Changes in Polyphenol Content of Olives Stored in Modified Atmospheres

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Coordinating olive (*Olea europaea* L.) harvest with oil extraction is difficult; thus, fruit are stored up to several weeks. Consequently, fruit suffer mechanical, physicochemical, and physiological alterations that lead to quality deterioration. Oils extracted from these damaged fruit are undesirable and must be refined, a process that raises costs and results in nutritional and market value losses.

Oils rich in polyphenols are quite resistant to rancidity (Vázquez et al., 1973); polyphenols disappear when the oil oxidizes (Chimi et al., 1988).

'Mission' table olives stored at 5°C under 2% to 5% O₂ and 2.5% to 10.5% CO₂ maintained good quality for up to 10 weeks (Woskow and Maxie, 1965). Nevertheless, 'Manzanillo' exhibited CO₂ injury when exposed to 5% CO₂ or more at the same temperature (Kader et al., 1990).

Siriphanich and Kader (1985) reported that atmospheres with high CO₂ and low O₂ inhibit vegetable tissue browning and decrease polyphenoloxidase activity. This activity is the main cause of polyphenol destruction in olives (Sciancalepore and Longone, 1984).

We, therefore, investigated changes in polyphenol content in olives stored under modified atmospheres (MAs) or in air in relation to the oil's resistance to oxidation.

Ripe 'Picual' olives grown in Seville, Spain, were picked from 20-year-old trees in early December. Random lots were sorted and matched for the different treatments,

Five storage conditions were tested: three MAs—20% O₂ + 77% N₂ + 3% CO₂; 5% O₂ + 92% N₂ + 3% CO₂; 5% O₂ + 94% N₂ + < 1% CO₂; air at 5°C and 90% to 96% relative humidity (RH); and one each in air at 5°C or ambient temperature (12 ± 5°C, 65% to 70% RH). MA storage conditions were maintained in sealed 60 × 40 × 40-cm plastic containers. Fruit in air were kept in similar, but open, containers.

Four trays (one per sampling date), each containing 6 kg of fruit, were put in each container. Fruit were sampled after 0, 15, 30, and 45 days of storage.

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Concentrations of O₂ and CO₂ were monitored daily using an infrared gas analyzer (model 1400; Servomex Co., Norwood, Mass.) for CO₂ and a paramagnetic gas analyzer (model 1400; Servomex Co.) for O₂. Corrections for atmospheric composition were made by injecting pressurized N₂, CO₂, air, or a combination. Excess CO₂ was corrected by bubbling the gas through 2 N aqueous KOH.

Polyphenol extraction was carried out in triplicate, after pit removal, according to Vázquez et al. (1971).

Polyphenols were determined by Association of Official Analytical Chemists (AOAC) procedures (AOAC, 1970) and a modification of the procedure of Swain and Hillis (1959). Analyses were conducted in triplicate and results were expressed as milligrams of 4-hydroxy-phenyl-ethanol (tyrosol) per grams of pulp (dry weight).

Sample differences were determined by analysis of variance; mean separation was performed by LSD at $P \leq 0.05$.

Storage at 5°C delayed the sharp decrease in polyphenol content compared to storage at ≈ 12°C (Fig. 1). At ≈ 12°C, polyphenol content decreased between days 15 and 30. In air at 5°C, there was a similar decrease, but only between days 30 and 45; thus, the lag phase during which polyphenol content fell slowly was prolonged.

Reducing O₂ concentration to 5% with either 1% or 3% CO₂ was not an appreciable advantage over refrigerating fruit in air during the first 30 days of storage. However, after 30

days of storage, polyphenol content decreased linearly throughout the storage period.

Keeping CO₂ at 3% gave significantly ($P \leq 0.05$) better polyphenol retention than storage in air at 5°C by day 45. Using high (3%) CO₂ and low (5%) O₂ resulted in the lowest polyphenol loss (significant at $P \leq 0.05$).

High CO₂ was more effective than low O₂; this result suggests that CO₂ may act as an antagonist of O₂ in polyphenol oxidation. The presence of an abnormally high CO₂ concentration in the storage atmosphere likely results in an increased CO₃²⁻ ion concentration in the cell cytoplasm. This action decreases internal pH and hinders organic acid decarboxylation.

A combination of high CO₂ and low O₂ seems to inhibit polyphenoloxidase activity significantly and is the main cause of polyphenol destruction in olives.

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Fig. 1. Changes in polyphenol content of olives during storage in modified atmospheres or air.