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Analytical Methods

Quality of extra virgin olive oils produced in an emerging olive growing area in north-western Spain

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ABSTRACT

Systematic studies of physico-chemical and stability-related properties, and chemical composition, of extra virgin olive oils (EVOOs) obtained from drupes cropped in specific regions are of special agricultural interest. This is particularly so with new production areas, where careful selection of the most suitable olive varieties for EVOO production is required. This paper reports the first comprehensive chemical characterisation of EVOOs obtained from three different olive varieties (viz., Picual, Morisca and Manzanilla de Sevilla) grown in a new cultivation area in Galicia (NW Spain).

The Morisca variety was that providing the highest industrial oil yield (21%). However, the three types of EVOO exhibited no statistically significant differences in standard quality-related indices other than acidity.

Morisca EVOO was that with the lowest content in oleic acid (mean = 68%) and highest content in linoleic acid (mean = 13%). Also, Morisca EVOO exhibited the highest sterol levels (mean = 1616 mg/kg) and Picual EVOO the lowest (mean = 1160 mg/kg).

Picual EVOO contained greater amounts of the phenolic compounds luteolin and pinoresinol than both Morisca and Manzanilla de Sevilla EVOOs. Finally, Manzanilla de Sevilla EVOO exhibited differential attributes, with banana and olive fruit aromatic series prevailing predominantly over bitter-like, pungent-like and leaf series.

1. Introduction

Spain is the world's top producer and exporter of olive oil and table olives. Also, it has the largest acreage of olive groves and the largest number of olive trees. In fact, olive is the country's second most extensive crop after cereals and can be found in 34 of the 50 Spanish provinces (AICA, 2014).

Apart from its territorial significance, cultivation of olive trees and their produce (olive oil and table olives) constitutes one of the foremost sectors in Spain's agrifood industry in both economic, social, environmental and public health terms (AICA, 2014).

In the Middle Ages, Galicia, a region in NW Spain, was a significant producer of olive oil. Early in the 21st century, the tradition of olive oil production, which had virtually disappeared, started to be recovered in SE Galicia, mostly in Quiroga (Lugo province) and other areas in the adjacent province of Ourense, with the cultivation of new, single-variety orchards. Mountain formations in the north and west protect this large area from the worst of Atlantic storms without suppressing the beneficial influence of the Mediterranean, which imparts the Sil valley a characteristic microclimate among the hottest and driest in Galicia. The area has gradually emerged as a new Spanish olive-growing zone producing virgin olive oils with distinct features due to the particular olive cultivar, environment and processing methods (Espinosa-Sánchez, 2010).

Olive oil consists mainly of triacylglycerols (~99%) and contains a low proportion of free fatty acids, mono- and diacylglycerols, and an array of lipids including hydrocarbons, sterols, aliphatic alcohols, tocopherols, and pigments, in addition to a plethora of phenolic and volatile compounds (Boskou, Blekas, & Tsimidou, 2006).

The most frequently assessed quality-related indices during olive oil production, storage and marketing are free acidity, specific coefficients of extinction (K_{232} and K_{270}), peroxide value and wax content. Free acidity is a measure of appropriate harvesting and handling (Jiménez-Herrera & Carpio-Dueñas, 2008). UV spectrophotometry is especially useful for assessing oxidation during storage (Tsimidou, 2006). The peroxide value measures primary oxidation of lipids and hence rancidity (Jiménez-Herrera & Carpio-Dueñas, 2008), while waxes (viz., esters of fatty alcohols with fatty acid) are useful to distinguish olive oil types (European Union Commission, 1991). Wax content and composition can be

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influenced by cultivar and processing methods (Boskou et al., 2006).

Phytosterols, together with fatty acids and various minor constituents such as phenolic compounds and volatile compounds, contribute to the unique character of olive oil. Sterols are important lipids associated to oil quality and used broadly for authentication purposes. These compounds have attracted attention from researchers because of their effects on plasma cholesterol levels (Piironen, Lindsay, Miettinen, Toivo, & Lampi, 2000). Sterol composition and total sterol content are influenced by cultivar, fruit ripeness and storage time prior to oil extraction, as well as by processing, crop year and geographic factors (Boskou et al., 2006). Erythrodiol and uvaol, which are the main co-eluting triterpene dialcohols identified in olive oil, are located in the olive exocarp (Christopoulou, Lazaraki, Alexiou, Synouri, & Frangiscos, 1996); as a result, their content in olive oil is mainly affected by the particular cultivar (Aparicio & Luna, 2002). The biological and nutritional significance of vegetable oils are linked to the nature of the fatty acids they contain. In fact, the fatty acid composition influences the commercial value of the oil and its stability (shelf-life) by effect of polyunsaturated fatty acids increasing rancidity (León, De La Rosa, Gracia, Barranco, & Rallo, 2008). The fatty acid composition of olive oil can differ between samples depending on fruit location, variety and ripeness (Boskou et al., 2006).

