Quality of Oils from Olives Stored Under Controlled Atmosphere

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Olive (*Olea europaea* cv. "Picual") fruits were stored under five different storage conditions (°C/%CO_2/%O_2: ambient; 5:0:21; 5:3:20; 5:3:5; and 5:<1:5) to determine their influence on the chemical and sensorial quality of oil extracted from the olives at the end of the storage period. Results showed that storage of fruits at 5°C prevented the fast alteration that is produced in oils extracted from fruits stored at ambient temperatures. The use of controlled atmosphere at 5°C with 3% CO_2 and/or 5% O_2 did not present clear advantages on acidity, peroxide value, K_{270} and K_{232} coefficients, stability and sensorial quality. Cooling of fruit keeps physical, chemical and sensorial characteristics of oil below maximum established values for the period of time assayed (60 d).

KEY WORDS: Cold storage, controlled atmosphere, *Olea europaea* cv. "Picual", olive oil, olives, quality.

Because of the difficulty in synchronizing fruit harvesting and extraction of its oil, the olive fruit industry is often forced to store the fruit piled up, commonly known as "trojes", for periods of up to several weeks under poor conditions. During this period, the fruit suffers mechanical, physicochemical and physiological alterations that may eventually cause the breakdown of their cell structures.

Oils extracted from the damaged fruit present high acidity, low stability and a characteristic smell referred to as "fusty", because of its origin. These oils require refining, which leads to consequent economic cost and loss of market value (1). To solve this problem, systematic investigation of several storage conditions of fruit, such as dipping in brine, modifying the atmosphere with SO_2 or CO_2, and applying vacuum have been carried out (2,3). The utilization of cold storage and controlled atmospheres in the preservation of table olives has been studied (4–6). In a previous paper (7), these techniques were applied to obtain a high-quality oil. For the "Gordal" variety of olive fruit, it was shown that at 5°C both the increase of CO_2 concentration up to 5% and the decrease of O_2 concentration to 1% were injurious to the fruit and the extracted oil.

This work shows the changes of quality indices, both physicochemical and sensorial, for oils prepared from the fruit of the most common cultivar variety in Spain ("Picual") placed under various storage conditions.

EXPERIMENTAL PROCEDURES

Biological material. Olive (*Olea europaea* cv. "Picual") fruits grown in Seville (Spain) were used. Fruits (126 Kg) coming from 20-year-old trees were picked in the first days of December at the ripening stage. Harvesting was done manually. Before storage, fruits were mixed to ensure homogeneous sampling.

Fruit storage. Five different storage conditions were assayed: three in a controlled atmosphere (CA) at 5°C and 90–96% relative humidity (RH) (air + 3%/CO_2; 5%/O_2 + 3%/CO_2; 5%/O_2 + <1%/CO_2), and two in air—one at ambient temperature and the other at 5°C and 90–96% RH. RH at 5°C (air and CA) was maintained with humidifiers. The olives for the three CA storage conditions were maintained in sealed plastic containers of 60 × 40 × 40 cm. The olives for the other two storage conditions were also maintained in similar containers, but they were kept open.

Four trays, each containing 6 Kg of fruit, were put in each container. Sampling was carried out after 15, 30, 45 and 60 d of storage. Each tray represented a sampling date. An additional sample of 6 Kg was taken for the initial assay (time zero). In the CA containers, the concentrations of respiratory gases were monitored and controlled manually each day. An infrared gas analyzer (Servomex 1400, range 0–10%) (Servomex Company, Norwood, MA) for carbon dioxide and a paramagnetic gas analyzer (Servomex 1400) for oxygen were used. The corrections of atmospheric composition were made by injection of pressurized N_2 and CO_2 and/or air. Excess amounts of CO_2 were corrected by bubbling the gas through an aqueous solution of 2N KOH.

Oil extraction. Oil was extracted in an Abencor analyzer (Comercial Abengon SA, Sevilla, Spain). This unit consisted of three basic elements—a mill, a thermobeater and a pulp centrifuge (8).

Physicochemical determinations. Titratable acidity, peroxide index and ultraviolet (UV) absorbance coefficients K_{232} and K_{270} were determined according to the Spanish standard methods (9–11). Stability was assayed by the Rancimat method (12,13). Determinations were carried out in duplicate, taking a single sample for each time and storage condition.

