Food Chemistry 212 (2016) 162–171

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Characterization of virgin olive oils produced with autochthonous Galician varieties

Patricia Reboredo-Rodríguez [a], Carmen González-Barreiro [a], Beatriz Cancho-Grande [a], Enrico Valli [b], Alessandra Bendini [b,c], Tullia Gallina Toschi [b,c], Jesus Simal-Gandara [a,*]

[a] Analytical and Food Chemistry Department, Nutrition and Bromatology Group, University of Vigo, Ourense, Spain
[b] Department of Agricultural and Food Sciences, Alma Mater Studiorum-University of Bologna, Cesena (FC), Italy
[c] Interdepartmental Centre for Agri-Food Industrial Research, Alma Mater Studiorum-University of Bologna, Cesena (FC), Italy

ARTICLE INFO

Article history:
Received 17 December 2015
Received in revised form 12 May 2016
Accepted 20 May 2016
Available online 20 May 2016

Keywords:
Characterization
Galician virgin olive oils
Phenolic compounds
Volatile compounds
Sensory analysis

ABSTRACT

The interest of Galician oil producers (NW Spain) in recovering the ancient autochthonous olive varieties *Brava* and *Mansa* has increased substantially in recent years. Virgin olive oils produced by co-crushing both varieties in two different proportions, reflecting the usual and most common practice adopted in this region, have gradually emerged for the production of virgin olive oils. Herein, the sensory and chemical characteristics of such oils were characterized by quality and genuineness-related parameters. The results of chemical analysis are discussed in terms of their effective contribution to the sensory profile, which suggests useful recommendations for olive oil producers to improve the quality of oils. Antioxidant compounds, together with aromas and coloured pigments were determined, and their contribution in determining the functional value and the sensory properties of oils was investigated. In general, given the high levels of phenolic compounds (ranging between 254 and 375 mg/kg oil), tocopherols (about 165 mg/kg oil) and carotenoids (10–12 mg/kg oil); these are oils with long stability, especially under dark storage conditions, because stability is reinforced with the contribution of chlorophylls (15–22 mg/kg oil). A major content of phenolic compounds, as well as a predominance of *trans*-2-hexen-1-al within odor-active compounds (from 897 to 1645 μg/kg oil), responsible for bitter sensory notes. This characterization allows to developing new antioxidant-rich and flavour-rich VOOs, when co-crushing with a higher proportion of *Brava* olives, satisfying the consumers' demand in having access to more healthy dishes and peculiar sensory attributes.

1. Introduction

Olive oil is a valuable product that is traditionally produced in Mediterranean countries. Olive groves are present in 34 of the 50 Spanish provinces and occupy an area of 2,584,564 ha (AICA, 2015). Spain is the largest olive oil producer worldwide. In the last few years, half of Spanish olive oil production is consumed domestically and the other half is exported (Morales, Aparicio-Ruíz, & Aparicio, 2013). Within the Spanish territory, Galicia (NW Spain) has gradually emerged as a new olive-growing zone producing virgin olive oils (VOOs) with autochthonous cultivars growing in particular environmental and pedoclimatic conditions that characterize this area. Although traditional Spanish varieties, such as *Arbequina* and *Picual* cv., are predominant in the new Galician plantations, the interest of oil producers in ancient autochthonous varieties (known by producers as *Brava* and *Mansa*) has increased substantially in recent years due to their suitable edafo-climatic adaptation.

Two previous studies have evaluated the potential of these ancient cultivars (Reboredo-Rodríguez et al., 2015a, 2015b). In the first, with the aim of providing extra value to the final VOOs, Galician *Arbequina* or *Picual* fruits, separately, were co-crushed with low proportions of a mixture of *Brava* and *Mansa* varieties (such a mixture is known by producers as *Local*). The experimental results showed that the effect of co-crushing on minor compounds, phenolics, and C_6 volatiles, both responsible for the sensory profile, cannot be easily modulated because of a complex, non-progressive, and non-predictable change in their composition, in contrast to most quality indices (*viz.* free acidity, peroxides, and UV extinction coefficients) and fatty acid composition, which change linearly in strict correlation with the fruit mass ratio. On the other hand, blending *Local* VOOs (also in low percentages) with *Arbequina* or *Picual* monovarietal VOOs might be another strategy to produce

* Corresponding author.
E-mail address: jsimal@uvigo.es (J. Simal-Gandara).

http://dx.doi.org/10.1016/j.foodchem.2016.05.135
0308-8146/

high quality VOOs with pre-established characteristics. In this case, previous knowledge of the quality-related indices and fatty acid composition as well as the concentrations of minor compounds of monovarietal VOOs make it possible to obtain oils "*à la carte*".

Nowadays, the current trend of the VOO market is production of high quality products from traditional minor olive varieties with a specific designation of origin and characteristic, well-defined sensory, nutritional, and health promoting properties (especially with respect to the aromatic and phenolic composition) (Bajoub et al., 2015; Del Monaco et al., 2015). Up to now, no investigations have been carried out on the chemical and sensory characterization of VOOs produced exclusively from *Brava* and *Mansa* autochthonous Galician cultivars. Nevertheless, since the local Galician producers traditionally co-crush different proportions of fruits from *Brava* and *Mansa* cultivars, the aim of this work was to characterize VOOs produced by mixing fruits of these varieties in different proportions, similar to the ones adopted by producers. Towards this aim, chemical parameters and sensory analysis were first investigated to classify olive oils according to EU Regulation 2568/91 and subsequent amendments. Moreover, antioxidant compounds, together with aromas and coloured pigments were determined, and their contribution in determining the functional value and the sensory properties of oils was investigated. This characterization allows to developing new VOOs by mixing these new varieties with other high-yield varieties with two main purposes: the search for new antioxidant-rich and flavour-rich oils for dressings. These are the two major trends driving the market sells today, since the consumers demand more healthy dishes and peculiar sensory attributes. Food chemists have the goal to satisfy consumers' demands and help food companies to increase the level of sales with this kind of innovations regarding olive oil-derived products and dishes.

