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Use of talc in oil mills: Influence on the quality and content of minor compounds in olive oils

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Chemical compounds studied in this article:
Talc PubChem CID: 73555547
Hydroxytyrosol PubChem CID: 82755
Tyrosol PubChem CID: 10393
Oleocanthal PubChem CID: 11652416
Pinoresinol PubChem CID: 73399
Trans-2-hexenal PubChem CID: 5281168
Hexanal PubChem CID: 6184
Trans-2-hexen-1-ol PubChem CID: 5318042
Cis-2-penten-1-ol PubChem CID: 5364919
1-Penten-3-one PubChem CID: 15394

A B S T R A C T

In oil milling, in order to obtain high-quality oils without reducing the industrial yield, to the use of coadjuvants with a physical action and adequate operating conditions is necessary. The aim of this study was to evaluate the influence of talc addition during the malaxation stage in an oil mill on the resulting oil. Moreover, the oil obtained by talc treatment can be classified as extra virgin olive oil as this coadjuvant has a physical action. Talc increases the extraction efficacy by up to 2.35%, but retains 26.2% of its weight in oil; therefore, it is disadvantageous to use a dose higher than 0.75%. The volatile compound contents were increased in trials using lower doses of talc. In contrast, the quantity of the phenolic compounds was increased in trials using higher talc doses. In low doses, talc does not influence the content of antioxidants and volatile compounds.

1. Introduction

Virgin olive oil (VOO) is the most important fat consumed in Mediterranean diet due its high production in this region and high nutritional and health-promoting qualities. Its consumption is very widespread due to its high content of oleic acid, a monounsaturated fatty acid. Furthermore, in addition to its unique characteristic flavor and aroma, VOO has great health benefits due to its great natural antioxidant potential (Altieri, Genovese, Tauriello, & Di Renzo, 2015). The facility at which oil is extracted from the olive is called an "almazara" (oil mill). The extraction of olive oil is a complex multi-stage procedure. All the operations in this process must be physical, rather than chemical or biochemical. Normally, olive oil extraction plants consist of a hummer crusher, a malaxer machine, a decanter (DC), and a vertical centrifuge (Di Giovacchino, Sestili, & Di Vincenzo, 2002).

The inability to extract all the oil content from the fruit is one of the main drawbacks in the extraction of olive oil. Coadjuvants are required to improve the extraction yields of difficult-to-extract pastes, such as those of early olives, olives that have been exposed to frost, or very ripe and wet olives. The influence of technological coadjuvants on the extraction yield and quality of VOO has been studied by several researchers in recent years (Caponio et al., 2016; Espínola, Moya, de Torres, & Castro, 2015; Moya et al., 2010; de Torres, Espínola, Moya, & Castro, 2016). Factors that affect the yield include not only the efficiency of the equipment, but also the maturity the olives and their growing conditions. Most frequently, "difficult" olive pastes are produced by olives at the early ripening stage and with higher moisture content (Majetic Germek et al., 2016).

A high level of moisture, the cellulose wall consistency, and high pectin content can result in emulsified pulps that are difficult to extract (Carrapiso, García, Petrón, & Martín, 2013; Sadkaoui, Jiménez, Pacheco, & Beltrán, 2016). To decompose such emulsions, the physical action of technological coadjuvants can be used (EEC, 2013); however, Spanish legislation only permits the usage of hydrated magnesium silicate (natural talc) and kaolinitic clays.

The technological variables used during the oil milling process can determine the phenolic and volatile compound content and profile of VOO. Additionally, olives contain a complex system of endogenous

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enzymes. The operating conditions in an oil mill affect the activity of these enzymes, in turn modifying the content of phenols and volatiles in the resulting olive oil (Alcalá et al., 2017; Clodoveo, Hbaieb, Kotti, Mugnozza, & Gargouri, 2014). The malaxation conditions can alter the phenol and volatile compound contents in VOO, and consequently its properties (Kalua, Bedgood Jr., Bishop, & Prenzler, 2006; GóMez-Rico, Inarejos-García, Salvador, & Fregapane, 2009; Servili et al., 2004). That is, the malaxation conditions affect not only the oil yield but also the composition and quality of the final VOO.

Phenolic compounds contribute to the higher oxidative stability of VOO compared to other edible vegetable oils. Some researchers have suggested that also contribute to the health benefits of the Mediterranean diet (Franco, Galeano-Díaz, Sánchez, De Miguel, & Martín-Vertedor, 2014; Parkinson & Cicerale, 2016). The sensory attributes of olive oil are also closely related to the volatile compounds present. The lipoxygenase (LOX) pathway is one of the main pathways by which these compounds are derived. These compounds are responsible for pleasant attributes of the oil, such as green and herbaceous or fruity and floral sensations (Kalua, Bedgood Jr., Bishop, & Prenzler, 2006). The main volatile compound is trans-2-hexenal, which gives the oil green and fruity notes such as bitter almond and apple. This compound, together with aldehydes and alcohols, constitutes a significant fraction of the volatile compounds (Sánchez & Salas, 2003).

