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Characterization of Arbequina virgin olive oils produced in different regions of Brazil and Spain: Physicochemical properties, oxidative stability and fatty acid profile

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ABSTRACT

Production of virgin olive oil is beginning in Brazil. This paper analyzes the characteristics of the EVOO Arbequina from Brazil in comparison with Spanish Arbequina from different regions. Quality parameters, oxidative stability, pigments, colour and fatty acid profile were assessed, and relationships with geographic and climatic conditions were studied. All the samples presented good quality and met EU standards for extra-virgin olive oil, but there were significant differences between regions and countries for many of the parameters evaluated. Major differences between Brazilian and Spanish samples were observed for free acidity and colour of the oils, as well as minor variations in the fatty acid profile. The colour differences were related to rainfall, whereas the fatty acid content was strongly influenced by altitude and temperature. These results highlight the fact that geographic area and environmental factors influence the characteristics of Arbequina oil and play an important role in newly introduced cultivars.

1. Introduction

The olive oil production has extended in recent years beyond the Mediterranean basin to non-traditional regions in the southern hemisphere (Rondanini, Castro, Searles, & Rousseaux, 2014). As an example of this trend, olive cultivation is gradually being introduced into Brazil, where small areas (around 500 ha) are currently being cultivated in the south and southeast of the country, in the regions of Minas Gerais and Rio Grande do Sul, respectively (Ballus et al., 2015). Nowadays, Brazil imports most of its olive oil and the final price is relatively high, making it inaccessible to a large part of the population (Ballus et al., 2014). Furthermore, in Brazil there is a risk of adulteration of olive oil, which further hinders access to a safe, high-quality product with nutritional benefits. Moreover, to date only very limited data have been reported about the quality and the composition of Brazilian olive oils, and from different cultivars (Ballus et al., 2014, 2015).

The expansion of olive production requires the adaptation of cultivars to climate characteristics (rainfall, temperature, humidity) associated with latitudes and altitudes different from those corresponding to the olive autochthonous regions. In consequence, the oil obtained from environments outside the Mediterranean Basin could differ in quality and composition of those arising from traditional Mediterranean regions (García-González & Aparicio, 2010; Rondanini et al., 2014; Romero, Saavedra, Tapia, Sepúlveda, & Aparicio, 2016). In addition to climate conditions and geographic area, many other factors, such as cultivar, fruit ripeness and agricultural practices, may also influence the composition and quality of olive oils (Bakhouche et al., 2013; Dabbou et al., 2009, 2010; Rondanini, Castro, Searles, & Rousseaux, 2011; Torres et al., 2009). Among chemical parameters affecting the quality of olive oils, the fatty acid profile is one of the most significant, and this condition may be greatly affected by environmental factors (Rondanini et al., 2014).

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The Spanish Arbequina olive cultivar is one of the most widely grown and marketed in the world. This popularity arises from its easy adaptation to high density cultivation systems and new environmental conditions, small size, precocity, high oil yield, good oil quality and other agronomic characteristics such as branch flexibility and easy fruit abscission (Rondanini et al., 2011; Torres et al., 2009; Yousfi, Weiland, & García, 2012). Arbequina olive oil is highly appreciated for its soft taste. Due to the combination of these positive factors, Arbequina is acclaimed in the international market (Bakhouche et al., 2013; García-González, Tena, & Aparicio, 2010; Yousfi et al., 2012) and is considered ideal for new and emerging markets, more acceptable than other oils, which can be more bitter and pungent. Thus, there are new producing countries of Arbequina cultivar over the world, such as Tunisia (Dabbou et al., 2010), Chile (García-González, Romero, & Aparicio, 2010), Argentina (Torres et al., 2009) or Australia (Mailer, Ayton, & Graham, 2010). In this line, Arbequina has recently started to be cultivated in Brazil.

As yet, little is known about how geographic and climate conditions may affect the properties of the olive oil that is being to be produced in Brazil. Also, information about the similarities and differences between the newly-introduced and the autochthonous cultivars is lacking. The aims of the present study were (i) to characterise the monovarietal Arbequina olive oil produced in Brazil; (ii) to compare it with the olive oils from the same cultivar produced in different regions of Spain; (iii) to classify the oil samples according to their geographic origin, on the basis of the analysed variables. For these purposes, quality parameters (free acidity, peroxide value, specific extinction coefficients), oxidative stability, pigments (chlorophylls and carotenoids), colour coordinates and the fatty acid profile were assessed.

