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Pilot Study on the Respiration Patterns of the Major South African Export Avocado Cultivars

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ABSTRACT

The respiration patterns of the five main cultivars produced in the Kiepersol area during the 1995 production season are reported on. Considerable variation between fruit was recorded. In most cases Hass displayed the highest metabolic rate and Ryan the lowest. Fuerte, Pinkerton and Edranol generally had intermediate metabolic rates. In certain instances the climacteric realized as two distinct peaks, which may be indicative of staggered ripening of two sets of tissues. Introductory observations on the reaction of the fruit to a modified atmosphere shock treatment directly after harvest as well as intermittently revealed the extreme manipulative nature of the fruit. The potential use of this technique as a tool to synchronize the respiration patterns of the fruit is mentioned.

INTRODUCTION

Like all living tissue, fruit respire. In this process oxygen is absorbed from the environment, used to burn sugars, and eventually returned to the environment as CO_2. In climacteric plants, which include the avocado, the fruit exhibit a specific respiratory pattern which is indicative of fruit maturity as well as fruit ripeness. Immature fruit have an initial high metabolic rate as the fruit grows. As mature fruit size is approached, respiration decreases. When the fruit starts to ripen, the respiration rate starts to pick up again due to increased metabolism as a range of chemicals in the fruit are converted to new products. In avocado the rise in respiration is initiated after the fruit has been harvested, and the climacteric respiration rate is quite vigorous when compared with other climacteric fruit (Wills *et al.,* 1989).

A thorough understanding of the respiration pattern of avocado is absolutely essential when appraising post-harvest aspects such as maturity parameters, cold storage temperatures, controlled atmosphere (CA) storage, modified atmosphere (MA) storage and artificial ripening. This paper reports on the respiratory pattern of the five main cultivars produced in the Kiepersol area during various stages of the production season, and on introductory observations on the reaction of the fruit to a modified atmosphere shock treatment directly after harvest, as well as intermittently.

MATERIAL AND METHODS

Fruit

The fruit used in this study was obtained from the farm Koeltehof in the Kiepersol district. A sample of fruit consisting of two Hass fruits from two different trees and one each of the following cultivars: Fuerte, Pinkerton, Edranol and Ryan was harvested on a weekly basis from March 1995 to July 1995 and sent to the laboratory at Nelspruit. Due to the transport of the fruit it was not possible to take respiratory readings on the day the fruit were harvested.

Respiration measurements

Respiration was measured in terms of millilitres of CO_2 produced per kilogram of fruit per hour. To achieve this fruits were placed singly in 6 ℓ desiccators for 6-8 h (the time spent in the desiccator was carefully recorded). After allowing the fruit to respire for the above period, the rise in the CO_2 level inside the desiccator was measured using a Isocell Oxycarb 3, and the CO_2 production calculated and expressed as a proportion of fruit Hass. The whole experiment was conducted inside an incubation chamber which was kept constant at 20 °C.

Modified atmosphere experiments

Two experiments involving modified atmosphere storage were conducted. In the first, the fruits were placed individually in desiccators and allowed to build up CO_2 for 5 days after which their respiration patterns were measured using methods similar to the above. In the second, the fruits were placed individually in the desiccators and subjected to intermittent periods of modified atmosphere storage. Two such experiments were conducted. In the first experiment the period was stepped down from three days to two days to one day followed by normal 7 h measurements. The second was less drastic than the first and involved four 17 h exposures followed by 8 h measurements.

RESULTS

The first observation was that there was considerable variation of respiration patterns between individual fruits. Figure 1 clearly demonstrates the variation between fruits of various cultivars and shows that each fruit reached its climacterium at a different time. This was not only evident when measuring various cultivars simultaneously, but also when measuring more than one specimen of the same cultivar (figure 1). Nevertheless, certain trends became apparent:

- In most cases Hass displayed the highest metabolic rate, and Ryan generally the lowest. Fuerte, Pinkerton and Edranol generally had intermediate metabolic rates. This was evident in the normal respiration measurements (figures 1-7) as well as in the modified atmosphere manipulations (figures 8-10).
- It seemed that the climacteric sometimes realizes as two distinct peaks. This

observation was made in all cultivars. This phenomenon is illustrated by the graphs for Hass, particularly in figures 2 and 3, and to a lesser extent in figure 4.

- There were indications that the interval between harvesting and the climacteric decreased as the season progressed. The patterns recorded for Ryan serve as a good reference. In the beginning of the season the fruit did not ripen at all, and it would seem as if no climacteric was reached (figure 5). Later in the season two distinct peaks were distinguishable (figure 6). At the end of the season no peak was recorded and respiration tailed off to an extremely low rate (figure 7).

