Storage of Mill Olives on an Industrial Scale

José M. García,* Francisca Gutiérrez, María J. Barrera, and Miguel A. Albi

Instituto de la Grasa y sus Derivados (CSIC), Avenida Padre García Tejero 4, 41012 Sevilla, Spain

Olives (*Olea europaea* cv. Blanqueta and Villalonga) used for oil production (130 000 kg for each variety) were stored at two different temperatures (ambient and 5 °C) on an industrial scale. Refrigeration of the olives at 5 °C delayed deterioration of the physical, chemical, and sensorial parameters, measures of oil quality, allowing an additional 30 days of storage without changes in the initial oil quality. The Blanqueta variety does not maintain oil quality under cold storage as well as the Villalonga variety.

Keywords: *Olea europaea; postharvest; refrigeration; oil quality*

INTRODUCTION

Olive oil quality is directly related to the physiological condition of the olives from which it is extracted. Normally, the Spanish production of mill olives exceeds the capacity of the oil extraction industry. Thus, a considerable quantity of fruit must be stored before being processed. The quantity for storage varies according to the production of each season (Kiritsakis, 1991). If these olives are stored carelessly, they quickly lose their original physiological quality, the processes of ripening and senescence are accelerated, and the olives suffer softening and become very sensitive to mechanical damage and to the action of pathogenic microorganisms. In a few days, the physical and chemical structure of the olives is altered and the oil extracted from them has a very poor quality, a characteristic fusty smell, high titratable acidity, low stability, and high values for the indices that measure the level of oxidation, such as the peroxide value and the specific extinction coefficients at 232 and 270 nm. This type of oil must be refined before consumption.

During four consecutive seasons the effects of different atmospheres, temperatures, and container capacities for fruit storage on the quality of the extracted oil have been studied on a laboratory scale (Pérez-Camino et al., 1992; Gutiérrez et al., 1992; Castellano et al., 1993; García, 1993). In the latter studies, the viability of the use of refrigeration at 5 °C in air atmosphere for maintaining the initial quality of the olives and of the oils obtained from stored olives was demonstrated for the Picual variety, the most widely cultivated variety of olives for oil production. However, Woskow and Maxie (1965) reported different responses of distinct table olive varieties to cold storage. Therefore, it is quite possible that mill olive varieties behave differently under refrigeration. Therefore, additional studies are necessary on the suitability of cold storage for other mill olive varieties.

In Spain, the region of Valencia has a well-known tradition of citrus fruit storage. At the same time, this region produces appreciable amounts of mill olives. For this reason, in Valencia the use of cold storage for maintaining the initial oil quality is economically feasible.

This paper reports on the first trial carried out by the olive oil extraction industry on cold storage of mill olives, using two varieties widely cultivated in the region of Valencia.

MATERIALS AND METHODS

Olives (*Olea europaea* cv. Blanqueta and Villalonga), cultivated in orchards of a co-operative society of Valle de Albaida (Valencia, Spain), were harvested (130 000 kg each variety) in plastic containers, commonly used for handling of citrus olives, with capacity for 14 kg of olives. Two different storage conditions were tested: refrigeration at 5 ± 1 °C with a relative humidity (RH) of 95%; and ambient conditions (12 ± 5 °C, RH 85 ± 5%). Samples of 5000 kg were used for each sampling date and treatment.

The percentage of rotten olives was quantified (olives with visible mycelial growth). Triplicate samples of 100 olives were examined per treatment. Each replicate was taken randomly from a different container. When the percentage of rotten olives in a treatment exceeded 40%, the storage was interrupted and all of the olives in this treatment were immediately processed for oil extraction.

Resistance of the flesh to deformation was determined in the same olives. A Zwick 3300 densimeter (Zwick Gmbh & Co., Ulm, Germany) with a 5 mm diameter disk was used (force required to depress the disk 2.4 mm into the olives), and the results were expressed in N/cm^2.

