Are Argon-enriched Atmospheres Beneficial ?

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Modified atmosphere packaging (MAP) technology relies upon development of an environment reduced in oxygen (O_2) and/or elevated in carbon dioxide (CO_2) levels inside a hermetically sealed container. There are numerous scientific studies which have documented the effects of reduced O_2 and/or elevated CO_2 atmospheres on reducing respiration, ethylene production, ethylene action, extending shelf-life, and maintaining quality of intact and fresh-cut horticultural commodities (Kader et al., 1989; Zagory and Kader, 1989). However, the use of novel gases, such as argon and helium, instead of nitrogen in gas mixtures has received little attention in the scientific literature. Argon-enriched atmospheres have been observed to reduce C_2H_4 biosynthesis and respiration rates (Lougheed and Lee, 1989). A recent report by Day (1996) as well as a patent by Powrie et al. (1990) have reported on the potential beneficial effects of using argon in gas mixtures. We tested the hypothesis that argon acts as a competitive inhibitor of molecular O_2 possibly by competing for O_2 binding sites and reducing activities of key enzymes involved in C_2H_4biosynthesis.

Materials and Methods

ACC-oxidase was extracted from near climacteric (166 µl $C_2H_4 \cdot kg^{-1} \cdot h^{-1}$) 'Bartlett' pears. Twenty grams of pear tissue were assayed for *in vitro* ACC-oxidase activity by the method described by Gorny and Kader (1997) with the following modifications. The standard reaction mixtures used in this assay were purged for 10 min with a gas mixture of air, 80% argon + 20% O_2, or 100% argon at a flow rate of 100 $mL \cdot min^{-1}$; 1.8 mL of the standard reaction mixture was then placed in each test-tube and sealed with a rubber stopper before addition of the enzyme preparation. An exhaust syringe needle was used to pierce the rubber stopper and allow for flushing with the three gas mixtures mentioned above at a flow rate of 100 $mL \cdot min^{-1}$ for 1 min . Using a syringe the enzyme assay reaction was initiated by adding 0.2 mL of enzyme preparation to each gas-flushed sealed, 15-mL test tube that contained the standard reaction mixture (1.8 mL). After a 1-h incubation with shaking at 30°C, a 1-mL gas sample was withdrawn with a syringe from headspace for C_2H_4 deter-mination by gas chromatography.

Results and Discussion

In vitro ACC-oxidase activity was similar when the enzyme assay was performed in air or 80% argon + 20% O_2 (Fig. 1). These data indicate that argon does not directly effect ACC-oxidase activity by competing for and displacing molecular O_2 at the attachment site on the protein itself. When O_2 was displaced in the reaction test-tubes with 100% argon, *in vitro* ACC oxidase activity levels were half of those found in air or 80% argon + 20% O_2. This is likely due to O_2 depletion within the test-tubes, not because of any direct effects of argon gas. Similar results have been reported when *in vitro* ACC-oxidase activity was measured in reaction tubes that were flushed with 0.25% O_2 + 99.75% N_2 (Gorny and Kader, 1996).

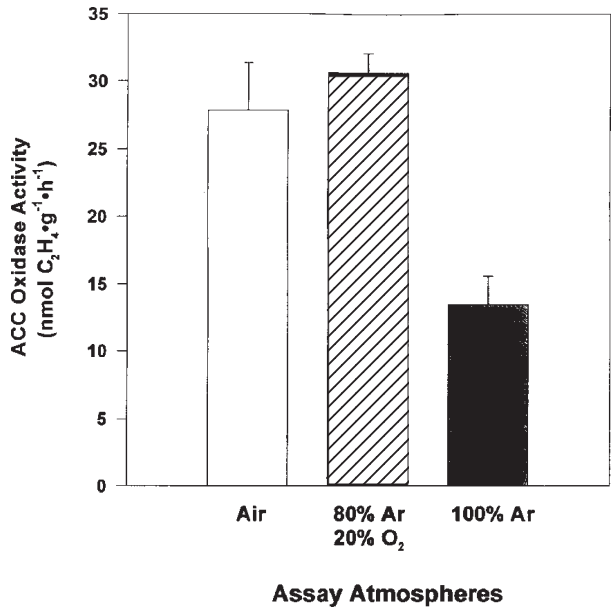

Fig. 1. *The effect of assay atmospheres of air, 80% argon + 20% O_2 or 100% argon on the in vitro ACC-oxidase activity of 'Bartlett' pears.*

Argon-enriched atmospheres, when sufficient O_2 is present, do not directly affect the metabolism of plant tissues by reducing the activity of enzymes (such as ACC oxidase), which require molecular O_2 for activity. Argon may, however, increase the diffusivity of gases such as CO_2 and C_2H_4 from plant tissues because of its higher density than nitrogen. A similar effect has been demonstrated by Burg and Burg (1965) using helium. Argon gas is utilized in the wine industry for sparging the headspace in wine bottles just before the cork is inserted because it displaces O_2 more quickly than N_2. Further research is needed to evaluate the benefit of more effectively displacing oxygen by argon in flexible packages of perishables. But since argon is more expensive than nitrogen, cost/benefit analysis is recommended before commercial application.

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