The determination of minor compounds with implied beneficial effects on nutritional value and sensory quality is gradually becoming an alternative method for assessing food quality. In oil, volatile compounds are responsible for aroma, whereas phenolic compounds are associated to taste (bitter and pungent notes), antioxidant properties and healthiness. Consequently, these compounds govern oil flavour (García-González, Tena, & Aparicio, 2010). The amount and composition of both families of compounds depend on various factors including olive cultivar, ripeness, and agronomic and production technology (Angerosa et al., 2004; Ghanbari, Anwar, Alkharfy, Gilani, & Saari, 2012).

The primary aim of this work was to characterise EVOOs from three different varieties (viz., Picual, Morisca and Manzanilla de Sevilla) grown in a new cultivation area in Galicia (NW Spain) in chemical terms by determining regulated physico-chemical and stability-related parameters in addition to fatty acids, sterols, triterpenic dialcohols, phenolics and aroma compounds.

2. Material and methods

2.1. Oil samples

Olives were harvested in the crop year 2011 (specifically, on November 30, 2011) in three olive orchards 10 km apart from one another at 42° 22′ 0.12″ N, 7° 49′ 59.99″ W in the valley of River Miño (Ourense province, NW Spain) and cropped with a different variety each.

The study was conducted on samples from a single crop year (2011) because previous research had shown variability between years to be negligible relative to variability with genotype, which is the main contributor to total variance in EVOO chemical composition (García-González et al., 2010; León et al., 2008; Luna, Morales, & Aparicio, 2006; Tous et al., 2005). Table 1a shows the climatic conditions for the study area over a period of three years including the crop year (i.e., 2010–2012). Because of the climatic similarities, cultivar was the dominant factor leading to differences between oils.

Since the trees in each olive orchard were of the same age, an amount of 400 kg of randomly sampled olives was used to assess quality differences in produce between orchards. An olive batch of approximately 400 kg was used to obtain two 200 kg oil replicates so as not to exceed the processing capacity of the oil mill plant. The three batches were mixtures of two cultivars, with one in a higher proportion than the other. It should be noted there obtaining mono-varietal oils at a semi-industrial scale in this area is virtually impossible. Thus, EVOO1 was obtained from a mixture of Morisca (90%) and Verdial de Badajoz; EVOO2 from Picual (85%) and Arbequina; and EVOO3 from Manzanilla de Sevilla (95%) and additional, "unknown" cultivars.

Olive ripeness index (Table 1b) was determined with the method endorsed by the International Olive Council (IOC, 2011), which assesses olive skin and pulp for colour by using 100 olives randomly drawn from 1 kg of each sample batch. Olives were distributed among 8 groups as follows: group 0 (bright green skin), group 1 (yellowish green skin), group 2 (green skin with reddish spots), group 3 (reddish brown skin), group 4 (black skin and white pulp), group 5 (black skin with <50% violet pulp), group 6 (black skin with ⩾50% violet pulp) and group 7 (black skin with 100% violet pulp). The ripeness index of each group was calculated from

Table 1a
Climatic conditions of the studied area over the period from 2010 to 2012 (*Source*: MeteoGalicia, 2014).

Climatic conditions						
Year	R (L/m^2)	T (°C)	TCT_7 (days)	RH (%)	MDOI (10 kj/m^2 day)	MBP (%)
2010	1005.7	14.7	10	72.3	1329.8	44.5
2011	906.2	14.6	24	72.4	1205.9	43.3
2012	664.7	15.0	15	71.2	1257.8	45.6

R, total rainfall; *T*, mean air temperature; TCT_7, total cold time (T < 7 °C); RH, mean air relative humidity; MDOI, mean daily overall irradiation; MBP, mean barometric pressure.

Table 1b
Fruit characteristics and oil content of the studied olives.

Oil	Ripeness index[a]	Moisture (%)	Industrial oil yield (%) (Abencor system)	Oil content (% f.w.)	Oil content (% d.w.)
EVOO1	3.4	51	21	24	50
EVOO2	2.2	61	10	15	37
EVOO3	2.1	52	18	21	43

EVOO1: Morisca (90%) + Verdial de Badajoz (10%); EVOO2: Picual (85%) + Arbequina (15%); EVOO3: Manzanilla de Sevilla (95%) + Unknown (5%).
[a] Ripeness index: 2 = olive skin yellowish with reddish spots. 3 = olive skin reddish or light violet.