2. Materials and methods

2.1. Chemicals

All chemicals were analytical reagent grade or higher purity and Milli Q water (Millipore, Bedford, MA) was used throughout the assays. Methanol, cyclohexane and n-heptane were supplied by Sigma (Sigma-Aldrich, St. Louis, MO). Acetic acid, chloroform, diethyl ether, ethanol 95%, phenolphthalein, potassium hydroxide, sodium hydroxide, potassium iodate, starch and sodium thiosulphate were acquired from Panreac (Barcelona, Spain). The fatty acid methyl ester standard mixture (Supelco 37 FAME Mix) was acquired from Supelco (Bellefonte, USA).

2.2. Sampling

Extra virgin olive oil (EVOO) from Arbequina cultivar was analysed. Two regions in Brazil (Minas Gerais and Rio Grande do Sul) and nine representative regions of olive oil production in Spain (Granada, Jaén, Málaga, Cádiz, Sevilla, Albacete, Toledo, Valladolid and Lérida) were selected to obtain the EVOO samples. Locations of the Spanish (samples 1-9) and Brazilian (samples 10 and 11) regions are shown in Fig. 1; geographic and climate characteristics of the production areas are shown in Table 1. Table 1 also classifies the areas according to the Köppen system, which divides the world's climates into major categories based on the global temperature profile and precipitations related to latitude (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). All the oils, kindly provided by the producers, were obtained under a two-phase extraction system and correspond to the same crop harvest (2014/15). After extraction, the samples were sent to CSIC laboratories (Granada, Spain) for performing the analysis. Samples were adequately packaged for preserving for light and high temperatures and promptly sent by courier service. The corresponding customs permission was obtained for Brazilian samples to avoid delay at the frontier. A total of 33 olive oil samples were evaluated (n = 3 from each producing region) and the analyses were carried out in triplicate. All samples were stored in dark glass bottles with nitrogen gas and maintained at 4 °C until analysis.

2.3. Quality parameters

The quality parameters assessed were free acidity (FA, expressed as percentage of oleic acid), peroxide value (PV, expressed as mEq O_2/kg of oil) and specific extinction coefficients at 232 and 270 nm (K_{232}, K_{270} and ΔK). All quality parameters were determined according to EU standard methods (Annexes II and IX of European Community Regulation EEC/2568/91).

2.4. Oxidative stability

The oxidative stability was measured by estimating the oxidation induction time, in a Rancimat 743 apparatus (Metrohm CH, Switzerland). A sample of olive oil (3 g) was heated to 120 ± 1.6 °C and subjected to an inflow of air (filtered, cleaned, and dried) at 20 L/h. The resulting volatile compounds were collected in water, and the increasing water conductivity was continuously measured. The time (in hours) taken to reach conductivity inflection was recorded.

2.5. Pigments (chlorophylls and carotenoids)

The pigments (chlorophylls and carotenoids) were assessed following the method described by Minguez-Mosquera, Rejano, Gandul, Sánchez, and Garrido (1991). The oil samples were dissolved with cyclohexane (1.5:5 w/v) and absorbance was measured using a UV spectrophotometer (Pharmaspec UV 1700, Shimadzu). The chlorophyll fraction was determined at 670 nm and the carotenoid fraction at 470 nm. The results obtained are expressed as mg of pheophytin "a" and lutein per kg of oil, respectively.

2.6. Colour

Instrumental colour (CIE L^*, a^*, b^*) was measured directly in the olive oil samples using a Minolta Colorimeter (CR-400, Konica Minolta Corp., Japan) with illuminant D65. The colorimeter was calibrated before use with a white ceramic tile. L^* is a measure of luminance or the lightness component, which ranges from 0 to 100 (black to white). Parameters a^* and b^* are termed opponent colour axes; a^* represents red (positive) versus green (negative) colours, b^* is positive for yellow and negative for blue. Colour features were obtained as the average of three measurements performed on each oil sample.

2.7. Fatty acid profile

The fatty acid profile was determined according to EU standard methods (Annexes II and IX of European Community Regulation EEC/2568/91). The methyl esters (FAME) were obtained by cold alkaline transesterification with methanolic potassium hydroxide solution and extracted with n-heptane. The fatty acid profile was determined with a Focus GC, Thermo Scientific (Milan, Italy) chromatograph equipped with a split/splitless injector, a FID detector and a SP-2560 fused silica capillary column (100 m × 0.25 cm i. d. × 0. 0.2 μm film thickness, Supelco, USA). Helium was used as carrier gas at an internal pressure of 110 kPa. The temperatures of the detector and injector were 275 °C and 260 °C, respectively. The oven temperature was programmed at 70 °C during the first