Extended modified atmosphere storage revealed the extreme manipulative nature of the fruit. After 5 days in a modified atmosphere all fruit demonstrated double peaked climacteria which were markedly synchronized (figure 8).

This was also true of fruits that subjected to intermittent periods of modified atmosphere storage. In this case only a single peak was apparent (figures 9 and 10).

Certain of the observations recorded in this study have been partly reported in previous studies. Zauberman & Schiffmann-Nadel (1972) reported that mature Fuerte fruit have a shorter pre-climacteric than less mature fruit. They also found that seed respiration contributes to the respiration rate of the fruit. They measured the respiration rate of seed independently and concluded that the contribution of seed respiration to whole fruit respiration declines as the fruit grows. Although certain of the patterns they recorded exhibited a tendency to form a second peak, no double peak configurations such as those found in this study were recorded. On the other hand, the respiration patterns of Zutano & Bacon as registered by Inoue & Takahashi (1991), clearly depict two separate peaks in many of their graphs. Interestingly, Eaks (1978) does not seem to have recorded double peaked patterns during ripening studies on Hass.

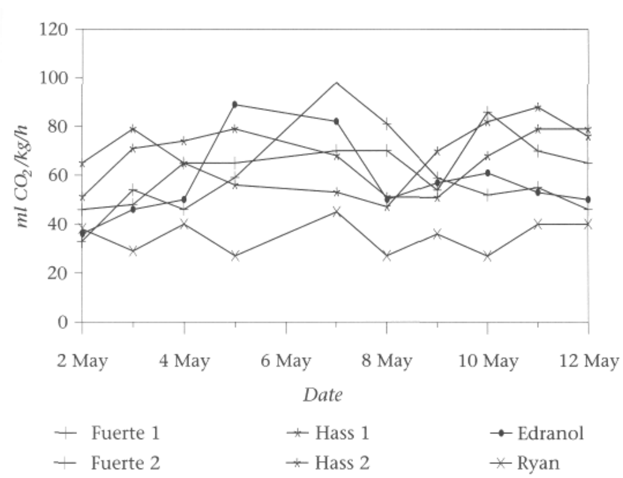

Figure 1
Respiration pattern of fruit from various cultivars measured as from 2 May 1995 to demonstrate the variation which exists between cultivars and between various fruit from the same cultivar

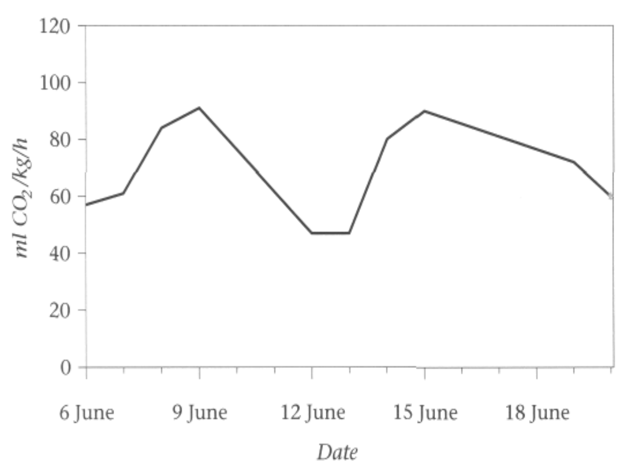

Figure 2
Respiration pattern of a Hass fruit as from 6 June 1995 demonstrating a double peaked climacteric pattern.

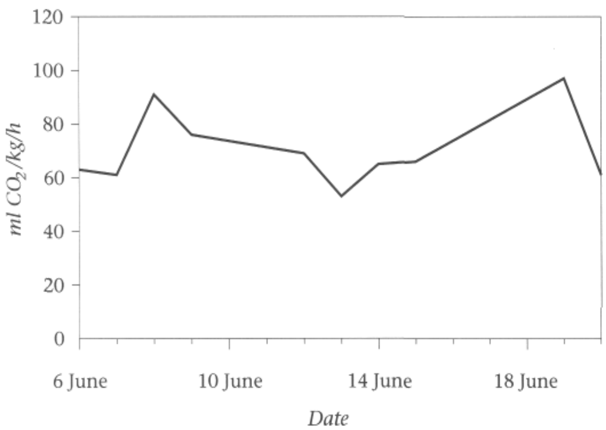

Figure 3
Respiration pattern of a second Hass fruit as from 6 June 1995 also demonstrating a double peaked climacteric pattern