The ripening index of olives was calculated using a subjective evaluation of the color of the olive skin and flesh (Uceda and Frías, 1975). This system is routinely used by the oil industry to characterize the degree of ripeness of olives arriving at the mill. The procedure consists in distributing 100 olives in 8 groups, according to the following characteristics: group 0, skin bright green; group 1, skin green-yellowish; group 2, skin green with reddish spots; group 3, skin reddish-brown; group 4, skin black with white flesh; group 5, skin black with <50% purple flesh; group 6, skin black with ≥50% purple flesh; and group 7, skin black with 100% purple flesh. The ripeness index is determined by the equation

$$\text{ripeness index} = \sum(i n_i)/100$$

where i is the number of the group and n_i the number of olives in it. The evaluation was performed in triplicate.

The oil from three containers of each treatment was extracted separately at each sampling date using an Abencor analyzer (Comercial Abengoa S.A., Sevilla, Spain). This unit consists of three basic elements: a mill, a thermobeater, and a pulp centrifuge (Martínez et al., 1975).

The titratable acidity, the peroxide value, and the coefficients of specific extinction at 232 and 270 nm (K_{232} and K_{270}) were determined in triplicate from the extracted oils according to the UNE standard Spanish methods (AENOR, 1973a−c).

Stability was measured in triplicate by the Rancimat method (Läubli and Bruttel, 1986; Gutiérrez, 1989).

Sensory quality was evaluated in triplicate by a 12-member analytical panel of the Instituto de la Grasa, according to the method described in Annex XII of the European Economic

0021-8561/96/1444-0590$12.00/0

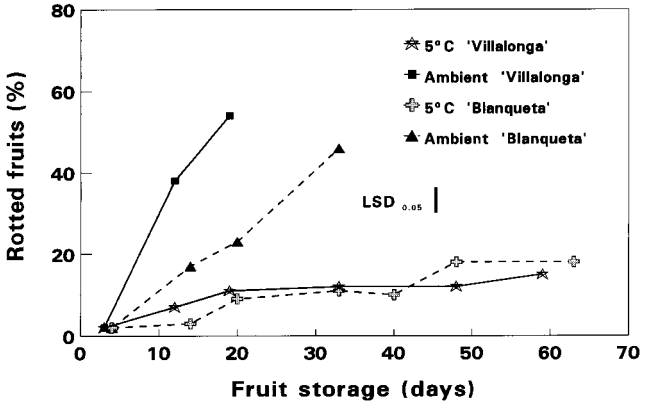

Figure 1. Changes in the incidence of decay (percent rotted olives) of olives stored at different temperatures.

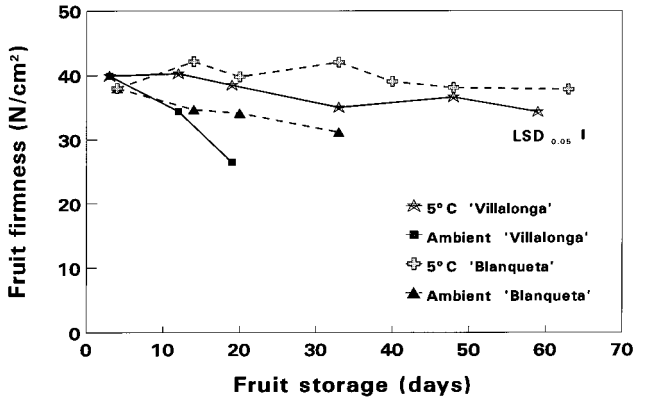

Figure 2. Changes in the firmness (N/cm^2) of olives stored at different temperatures.

Community Rules (2568/91). Each oil was graded according to a scale of 9 points, 1 being the value for very poor quality and 9 the value for optimum quality.

Analysis of variance was carried out on all data. A 5% level of least significant difference (lsd), calculated by Duncan's multiple range test, was employed to establish differences between the means obtained for the treatments.

