ETHYLENE LEVELS OF "Blanca de Aranjuez" PEARS IN LOW-OXYGEN ATMOSPHERE STORAGE

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Abstract

Low-oxygen storage reduced the respiration rate and ethylene production of "Blanca de Aranjuez" pears. On removal from storage, internal ethylene levels were slightly higher in 3% O₂ stored fruits compared to those stored in air. We noticed a ratio between the evolution of the internal gases during the first hours at 20 °C and the length of the storage period. A significant increase in the internal ethylene levels, over the first hours at 20 °C, and a rapid softening during ripening, were detected in pear stored in low-oxygen atmosphere.

1. Introduction

Generally, the reduction of respiration rate and ethylene production by fresh pear has been assumed as the main reason for the beneficial effect of reduced O₂ and/or elevated CO₂ (Yoshida *et al.*, 1986). However, elevated CO₂ concentration above to 6 % can result in the development of brown-core in pears (Hansen and Mellenthin, 1962; De la Plaza, 1973). Likewise, storage in low-oxygen (1% O₂) has been reported to bring about a more rapidly softening at 20 °C, than those stored in air (Blankenship and Richardson, 1985).

Most researchers have studied the ethylene production and respiration rate at 20 °C after cold storage, but little information is available regarding the immediate response in the internal ethylene and carbon dioxide levels on removal of fruit from different cold storage period in either air or CA. This study was performed during the first 48 hours at 20 °C.

2. Material and methods

"Blanca de Aranjuez" pears were harvested with 5.8 Kg firmness. The pears were exposed to -1 °C to induce ethylene production and hold in this condition for 53 days prior to establishment of the CA storage conditions ("Deferred CA").

The pears were stored at 0 °C in a continuous flow atmosphere of 0.03–0.09 % CO₂ and 2.8–3.1 % O₂. After storage for 4, 5 or 6 weeks, fruits from each storage period were transferred to 20 °C for ripening.

2.1. Fruit firmness

Fruit firmness was determined on peeled fruit with a texturometer Instron mod. 1140 with an 8 mm plunger tip. Firmness was measured at harvest, and at each removal from 0 °C, after 2 and 6 weeks of storage. Three pieces were used, and 3 readings per fruit were made for the firmness measurement.

2.2. Respiration and ethylene production

Respiration was measured by monitoring CO₂ production. Gas samples were withdrawn from the outlet part of each chamber and CO₂ analyzed by gas chromatography. Carbon dioxide was determined with a Varian 3700 equipped with a Porapak Q column, a molecular sieve column and a thermal conductivity detector. Ethylene was determined in the same gas sample with a flame ionization detector.

2.3. Internal ethylene concentration

The system for extracting internal gas from pears, without a large internal cavity, consisted of an hypodermic needle capped with a serum stopper of 1.7 ml of volume covered by a septum of silicone. The needle was sterilized, to avoid excessive wounding, and inserted to 3 cm depth into the fruit. The needle was inserted into the fruit on removal from cold storage and remained for the ripening (Merodio, 1987).

Gas samples were taken every 15 minutes with hypodermic syringes and ethylene and carbon dioxide contents were determined by gas chromatography. Consistent results have been obtained when 1 ml samples were withdrawn from pears at 15 minutes intervals (figure 1). After 60 minutes of inserted the capped needle, the internal atmosphere into the serum stopper was equilibrated with that inside the fruit. At this time the dilution of extracted gases was minima.

2.4. ACC determination

A 10 g sample of cortex tissue taken from 15 fruits were extracted with methanol. After centrifugation, an aliquot of the supernatant was concentrated in vacuum at 40 °C and used for ACC analysis according to the method of Lizada and Yang (1979).

3. Results and discussion

Lowering the O_2 level around fresh pears decreased their respiration rate. So, we found that the respiration rate in 3 % O_2 was a 22.38 % relative to that in air at $0^\circ C$ (table 1). Although at 3 % O_2 the ethylene production was reduced, this low-oxygen storage did not cause a reduction in internal ethylene, moreover the dates in the figure 2, showed that the internal ethylene on removal from CA was highly higher than from air-storage. The values plotted in figure 2, were the initial values of fruits removed on the same day from cold room, and were reported as reflection of the activity of the fruit on the different storage conditions. These findings are in line with the reports of Chen *et al.* (1981) on increased internal ethylene from pears stored in low-oxygen atmosphere.