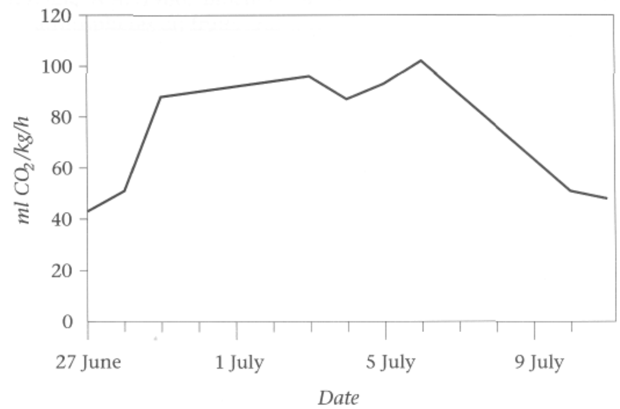

Figure 4
Respiration pattern of a Hass fruit as from 27 June 1995 demonstrating a single, notched climacteric

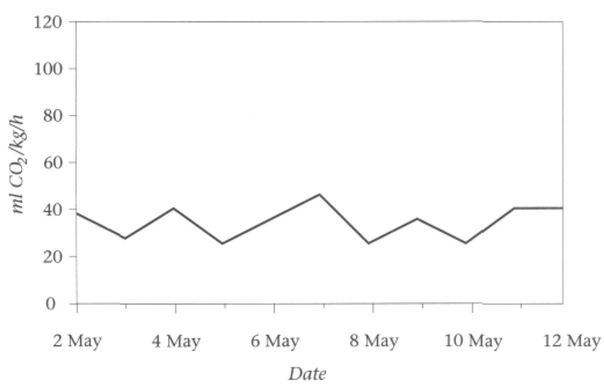

Figure 5
Respiration pattern of a Ryan fruit as from 2 May 1995 demonstrating early season absence of a climacteric

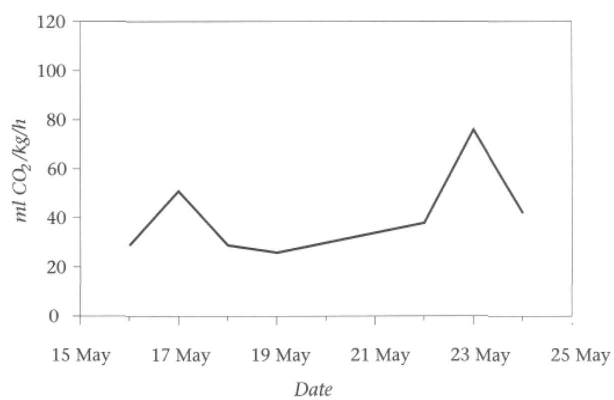

Figure 6
Respiration pattern of a Ryan fruit as from 15 May 1995 demonstrating a double peaked climacteric pattern

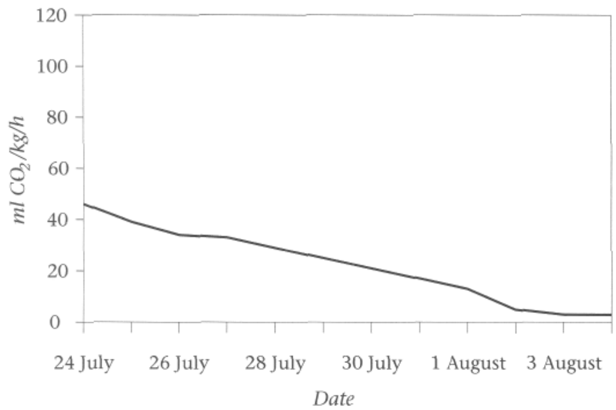

Figure 7
Respiration pattern of a Ryan fruit as from 24 July 1995 demonstrating a post-climacteric respiration pattern

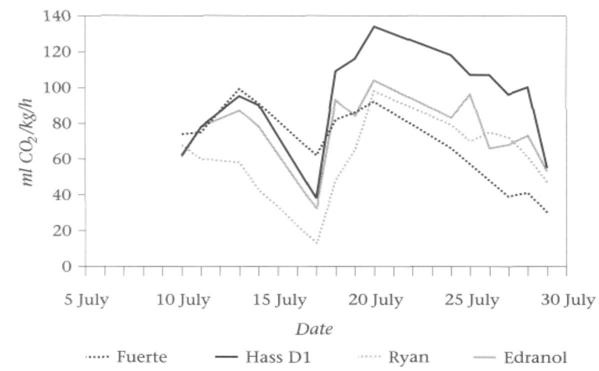

Figure 8
Synchronized double peaked climacteric induced after five days of modified atmosphere storage at 20 °C