RESULTS AND DISCUSSION

Cold storage significantly delayed ($P \leq 0.05$) the increase of percentage decay in both varieties (Figure 1). After 60 days, only about 20% of the refrigerated olives were rotten, while the olives maintained at ambient temperature exceeded this value before 20 days. In ambient conditions, cv. Blanqueta olives were significantly ($P \leq 0.05$) more resistent to fungal infection than cv. Villalonga olives. However, no significant differences were found between the varieties when the olives were refrigerated.

Refrigeration at 5 °C delayed olive softening in both varieties (Figure 2), which retained about 90% of the initial firmness value after 60 days of storage. On the other hand, olives stored under ambient conditions showed a significant ($P \leq 0.05$) loss of firmness, decreasing a mean of 20% from the initial value after 20 days. In both treatments cv. Blanqueta was firmer than cv. Villalonga.

The changes in the maturity indices, of each variety, as measured by the changes in the skin and flesh color, showed different trends (Figure 3). In both treatments, Villalonga olives ripened more rapidly than the Blanqueta variety. Cold storage at 5 °C significantly delayed ($P \leq 0.05$) ripening of the olives.

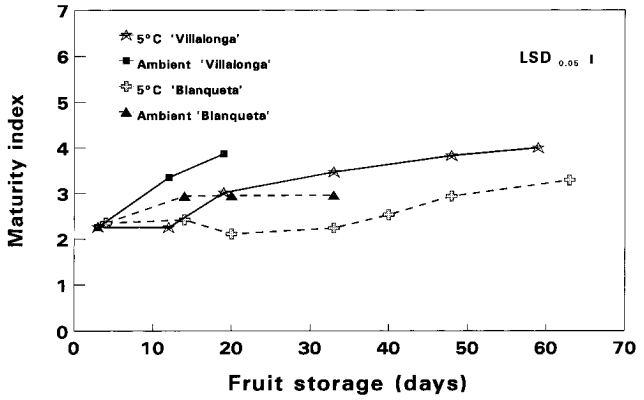

Figure 3. Changes in the maturity index on a subjective scale according to the skin color of the fruit (0, skin bright green; 1, skin green-yellowish; 2, skin green with reddish spots; 3, skin reddish-brown; 4, skin black with white flesh; 5, skin black with <50% purple flesh; 6, skin black with ≥50% purple flesh; 7, skin black with 100% purple flesh) of olives stored at different temperatures.

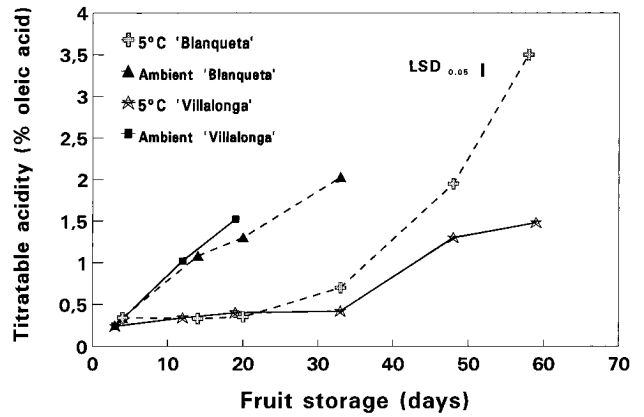

Figure 4. Changes in the titratable acidity (percent oleic acid) of oils obtained from olives stored at different temperatures.

Refrigeration of olives at 5 °C allowed the initial titratable acidity levels of oil extracted from the olives to be practically maintained for more than 30 days. During this time the values were lower than 1%, this being the limit accepted in the European market for the best olive oil quality ("extra"). The oil obtained from nonrefrigerated olives lost the "extra" quality as judged by titratable acidity in less than 15 days of fruit storage. After 30 days of cold storage, the varieties differed significantly ($P \leq 0.05$), the increase observed being higher in oil obtained from the Blanqueta olives. Normally, the titratable acidity of an oil is strongly related to the percentage of decayed olives in the lot from which it was extracted; this relationship arises because the titratable acidity mainly depends on the lipolytic activity of pathogenic lipases. However, in ambient storage there were fewer rotten Blanqueta olives than Villalonga olives, and at 5 °C both varieties showed similar decay percentages (Figure 1). The oil extracted from Blanqueta olives stored at ambient temperature had a titratable acidity similar to that of Villalonga olives stored under the same conditions. The titratable acidity of the oil from Blanqueta olives stored at 5 °C was higher than that of oil from Villalonga olives stored at 5 °C (Figure 4). Probably, the lipolytic action of fungi was more effective in this variety.