Sensorial analysis. The evaluation of sensorial quality of oil samples was carried out by the analytical taste panel of the Instituto de la Grasa y sus Derivados (Seville, Spain) composed of 12 members. The fats were run according to Rule COI/T20 Doc.3. (COI Organoleptic assessment of olive oil COI/T20 Doc./3 Resolution n. Res 5/56/IV/87, International Olive Oil Council, Madrid, Spain).

A quantitative descriptive analysis (QDA) was applied by using a structured intensity scale of five points; one being imperceptible and five being extreme. The value of each attribute is represented by its mean intensity, determined by the arithmetic mean of intensities given by the panel. Each oil was evaluated according to a scale of nine points, one being the value for very poor quality and nine for optimum quality. Because of the limited amount of oil, determinations were done on single samples.

RESULTS AND DISCUSSION

Yield of extracted olive oil. The yield of oil extracted from olives stored at ambient temperature was lower than that from fruit stored at 5°C (Fig. 1). All of the olive fruits stored at ambient environment showed evidence of rot in this period of time (14). This caused noticeable decay of tissue structure and fluid secretion, which, in turn, caused stable emulsions in slurry. No differences were found in yield between fruit stored at 5°C with different atmosphere compositions. Thus, neither the increase of

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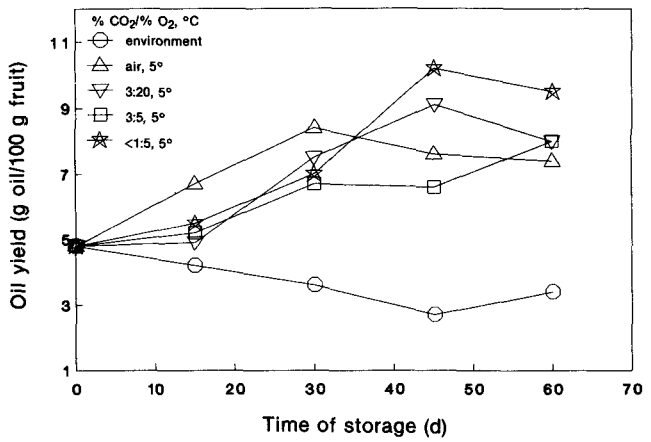

FIG. 1. Evolution of yield of extracted oil during the period of storage.

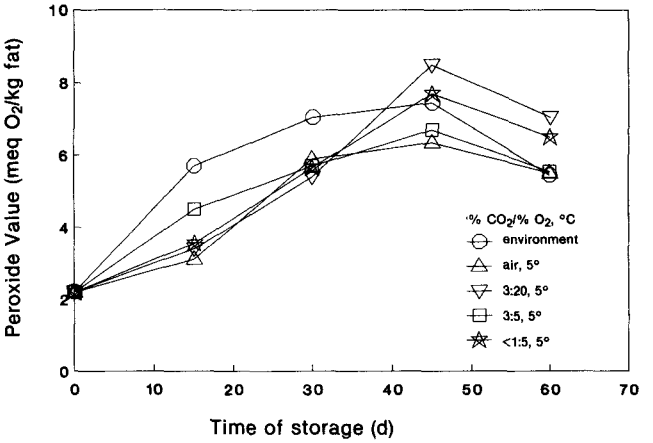

FIG. 2. Effect of fruit storage time on peroxide value of extracted oil.

TABLE 1

Effect of Fruit Storage Time on Acidity of Extracted Oil

Time (d)	Acidity (% oleic acid)				
	Ambient environmental conditions	5°C			
		air	3% CO_2	3% CO_2/5% O_2	5% O_2
0	0.15	0.15	0.15	0.15	0.15
15	0.31	0.15	0.16	0.14	0.14
30	24.60	0.33	0.33	0.28	0.22
45	31.60	0.69	1.03	0.64	0.46
60	31.60	1.88	3.41	2.23	1.38

CO_2 concentration, nor the decrease of O_2 concentration to 5%, seems to influence the quantity of extracted oil.

Acidity. As shown in Table 1, acidity of the oils extracted from different samples depended on the period of time from harvesting to milling, with the storage temperature being the most important factor. Thus, during the first 15 d, acidity did not change in samples stored at 5°C, whereas at ambient temperatures acidity was doubled. This process was accelerated and, after 30 d of storage, the acidity of oil had reached 164 times the initial value.