The influence of talc was evaluated within the malaxation stage of olive paste. Trials in oil mill were carried out to obtain results at industrial level. The extraction efficacy and the changes produced in the composition of olive oils obtained in this stage were assessed.

2. Materials and methods

2.1. Raw materials

Olive fruits (*Olea europaea* L.) cv. Picual, were harvested during the 2016–2017 season in Mancha Real (*Jaén, Spain*). The olives were collected from irrigated land. A homogeneous lot of approximately 60000 kg was used for the experimental trials. The olive fruits were processed within 6 h of harvest at a local olive oil mill. To analyze the operating factors in the mill, three samples of olives, paste, pomace and oil were collected at approximately 20 min intervals, about halfway through each trial. The entire study was conducted during continuous operation of the mill; therefore, the objective of the trial was to analyze olives, pomaces, and oils corresponding to the same initial raw material throughout the continuous process. The results of the characterization of the samples are shown in Table 1. The maturity index (MI), or ripening degree, was determined according to the method described by Espínola, Moya, Fernández, and Castro (2009). The moisture content was determined by the drying the milled paste at 105 °C, and the oil content was determined by the Soxhlet method. The extraction efficacy (EE) is defined as the percentage of the initial oil content that is extracted (Moya et al., 2010).

Table 1
Details of the industrial trials and the characteristics of the milled olives (*Olea europaea*, L. cv. Picual).

Trial	Coadjuvant	Dosage, %	Olive characteristics[a]			
			Maturity Index	Oil, %	Moisture, %	Solids, %
A	None	–	4.41	27.24	45.20	27.56
B	Talc	0.6	4.40	26.85	47.18	25.97
C	None	–	4.41	26.12	46.57	27.31
D	Talc	2.1	4.41	26.33	44.50	29.16
E	None	–	4.40	26.51	48.27	25.21
F	Talc	2.9	4.40	25.65	48.95	25.40
Fisher's LSD			0.06	0.47	0.80	0.82

[a] Means of three replicates.

2.2. Oil mill

The oil mill is located in "Cortijo Virgen de los Milagros", Mancha Real (Spain). It is equipped with a plant for the continuous extraction of olive oil, which was used to carry out all the trials. The model is SPI 77 Pieralisi (Jesi, Italy), and its total working capacity is 4000 kg/h. The plant involves five elements: a hummer crusher that can accommodate different types of sieve; a horizontal malaxer (Pieralisi 1250 2C) with a capacity of 8000 kg, with two bodies of 4000 kg each; a two-phase centrifugal DC operating at 3200 rpm, with a processing capacity of 4000 kg/h; and a vertical centrifuge operating at 6400 rpm. All samples were obtained in the industrial oil mill under normal operating conditions; the only factor that was modified was the usage of the coadjuvant. The predetermined operating conditions were a hole diameter of 6 mm in the crusher, a malaxation temperature of 22 °C (no heating or cooling fluid was used), and a paste addition flow rate of 3250 kg/h in the DC. This flow rate was used to determine all sampling times and delays.

The malaxation time was approximately 150 min based on the 8000 kg of capacity of the malaxer. Therefore, each sample of olives collected from the mill corresponded to the oil and pomace samples collected from the DC at 150 min, assuming that the residence times in these apparatuses were negligible. All the samples at different stages of the process were collected at the halfway point of each trial and with intervals of 20 min between each sample collection.

Based on the capacities of the machines and the flow rate used, each test lasted 225 min. However, during continuous operation the trials overlapped, because the DC was still processing the output from the second malaxer body while the first body was being filled with the olives from the subsequent trial. Therefore, the total operating time was 17.5 h, (1050 min), with a duration of 225 min for the first and last trials and 150 min for all other trials. In total, 56785 kg of ground olives was processed.

To analyze the talc activity, the trials were alternated and compared in pairs, one trial without talc and the other with talc, and also to minimize variations in the raw material. This sequence was repeated, as permitted by the talc addition pump, progressively increasing the talc proportion. The operation sequence is shown in Table 1.

Talc was added using a dosing pump. Talcoliva®, which is micronized talc (2.5 μm average diameter), was used in the oil mill and was purchased from Imerys (Málaga, Spain). The amount of talc was controlled by varying the rotation speed of the pump. At the minimum pump rotation speed, the talc dosage was 0.6%; at intermediate speed, 2.1%; and at maximum speed, it was 2.9%.

2.3. Analysis of olive oil quality parameters

The quality criteria of free acidity, peroxide index, and the extinction coefficients K_{232} and K_{270} were determined for all the oil samples according to EEC (1991).

2.4. Analysis of pigments, chlorophylls, and carotenoids

The pigment composition of the oil samples was measured following the procedure proposed by Minguez-Mosquera, Rejano-Navarro, Gandul-Rojas, SanchezGomez, and Garrido-Fernandez (1991). The absorbance was measured using a Shimadzu UV-1800 spectrophotometer. For determination of pigments, the olive oils were measured using a wavelength of 470 nm for the carotenoid pigments and a wavelength of 670 nm for the chlorophyllic pigments; cyclohexane was used as the solvent. The pigment concentration of the sample is expressed in mg of pigment per kg of oil.