Table 1 - Respiration rate of pears stored in 3 % O_2 and in air at $0^\circ C$
($ml\ CO_2\ Kg^{-1}\ h^{-1}$)

Treatment	Time (weeks)					
(% O_2)% CO_2	3.14	3.57	4.14	4.58	5.00	6.14
(3)0	0.26	0.42	0.76	0.84	0.99	0.70
(21)0	1.43	1.83	1.29	3.11	3.78	3.98

Figure 1- Effect of repeated withdrawals of 1 ml gas samples from pear on the concentration of ethylene in the samples

It's evident from the data showed in the table 2, that pears in 3 % O_2 storage produced physiologically active levels of ethylene that caused light softening during cold storage. In spite of delay in establishing the CA conditions, i.e. "Deferred Controlled Atmosphere" (De la Plaza, 1977), the data in table 2 showed at the end of storage differences in the firmness. Pears under low-oxygen atmosphere were firmer than those stored in air. On the contrary, at 20 °C, 3 % O_2 stored fruits were light more soft than air-stored pears. Accelerated softening during ripening of pear stored in low oxygen has been before reported (Blankenship and Richardson, 1986)

Figure 2 - Changes in the internal ethylene content of pears during cold storage, either in 3 % O_2 (□) or in air (■).

We have characterised the internal ethylene and carbon dioxide concentrations over the first 48 hours after storage at 0 °C in either air or 3 % O_2 . The period for analysis 4, 5 or 6 weeks were chosen to reflect different physiological states in the low-oxygen pears. Although air-storage fruits were ripe at the end of storage, for the purpose of comparing the influence of storage time on the immediate synthesis of ethylene at 20 °C, pears of identical chronological cold storage were chosen.

Table 2 - Fruit softening patterns of pears during cold-storage at 0 °C, either in 3 % O₂(plus 0.03 % CO₂) or in air , and during ripening at 20 °C, in Kg

Treatment	Storage time (weeks at 0 °C)			
	Two		Six	
	Days at 20 °C			
	0	0	2	6
(3)0	4.8 $\pm$ 0.20	3.52 $\pm$ 0.07	1.64 $\pm$ 0.19	0.85 $\pm$ 0.05
(21)0	4.3 $\pm$ 0.16	1.47 $\pm$ 0.10	1.01 $\pm$ 0.07	0.93 $\pm$ 0.09

We noticed that the immediate synthesis of ethylene at 20 °C depends on the storage period. So, we showed (figure 3,A) a significant increase in internal ethylene in about 4 hours at 20 °C. After 5 or 6 weeks on low-oxygen storage, this increase in internal ethylene becomes more pronounced when the storage dates were extended (figure 3, B and C). These results showed relation between the first reaction on synthesis of ethylene and lenght of cold storage. These findings could be in line with the idea about the abrupt ripen of pear stored on low-oxygen conditions. On the contrary, the internal ethylene of air-stored pears remains fairly constant during the first 48 hours at 20 °C.

In relation to the content of ACC, we found that after 3 weeks of cold storage, there was more ACC in pear stored in low-oxygen than in pears stored in air (data not shown), but more analytical data are necessary at the end of cold storage.

The same as ethylene, the internal CO₂ evolution on removal from low oxygen storage, was a function of lenght of storage period. As shown in figure 4 (A,B and C) a more pronounced increase in the internal carbon dioxide levels was detected during the first hours at 20 °C, for the more mature fruits(6 weeks). Also in this figure we observed that the rise in internal CO₂ followed the increase in internal ethylene concentration as shown comparing figures 3 and 4.

On the contrary, the maturation of pears stored in air during 4, 5 or 6 weeks (figure 4) was enough to induce an

Figure 3 - Changes in the internal ethylene content of pears during the first 48 hours at 20 °C following storage for 4 (A), 5 (B) or 6 (C) weeks at 0 °C — either in 3 % O₂ (□) or in air (■).

Figure 4 - Changes in the internal CO₂ content of pears during the first 48 hours at 20 °C following cold storage for 4 (A), 5 (B) or 6 (C) weeks at 0 °C, either in 3 % O₂ (o) or in air (●).

immediate rise in endogenous carbon dioxide levels at 20 °C

According to this, it could be possible, by following the changes especially in the internal ethylene concentration during the first hours at 20 °C, to estimate the physiological maturity of fruit held in cold storage.

In pear "Blanca de Aranjuez", we found that upsurge in ethylene synthesis can be considered as the critical factor inducing the respiratory rise.

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