Cold storage avoids this sharp increase, so after 45 d, practically every oil from fruit stored at 5°C could be considered as being in the "extra" category according to the degree of acidity (values lower than 1). Between 45 and 60 d, differences are sharper between storage atmospheres used at 5°C. After that storage period, the most effective treatment was the decrease of O_2 concentration to 5% without enrichment of CO_2 (degree of acidity, 1.38); followed by air atmosphere (1.88). Higher values were found with 3% CO_2. When 3% CO_2 was accompanied by an O_2 concentration similar to air, the value of acidity (3.41) was higher than with 5% O_2 (2.23). The sudden increase of acidity in oils extracted from fruit stored at environmental temperature coincided with the development of rot. It is possible that both events were closely related and that the sharp increase of acidity was caused by fatty acids released as a consequence of lipolitic activity of molds (15).

Peroxide index. The results (Fig. 2) showed similar behavior in every assayed condition, with a gradual increase

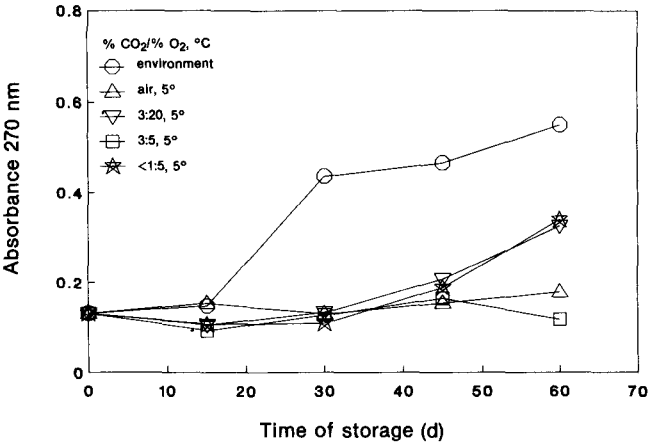

FIG. 3. Effect of fruit storage time on ultraviolet absorbance E_{270} of extracted oil.

of peroxide value (PV) up to 45 d, followed by a slight decrease up to 60 d. A faster increase of PV was observed in oils from fruit stored at ambient temperatures, presenting higher values than the rest of the assayed conditions in samples at 15 and 30 d. Formation of carbonyl compounds, demonstrated by increasing K_{270} values (Fig. 3), may be the cause of decreasing PV values of oils extracted from the fruit in every sample after 45 d of storage. It has been demonstrated that it is necessary to drop the O_2 content in the atmosphere to decrease the oxidation rate significantly. Thus, at 5°C the reduction of O_2 concentration to 5% showed no significant decrease in the PV of the oils.

Evolution of K_{270} and K_{232} coefficients. Oxidation of linoleic or linolenic acid produces hydroperoxides and conjugate dienes that absorb UV light. Hydroperoxides from linoleic acid, as well as conjugate diene, that may result from their decomposition show absorbance at 232 nm, while secondary oxidation products, specially diketones, show absorbance at 268 nm. Conjugate trienes show a triple absorption band with a main peak near 268 nm, and a second one at 278 nm. UV specific extinction determination permits an approximation to the oxidation process in unsaturated oils. Changes in these coefficients are pre-

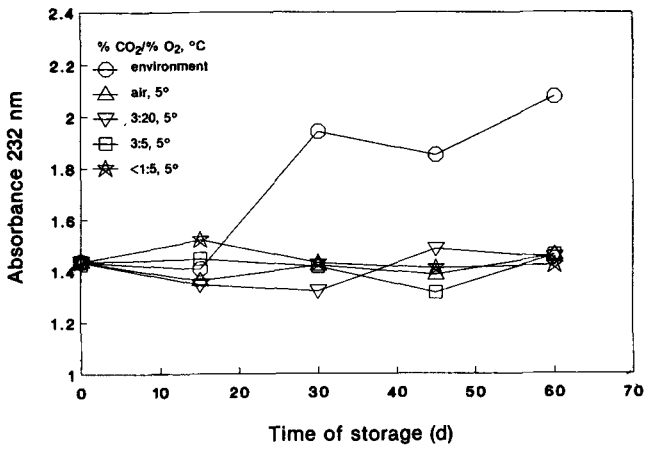

FIG. 4. Effect of fruit storage time on ultraviolet absorbance E_{232} of extracted oil.