Cold storage of the olives at 5 °C significantly delayed ($P \leq 0.05$) the increase in the peroxide value of the oils (Figure 5). At ambient temperature the oil obtained from Villalonga olives had a significantly higher ($P \leq$

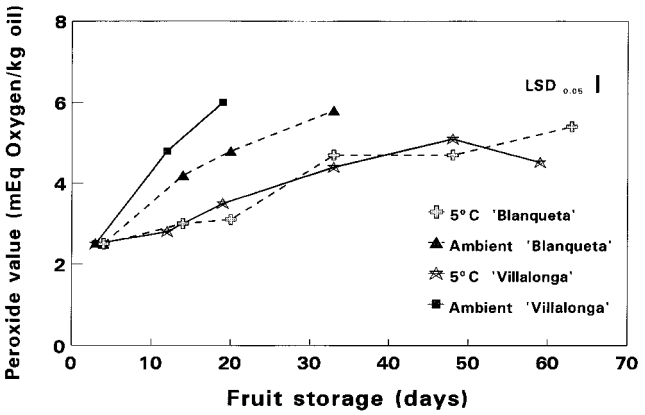

Figure 5. Changes in the peroxide value (mequiv of oxygen/kg of oil) of oils obtained from olives stored at different temperatures.

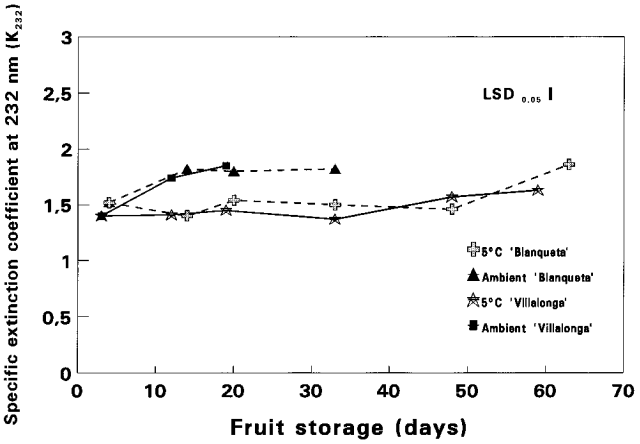

Figure 6. Changes in the specific extinction coefficient at 232 nm (K_{232}) of oils obtained from olives stored at different temperatures.

0.05) peroxide content than oils extracted from Blanqueta olives. The level of this oxidation parameter was very low. None of the samples tested exceeded the limiting accepted value for "extra" quality olive oil (20 mequiv of oxygen/kg of oil). Gutiérrez et al. (1992) found similar results in oil extracted from stored olives of the Picual variety. On the other hand, García and Streif (1991) found a marked increase in the peroxide value of oils extracted from stored olives of the Gordal variety.

Conjugation of diunsaturated fatty acids in oil obtained from stored olives, measured by their K_{232} value, remained the same under refrigeration at 5 °C (Figure 6), while the oils obtained from olives stored at ambient temperature showed significantly ($P \leq 0.05$) higher values. Nevertheless, the limiting value accepted for "extra" quality olive oil (2.40) was not exceeded in any of the oils analyzed. There were no differences between the varieties assayed with respect to this parameter.

