Comparison of the ripening inhibitory effects of controlled atmosphere and balanced atmosphere on South African 'Hass', 'Maluma' and 'Fuerte' avocado fruit under laboratory conditions during the 2019 season

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ABSTRACT

In the recent past, almost all avocados exported from South Africa were shipped at a controlled atmosphere (CA) ratio of 6% CO_2 : 4% O_2. During the last two seasons, a balanced atmosphere (BA) combination consisting of 8% CO_2 : ± 13% O_2 was introduced to the industry. As a degree of scepticism existed regarding the effectiveness of this combination, laboratory-based studies consisting of 3 'Hass' trials, 3 'Maluma' trials and 4 'Fuerte' trials were performed. The results indicated that, when taking the natural ripening variability within avocado fruit samples into account, the two techniques rendered similar post-storage ripening patterns. Feedback received from back-to-back commercial trials performed by industry members supported the current observations.

INTRODUCTION

Controlled atmosphere (CA) has been used for the storage of South African export avocados since 1995, when a small number of containers were exported. Since then, the use of CA has become standard practice with the preferred CO_2 : O_2 combination being 6% : 4%. This ratio is attained by using different technologies which may include flushing, filtering, purging and scrubbing.

During the last two seasons, balanced atmosphere (BA) storage has been introduced to the South African avocado export industry. This technique entails the passive build-up of CO_2 to 8% in a shipping container. During this period, the O_2 concentration in the air reduces from 21% at more or less the same rate that the CO_2 increases and it stabilises at around 13%.

The present report deals with a series of trials that were performed with the 'Maluma', 'Hass' and 'Fuerte' cultivars during the 2019 season which aimed to compare the effectiveness of BA with that of CA under laboratory conditions.

MATERIALS AND METHODS

Ten trials were performed during the mid-season (DM: 25-30%) using fruit from the Tzaneen area. Three trials each were performed with the 'Maluma' and 'Hass' cultivars and 4 trials with the 'Fuerte' cultivar. Count 18 fruit were used in most trials. The 'Hass' and 'Maluma' fruit were stored for 30 days at 6°C while 'Fuerte' was stored for 15 days at 5°C (as a precautionary measure to prevent "soft landings").

In the case of the BA treatments, the fruit were stored in 20 litre drums with a series of pin sized perforations in the lid. All the perforations were sealed before the fruit were placed into the drums. The CO_2 content inside the drum was then measured at eight-hour intervals by circulating the air inside the drum through a CO_2 meter. Upon reaching a CO_2 level of 8%, an appropriate number of perforations were opened to retain the CO_2 level between 8 and 8.2%.

A comparable setup was used for the CA treatments. However, in this case, the drums were flushed with a 5% CO_2 : 5% O_2 mixture after loading. This mixture was also used to maintain the required CO_2 (6%) and O_2 (4%) levels during storage.

In all cases, a regular atmosphere (RA) treatment was used as control.

Ripening was performed at 20°C. The number of days required for each fruit to reach the ready to eat

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stage was determined after the avocado was dissected and the incidence of external and internal physiological/pathological disorders determined.

RESULTS

The percentage 'Maluma' fruit that reached the ready to eat stage per day are shown in Table 1, while the 'Hass' results are to be found in Table 2 and the 'Fuerte' results in Table 3. In all cases, the RA treatments started to ripen before the CA and BA treatments.

Although a fair amount of variation occurred between trials, the general ripening inhibitory effect brought about by the CA and BA treatments were comparable. The fruit quality was excellent and virtually no physiological or pathological disorders were recorded.

Table 1: Percentage of 'Hass' fruit reaching the ready to eat stage per day during ripening at 20°C after storage for 30 days at 6°C

Trial 1															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA			33	56	11										
CA: 6% CO_2: 4% O_2					11	22	22	17	6	11	6	6			
BA: 8% CO_2							11	22	11	17	22	11		6	
Trial 2															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA		17	22	22	17	22									
CA: 6% CO_2: 4% O_2				11	17	28	33		6					6	
BA: 8% CO_2			17	11	22	22	28								
Trial 3															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA	44	13	31	13											
CA: 6% CO_2: 4% O_2					38	44	13	6							
BA: 8% CO_2					38	56	6								

Table 2: Percentage of 'Maluma' fruit reaching the ready to eat stage per day during ripening at 20°C after storage for 30 days at 6°C

Trial 1															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA			19	31	19	31									
CA: 6% CO_2: 4% O_2					19	25	31		6		13		6		
BA: 8% CO_2					19	19	25	6	13	13	6				
Trial 2															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA			25	13	25	38									
CA: 6% CO_2: 4% O_2				13	25	25	38								
BA: 8% CO_2				13	25	31	31								
Trial 3															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA		19	25	19	38										
CA: 6% CO_2: 4% O_2			13	25	38	25									
BA: 8% CO_2				25	13	19	44								

Table 3: Percentage of 'Fuerte' fruit reaching the ready to eat stage per day during ripening at 20°C after storage for 15 days at 5°C

Trial 1															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA							31	25	25	6	13				
CA: 6% CO_2: 4% O_2								31	25	6	19	6	6	6	
BA: 8% CO_2								33	27		7	7	7	13	7
Trial 2															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA				19	31	31	19								
CA: 6% CO_2: 4% O_2							44	38	6	6	6				
BA: 8% CO_2							28	22	11	17	17	6			
Trial 3															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA			38	25	31	6									
CA: 6% CO_2: 4% O_2						25	19	19	13	13	6	6			
BA: 8% CO_2							19	19		19	6	13	13	6	6
Trial 4															
Treatment	Ripe fruit per day no (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RA		25	54	8	4	4	4								
CA: 6% CO_2: 4% O_2					29	29	17	13	13						
BA: 8% CO_2				21	25	17	17	21							

DISCUSSION

The current results compare favourably with those generated in the laboratory in South America (Cruz, 2019). It is also consistent with the outcomes generated during commercial trials performed with South African fruit during the 2019 season by commercial exporters (results not shown). It would therefore be reasonable to conclude that BA may be used as an alternative for CA, both commercially (Kruger *et al.,* 2019a) and for experimental purposes (Kruger *et al*., 2019b). From the results it would further appear that our currently performed study, aimed at establishing temporary balanced atmosphere conditions in refrigerated trucks and cold rooms (Kruger *et al*., 2020), is justified.

Acknowledgements

The authors would like to thank all contributors and funders as well as Mark Penter who edited the manuscript.

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