2. Materials and methods

2.1. Olive oil samples

Olives were harvested in the 2013/2014 crop season (specifically, between November 2013 and January 2014) in a cultivation area under organic agricultural practices located between two municipalities, Ribas do Sil (42° 27′59.8″ N 7° 17′15.8″W) and Quiroga (42° 29′04.8″ N 7° 12′33.4″W) in the Lugo province (NW Spain). Table 1 shows the climatic conditions for the study area over the crop year 2013.

Four VOOs (coded as VOO1, VOO2, VOO3, VOO4) were produced by co-crushing of different proportions of two varieties known by the local producers as *Brava* and *Mansa*. Neither of the autochthonous varieties are included in the database of the World Olive Germplasm Bank of Córdoba, Spain (WOGBC), which is one of the world's largest collections of olive germplasm (Trujillo et al., 2014).

It should be noted that obtaining monovarietal oils of *Brava* and *Mansa* at a semi-industrial scale in this area is economically unprofitable due to the low production. In particular, VOO1 and VOO2, crushed on 27 November and 9 December, respectively, were the result of mixing 70% *Brava* and 30% *Mansa*. On the other hand, VOO3 and VOO4 were both obtained by co-crushing 90–100% *Mansa* and 0–10% *Brava* olives, but on 9 and 17 January, respectively. To summarize data from oils obtained by the same percentages of the two varieties, despite their different maturation indexes, all analyses individually performed on VOO1 and VOO2 were averaged, resulting in VOOa (n = 2). The same was performed with the other oils (VOO3 and VOO4), resulting in VOOb (n = 2). These percentages are among the most common that it is possible to find in the cultivation area under study.

To suppress variability due to the extraction procedure, oils were obtained under identical conditions at a semi-industrial scale in a local two phase mill. Oils were allowed to settle and racked several times for about 4 months before sampling, since this is the procedure typically used by local producers before marketing their oil. Three replicates of each of the four oils were sampled and analyzed. Once in the laboratory, samples were kept at a constant temperature of 10 ± 2 °C in amber bottles without headspace until analysis.

Table 1
Climatic conditions of the growing area in the crop year season 2013.

Climatic conditions					
Year	**R (L/m^2)**	**T (°C)**	**TCT$_7$ (hours)**	**RH (%)**	**MBP (hPa)**
2013	1044.5	13.3	1954.9	76.9	987.9

R, total rainfall; **T**, mean air temperature; **TCT$_7$**, total cold time (T < 7 °C); **RH**, mean air relative humidity; **MBP**, mean barometric pressure.

2.2. Analytical plan

2.2.1. Chemical and sensory parameters for classification of olive oils in different commercial classes

In conjunction with sensory analysis, the following chemical parameters, valid for establishing quality and authenticity criteria of VOOs, were determined by using the analytical methods proposed in the different Annexes of EU Regulation 2568/91 and subsequent amendments. The acceptable values for these parameters in olive oil are regulated by the European Union (EU Regulation 1348/2013).

2.2.1.1. Free acidity (FA). FA, expressed as a percentage of oleic acid, was determined by a simple acid-base titration with 0.1 M KOH of free fatty acids in an oil sample previously dissolved in ethanol/ether 2:1 (v/v) (EU Regulation 702/2007).

2.2.1.2. Peroxide value (PV). PV, expressed as milliequivalents of active oxygen per kg of oil (meq O_2/kg) was determined by titration with 0.01 N $Na_2S_2O_3$ of an oil sample previously dissolved in acetic acid/chloroform 3:2 (v/v) in the presence of KI (EU Regulation 2568/91).

2.2.1.3. Specific UV extinction coefficients (K_{232} and K_{270}). K_{232} and K_{270} extinction coefficients were calculated from absorption values at 232 and 270 nm, respectively, and measured with an UV–Vis 1800 spectrophotometer (Shimadzu Co., Kyoto, Japan), previously calibrated with an optical glass filter containing holmium oxide (Type 666-F1, Hellma GmbH & Co., Müllheim, Germany) by analyzing a 1% solution of the oil in cyclohexane and quartz cuvette with a path length of 1 cm (EU Regulation 299/2013).

2.2.1.4. Sensory analysis. Sensory evaluation of olive oil samples was carried out by nine fully trained judges of the panel of the Department of Food Science (University of Bologna, Italy) recognized in 2006 by the Italian Ministry (MIPAAF, Ministry of Agricultural Policies, Food and Forestry), and in accordance with the official method of International Olive Oil Council (IOC/T.20/Doc.N°15/Rev.7/2015) within the framework of EU Regulations 1348/2013.

The trained tasters evaluated positive gustatory (bitter), olfactory-gustatory (fruity), and tactile/(pungent) attributes, as well as negative attributes, namely fusty/muddy sediment, musty-humid-earthy, winey-vinegary-acid-sour, frostbitten olives, rancid, and others (heated, burnt, hay-wood, rough, greasy, vegetable water, brine, metallic, esparto, grubby, cucumber). In addition, the tasters had the possibility to describe each oil with positive olfactory descriptors (i.e. greenly fruity, ripely fruity, red fruits, exotic fruits, apple, almond, grass, green-leaf, floral, aromatic