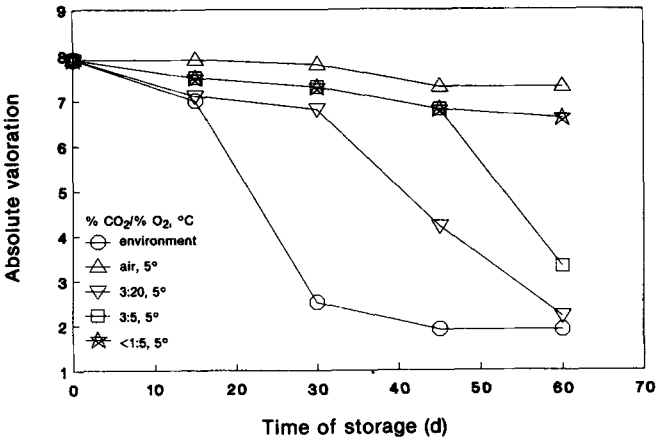

FIG. 6. Effect of fruit storage time on sensorial evaluation (absolute valoration) of extracted oil.

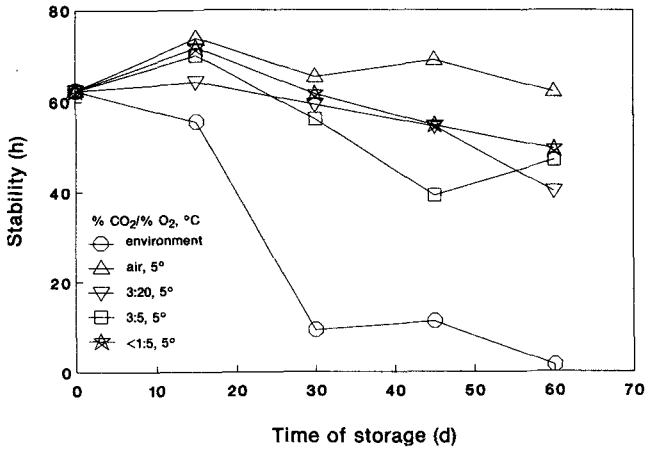

FIG. 5. Effect of fruit storage time on stability of extracted oil.

sented in Figures 3 and 4, respectively. Increases in K_{270} and K_{232} were observed in oils extracted from fruit stored at ambient temperature after 15 d of storage. After 30 d the maximum established limit (K_{270} = 0.20 and K_{232} = 2.40) for "extra" virgin olive oil was passed. The coefficients for the rest of the oils were practically constant, except K_{270} of oil extracted from fruit stored in air + 3% CO_2, which increased after one month of storage, surpassing the maximum established limit after 60 d.

Stability. The stability study (Fig. 5) demonstrated the different behavior of olive fruits stored at 5°C in relation to those stored at ambient temperature. In oils extracted from fruits stored at ambient environment, the stability underwent a remarkable decrease within 30 d of storage, and zero stability was measured after two months. In different atmospheres at 5°C, stability is practically constant during the first 30 d. Stability is reduced slightly after 60 d. CO_2 presents an injurious effect, which is not helped by decreasing the O_2 level.

A bad correlation between stability and PV was observed, suggesting the existence of other factors, in addition to oxidation state, that influence the stability of oils. In that case, the presence of high concentrations of free fatty acids, measured by the increase of acidity as a consequence of hydrolytic action of molds, may be the major factor for this decrease of stability.

Sensorial analysis. Figure 6 shows the evolution of oil quality measured as a global score given by the Test Panel. Sensorial analysis is the most suitable technique for finding differences between the different treatments. Quality decreased with storage time, although differences between treatments are noticeable. Thus, when fruits were stored in air at ambient temperatures, the loss of oil quality was sharp after 15 d, becoming unacceptable for direct consumption after 30 d. In oils extracted from fruits stored at 5°C and atmosphere with 3% CO_2 (in air or with 5% O_2), the sharp decrease of their scores was delayed, but both of them were unacceptable at 60 d. On the other hand, oils extracted from fruit stored at 5°C in atmospheres with less than 1% CO_2 keep their "extra" quality (absolute score >6.5) up to the end of the considered period, although their scores did go down steadily. Descriptive analysis shows that the negative attributes (winey, mushiness, muddy, sediment and fusty) only appear in fruit stored at environmental temperature after 15 d and 30–45 d in fruit stored in atmospheres with high levels of CO_2.

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