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Retention of color and volatile compounds of Spanish-style green table olives pasteurized and stored in plastic containers under conditions of constant temperature

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ABSTRACT

Spanish-style green table olives pasteurized and stored in two types of pasteurizable plastic pouches and glass bottles were analyzed for color parameters and volatile components after 6.5 months of storage at 30 °C. Color parameters in pouches made of aluminium oxide coating on polyethylene terephthalate + medium-density polyethylene (AlOx-coated PET + MDPE) were acceptable and, in general, did not significantly differ from those in glass, but unacceptable values corresponding to dark visual colors of both olives and brine were found in pouches made of polyethylene terephthalate + medium-density polyethylene/ethylene vinyl alcohol (PET + MDPE/EVOH). Forty-three volatile compounds were identified and quantified in olive pulp by solid phase micro-extraction (SPME) and gas chromatography coupled to mass spectrometry (GC-MS), 36 of these compounds being significantly different between the plastic and glass treatments. The type of plastic container had an impact on the volatile composition of product. Oxidation and scalping were considered to be the most probable causes for the differences in volatile components between PET + MDPE/EVOH pouches and glass containers, but in AlOx-coated PET + MDPE pouches no oxidation process was apparent.

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1. Introduction

Fermented green olives have been consumed around the world for thousands of years. Alkali-treated green olives in brine, also known as Spanish-style green olives are the most widely distributed and investigated type of table olive. This is a fermented product whose long-term preservation is usually carried out by its own physico-chemical characteristics without the need of a pasteurization treatment if pH is sufficiently low (<3.5) and NaCl content is 5–7 g/100 g (Rejano, Montaño, Casado, Sánchez, & de Castro, 2010). However, the progressive preference of consumers for milder levels of acidity and salt has modified such conditions and the stabilization of the final product requires the use of pasteurization. This heat treatment results in shelf stable products by killing the major spoilage microorganisms, lactic acid bacteria and yeasts, as well as by inactivating enzymes that may contribute to fruit softening (Breidt, Sandeep, & Arritt, 2010).

Since the development of the commercial pasteurization process, all pasteurized table olives have been packaged in glass or varnished can containers which do not react chemically with food components. The main function of food packaging is to achieve preservation and the safe delivery of food products until consumption (Han, 2013). However, there is an increasing interest in the use of plastic packaging by industry due to factors such as reduced weight of plastic containers, lower production costs compared to glass, less apt to shatter, transparent, flexible, and convenient to the consumer (Sajilata, Savitha, Singhal, & Kanetkar, 2007). In spite of all these advantages, plastic containers are likely to have at least a limited level of oxygen permeability. This could negatively affect the quality of pickled vegetables, which are known to be susceptible to oxidation (Cleary & McFeeters, 2006; Zhou, McFeeters, & Fleming, 2000) and reduce the shelf life of products. In addition to oxidation, it must be taken into account that plastic packaging materials can absorb different compounds from the food, a phenomenon called scalping (sorption). In particular, flavor

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scalping is a term used to describe the loss of quality of a packaged food due either to its volatile flavors being absorbed by the package or the food absorbing undesirable flavors from the packaging material. Sorption of food aromas, particularly by plastic packaging materials, is usually perceived as a major factor contributing to the quality alteration of most foods during storage (Sajilata et al., 2007). Interactions between flavor compounds and plastic packages have been demonstrated in different food products such as orange juice (López-Gómez, Ros-Chumillas, & Belisario-Sánchez, 2009), wine (Reeves, 2009), beer (Bamforth & Krochta, 2009), milk (Kontominas, 2009), yogurt (MacBean, 2009), or vegetable oils (Piergiovanni & Limbo, 2009). However, to our knowledge, this type of study has not been carried out with any fermented vegetable.

The selection of proper packaging materials that are compatible with fermented olives while maintaining quality during pasteurization treatment and storage is critical to proposing a change from traditional glass containers to plastic packaging. The objective of this work was to identify differences in the color and volatile component profiles of Spanish-style green table olives pasteurized and stored at constant temperature (30 °C) in two distinct pasteurizable plastic containers in comparison with the traditional product packed in glass containers.

2. Materials and methods

2.1. Materials and chemicals

Pitted Spanish-style green table olives (Manzanilla cultivar) were supplied in bulk by Angel Camacho SL (Seville, Spain). Physico-chemical characteristics of the corresponding brine were the following: pH, 3.47; titratable acidity, 0.91 g/100 mL (as lactic acid); combined acidity, 0.047 mol/L; and NaCl, 8.34 g/100 mL. Two types of plastic pouches, named as pouches A and B, were used. Both pouches were supplied by SP Group (Córdoba, Spain). Pouches A were made of PET + MDPE/EVOH (polyethylene terephthalate + medium-density polyethylene/ethylene vinyl alcohol) with oxygen permeability ≈ 3 $cm^3/m^2/d$ at 23 °C and 50% r.h., and thickness of 106 μm. Pouches B were made of AlOx-coated PET + MDPE (aluminium oxide coating on polyethylene terephthalate + medium-density polyethylene) with oxygen permeability ≈ 1 $cm^3/m^2/d$ at 23 °C and 50% r.h., and the same thickness as pouches A.