Refrigeration of the olives had no significant effect ($P \leq 0.05$) on the content of carbonylic compounds of the oils extracted from the same variety under different storage, as measured by the K_{270} values (Figure 7). However, the oil obtained from refrigerated olives showed lower values during the time that both storage conditions could be compared, being significantly lower at 20 days of olive storage only. The oil obtained from the Villalonga olives had significantly higher ($P \leq 0.05$) values than that extracted from Blanqueta olives during the first 30 days of storage. Subsequently, the values converged. By the end of the storage, oil obtained from

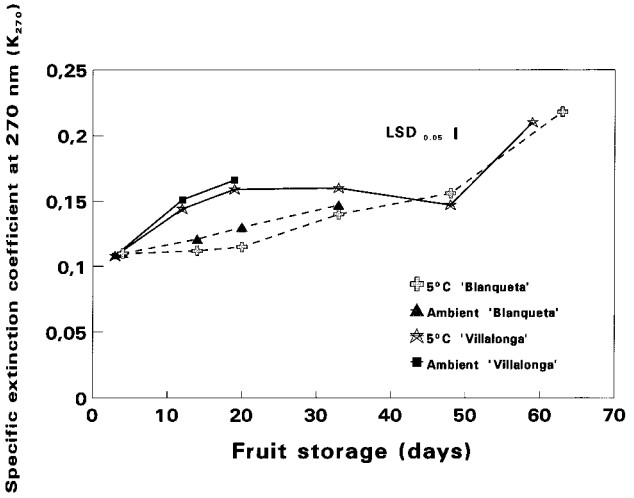

Figure 7. Changes in the specific extinction coefficient at 270 nm (K_{270}) of oils obtained from olives stored at different temperatures.

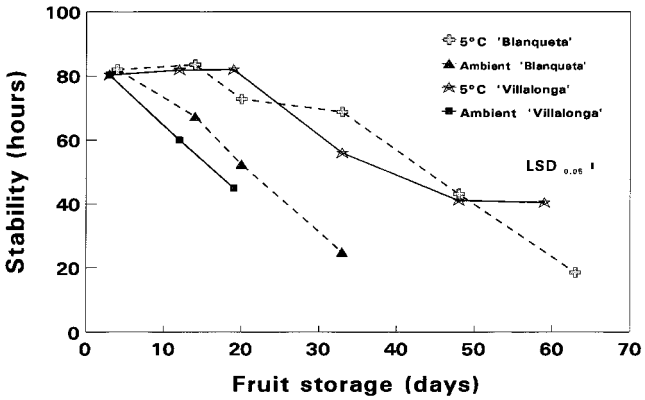

Figure 8. Changes in the stability to oxidation (hours) of oils obtained from olives stored at different temperatures.

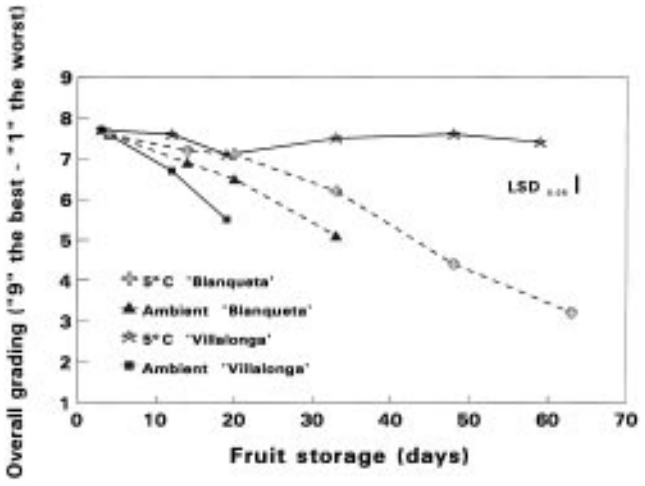

Figure 9. Changes in the sensory evaluation of oils obtained from olives stored at different temperatures (overall grading on a subjective scale where "9" means the best and "1" the worst).

refrigerated olives only slightly exceeded the limiting value of K_{270} established for "extra" quality oil (0.20).

