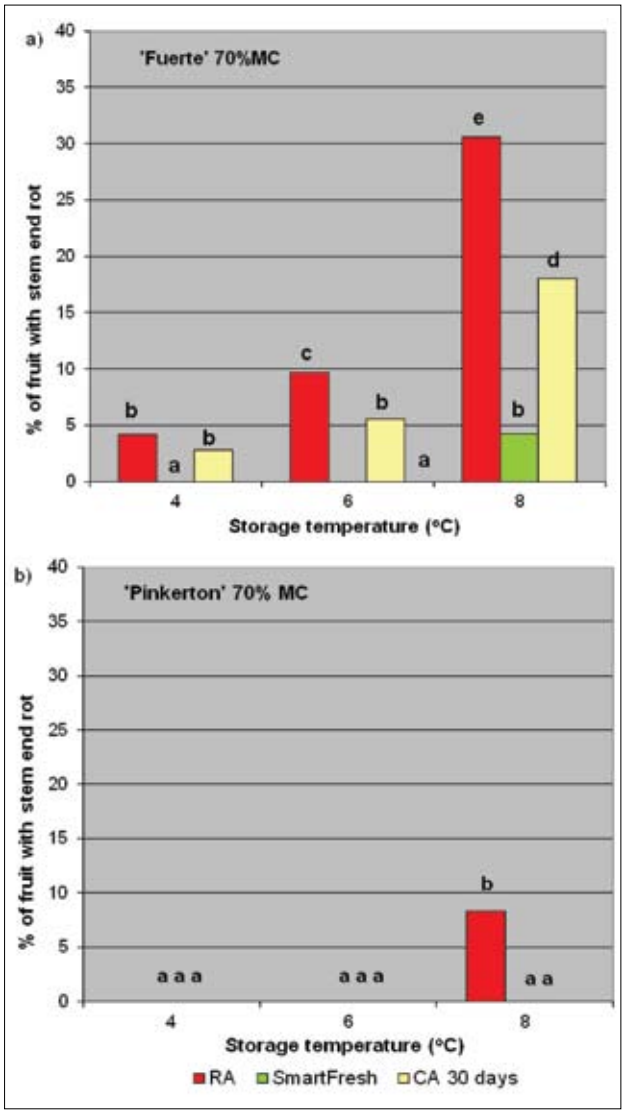

Figure 11. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit with stem-end rot after storage at different storage temperature settings.

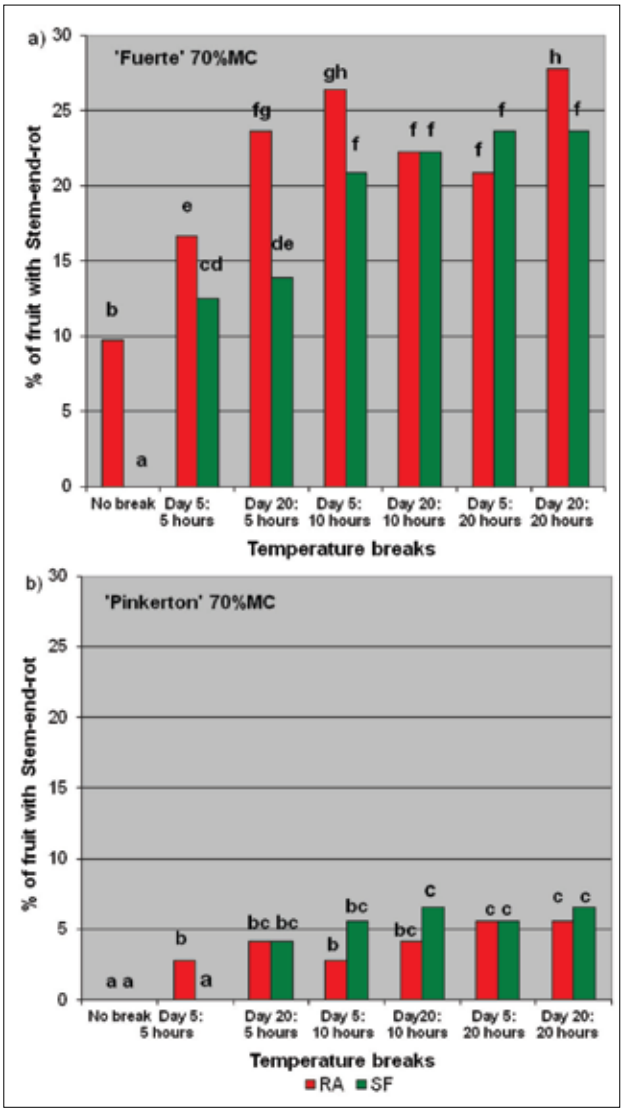

Figure 12. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit with stem-end rot after being stored at 6°C and subjected to different cold chain breaks.