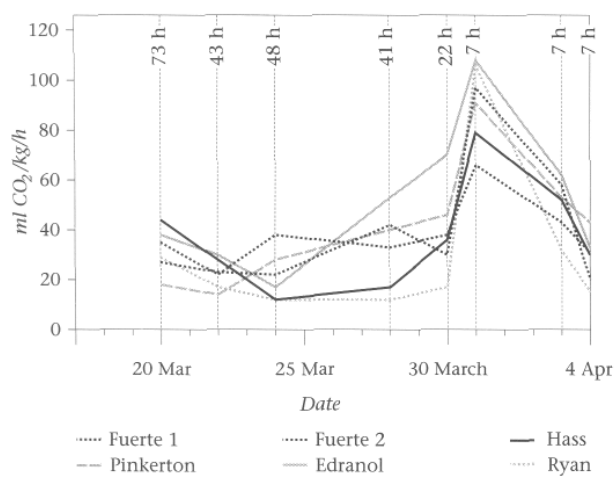

Figure 9
Synchronized single peak climacteric induced after severe step down intermittent modified atmosphere storage at 20 °C

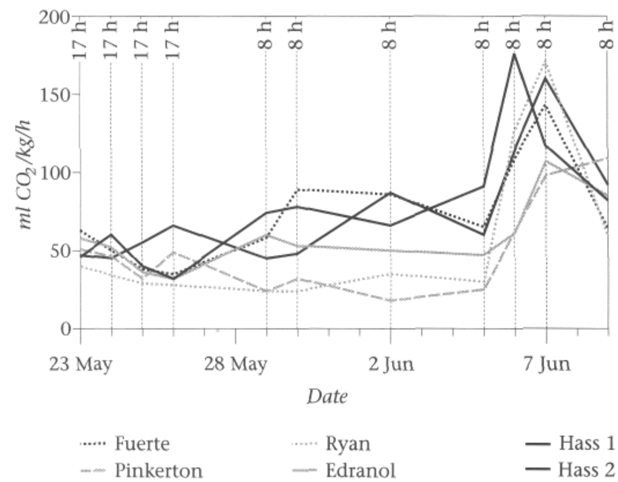

Figure 10
Synchronized single peak climacteric induced after mild intermittent modified atmosphere storage at 20 °C

The most logical explanation for the double peaked patterns recorded in this study is that two sets of tissue reach the climacteric at different times. Obviously one of these is the mesocarp, and the studies of Zauberman & Schiffmann-Nadel (1972) hint that the other may be the seed. However, the rind may certainly also plays a role. Ledger & Barker (1994) have found that the skin colouring and softening in Hass fruit is often not synchronized. Further research into this is indicated.

The high respiration rate registered for Hass is concurrent with the results of Blanke & Whiley (1995) who found that the respiration rate of Hass was higher than that of Fuerte. At the other end of the scale, the low respiration rate of Ryan may be one of the reasons why this fruit is marketed so late in the production season.

The results obtained by means of the modified atmosphere exposures may have potential application. It is well known that post-storage respiratory suppression can be induced in fruit and vegetables by restraining mitochondrial oxidative activity in a low oxygen environment (Kader, 1986; Rahman *et al.,* 1995). However, the significance of the current results is to be found in the level of synchronization that was induced. Uneven ripening of fruit is a major problem to importers and distributors, especially when artificial ripening is involved. A simple method that may possibly promote synchronized ripening is therefore always welcome.

It has been demonstrated that pre-storage low oxygen and modified atmosphere shock treatments show potential to reduce chilling injury, improve fruit quality and lengthen shelf life in Fuerte fruit (Pesis *et al.,* 1994; Allwood & Cutting, 1994; Allwood & Wolstenholme, 1995). It has also been found that an intermittent CO_2 treatment of Hass reduces chilling injury (Marcellin & Chaves, 1983) and that modified atmosphere storage in polyethylene bags reduces cold injury symptoms (Scott & Chaplin, 1978).

Climacteric fruit shows varying levels of sensitivity to chilling injury during various stages of the respiration cycle. Avocado fruit is least susceptible to cold damage in the post-climacteric phase (Kosiyachinda & Young, 1976). Synchronization of the respiration patterns of the fruit may therefore be potentially useful in preventing chilling injury.

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