Refrigeration of the olives at 5 °C significantly delayed ($P \leq 0.05$) the decrease in oil stability (Figure 8). After 20 days of storage, nonrefrigerated olives produced oil that had lost 40% of its initial stability, while oil obtained from olives stored at 5 °C for the same length of time had not changed. At ambient temperature, the

Blanqueta olives produced oil with a significantly higher ($P \leq 0.05$) stability than that obtained from the Villalonga olives. On the other hand, no clear differences were found between the oils obtained from the refrigerated olives of both varieties.

Sensory analysis demonstrated that cold storage of olives maintained the initial quality of the oil significantly better ($P \leq 0.05$) than ambient temperature (Figure 9). Nevertheless, the behaviors of the two varieties were quite different. Oil extracted from refrigerated Villalonga variety displayed no loss of quality parameters during fruit storage and maintained better values than the accepted limit for "extra" quality oils according to the sensory analysis criteria (6.5). Oil obtained from refrigerated Blanqueta olives exhibited a linear decrease, losing the "extra" quality after 30 days of storage. During olive storage, Blanqueta olive oil developed off-flavors more easily than Villalonga olive oil. For this reason Villalonga olives are better than Blanqueta olives for cold storage.

ACKNOWLEDGMENT

We thank the Cooperativa Comarcal del Valle de Albaida for providing all of the material used and for confiding in us. We also thank M. C. Martínez and M. A. Viera for technical assistance.

LITERATURE CITED

AENOR. Spanish standard, UNE 55011-73; Asociación Española de Normalización y Certificación., Madrid, 1973a.

AENOR. Spanish standard, UNE 55023-73; Asociación Española de Normalización y Certificación, Madrid. 1973b.

AENOR. Spanish standard, UNE 55047-73; Asociación Española de Normalización y Certificación, Madrid, 1973c.

Castellano, J. M.; García, J. M.; Morilla, A.; Perdiguero, S.; Gutierrez, F. Quality of Picual olive olives stored under controlled atmosphere. *J. Agric. Food Chem.* **1993**, *41*, 537−539.

García, J. M. Effect of CO_2 in fruit storage atmosphere on olive oil quality. *Grasas Aceites* **1993**, *44*, 169−174.

García, J. M.; Streif, J. The effect of controlled atmosphere storage on fruit and oil quality of Gordal olives. *Gartenbauwissenschaft* **1991**, *56*, 233−238.

Gutiérrez, F. Determination of oxidative stability in virgin olive oils: comparison between active oxygen method and Rancimat method. *Grasas Aceites* **1989**, *40*, 1−5.

Gutiérrez, F.; Perdiguero, S.; García, J. M.; Castellano, J. M. Quality of oils from olives stored under controlled atmosphere. *J. Am. Oil Chem. Soc.* **1992**, *69*, 1215−1218.

Kiritsakis, A. K., Ed. *Olive Oil*; American Oil Chemists' Society: Champaign, IL, 1991.

Läubli, W.; Bruttel, P. A. Determination of the oxidative stability of fats and oils by the Rancimat method. *J. Am. Oil Chem. Soc.* **1986**, *63*, 792−794.

Martínez, J. M.; Muñoz, E.; Alba, J.; Lanzón, A. Report about the use of the Abencor yields analyser. *Grasas Aceites* **1975**, *26*, 379−385.

Pérez-Camino, M. C.; García, J. M.; Castellano, J. M. Polar compound concentration in virgin oils from stored cultivar Picual olive olives. *J. Agric. Food Chem.* **1992**, *40*, 2260−2262.

Uceda, M; Frías, L. Harvest dates. Evolution of the fruit oil content, oil composition and oil quality. In *Proceedings of II Seminario Oleícola Internacional*; International Olive-oil Council: Cordoba, Spain, 1975; pp 125−130.

Woskow, M.; Maxie, E. C. Cold storage studies with olives. In *44th Annual Technical Report of the California Olive Association*; University of California: Davis, CA, 1965; pp 6−8.

Received for review July 25, 1995. Accepted November 3, 1995.[⊗] We express our sincere gratitude to CICYT for supporting this research project, ALI92-0393.

JF950479S

[⊗] Abstract published in *Advance ACS Abstracts*, December 15, 1995.