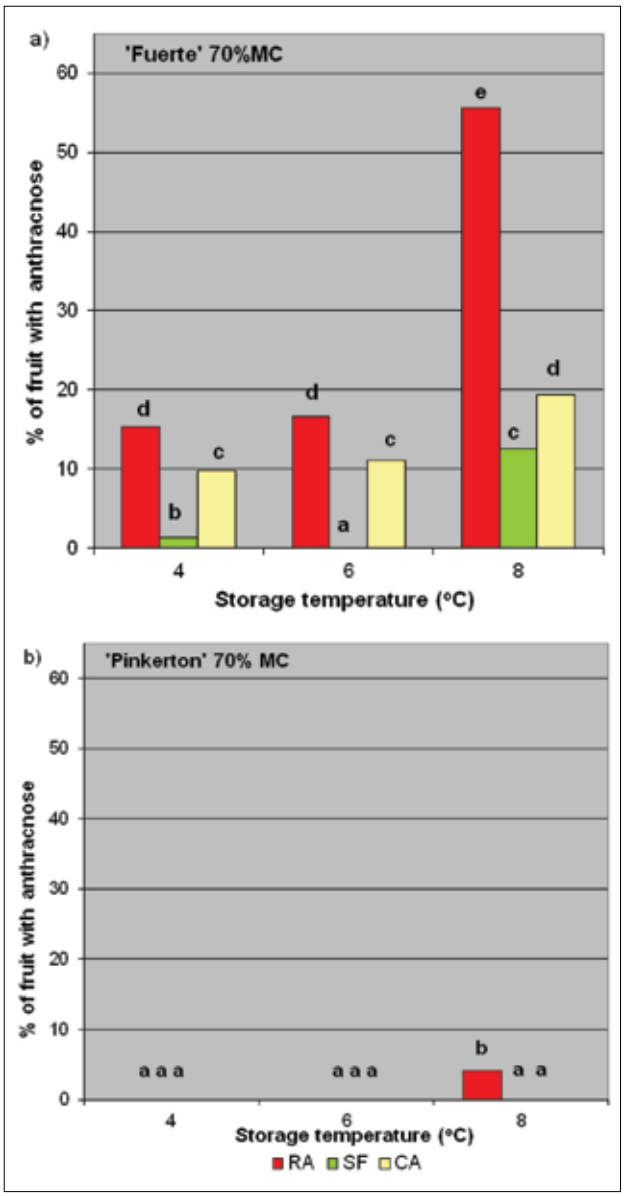

Figure 13. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit with anthracnose after storage at different storage temperature settings.

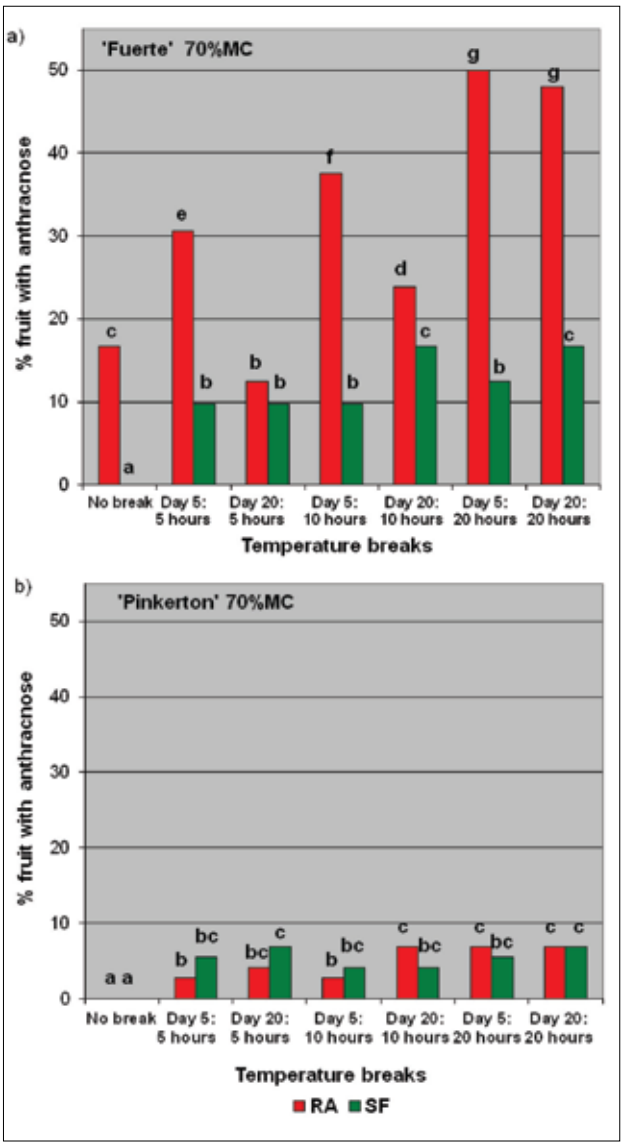

Figure 14. Percentage of 'Fuerte' (a) and 'Pinkerton' (b) avocado fruit with anthracnose after being stored at 6°C and subjected to different cold chain temperature breaks.