Potassium sorbate, ascorbic acid, sodium benzoate, citric acid, sodium chloride, and all volatile compounds used as reference standards were purchased from Sigma-Aldrich (St Louis, MO). Deionised water was obtained from a Milli-Q system (Millipore, Bedford, MA). All other chemicals and solvents (orthophosphoric acid, potassium dihydrogenorthophosphate, dipotassium hydrogenorthophosphate, sodium hydroxide, silver nitrate, methanol, acetonitrile, etc.) were of analytical or chromatographic grade from various suppliers (Panreac, Barcelona, Spain; VWR, Barcelona, Spain; Merck, Darmstadt, Germany).

2.2. Packing of Spanish-style green table olives

Olives were packed in plastic pouches A, plastic pouches B, and glass bottles using an acidified brine as cover liquor. This acidified brine consisted of citric acid, NaCl, ascorbic acid, potassium sorbate, and sodium benzoate to give equilibrium values of 0.50 g/100 mL titratable acidity (expressed as lactic acid), 4.7 g/100 mL NaCl, 0.4 g/L ascorbic acid, 0.5 g/L sorbic acid, and 0.5 g/L benzoic acid, respectively. Use of additives (ascorbic acid, sorbates and benzoates) was justified as it is a common practice in the olive industry, even in case of pasteurized samples. Ascorbic acid has been demonstrated to have a positive effect on fruit color (Casado, Sánchez, Rejano, de Castro, & Montaño, 2010; Casado et al., 2011) whereas sorbates plus benzoates can prevent surface films of yeasts and fungi in packed table olives once the packaging has been opened (Borbolla y Alcalá, Fernández-Díez, & Cancho, 1961; Chipley, 2005).

In both types of pouches the drained net weight of olives was 61.5 g (17 olives) and the brine volume was 86 mL. In glass containers the drained net weight and brine volume were 96.5 g (26 olives) and 135 mL, respectively, giving the same weight-to-volume ratio (0.715) as in the plastic pouches. For the corresponding calculations, the moisture content of pitted olives was assumed to be 75 g/100 g pulp (w/w). In case of packing in glass bottles, cover brine was added hot (≈70 °C) in order to achieve and maintain a vacuum inside the bottles. After packing (10 containers per packaging treatment), the plastic pouches and glass containers were subjected to pasteurization and then stored at 30 °C for 6.5 months in a Binder BD 720 (Tuttlingen, Germany) incubator with opaque doors and walls, natural convection and without any control of humidity. A storage temperature of 30 °C was selected to accelerate the possible reactions occurring inside the containers, and also taking into account the relatively high temperatures in our region. The pasteurization was carried out in a computer-controlled retort equipped with a water cascading system (Steriflow, SAS, Paris, France). Plastic pouches and glass containers were pasteurized separately. The process applied to both plastic bags and glass containers consisted of the following stages: (1) pre-heating from the initial retort temperature (40 °C) to the final temperature (93 °C), duration 10 min; (2) pasteurization at 93 °C for 7 min; and (3) cooling with tap water at ambient temperature, duration 10 min. After the period of storage, three replicate containers (pouches or bottles) were analyzed.

2.3. Color parameters

Surface color of olives was measured using a Color-View Model 9000 spectrophotometer (BYK-Gardner, Inc., Silver Spring, MD) with a measurement area of 11 mm diameter, 45° circumferential illumination, and observation angle of 0°. All measurements were done on the CIE 1976 L*a*b* scale using illuminating conditions CIE type C, 10° observer. Results were expressed as the mean of 10 replicate measurements, each made on 1 olive. In addition, from the reflectance curve supplied by the apparatus, a color index (i) was obtained, as described by Sánchez, Rejano, and Montaño (1985):

$$i = (4R_{635} + R_{590} - 2R_{560})/3$$

where R_{635}, R_{590}, and R_{560} are the values of reflectance at 635, 590, and 560 nm, respectively. Olive color can be analytically classified as excellent ($30.2 < i < 33.6$), good ($26.8 < i < 30.2$), acceptable ($23.7 < i < 26.8$), bad ($21.0 < i < 23.7$), and very bad ($i < 21.0$).

Brine color was estimated by measuring the difference in absorbance at 440 and 700 nm, ($A_{440} - A_{700}$), as described by Montaño, Sánchez, and Rejano (1988). A value of 0.23 absorbance unit (AU) has been proposed as acceptance limit, above which the brine color is considered unacceptable for packed green table olives.

2.4. Analysis of additives

The ascorbic acid in brine was analyzed using an HPLC method previously used in table olives (López, Montaño, García, & Garrido, 2005). The HPLC system consisted of a Waters 2690 separations module connected to a Waters 996 photodiode array detector,

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