Available online at www.sciencedirect.com

SCIENCE DIRECT®

Food Chemistry 100 (2007) 568–578

Food Chemistry

www.elsevier.com/locate/foodchem

Influence of different irrigation strategies in a traditional Cornicabra cv. olive orchard on virgin olive oil composition and quality

Aurora Gómez-Rico [a], M. Desamparados Salvador [b], Alfonso Moriana [c], David Pérez [c], Nicolás Olmedilla [c], Francisco Ribas [c], Giuseppe Fregapane [a,*]

[a] *Departamento de Química Analítica y Tecnología de los Alimentos, Faculdad de Quimicas, Universidad de Castilla-La Mancha, Avda. Camilo Jose Cela 10, 13071 Ciudad Real, Spain*

[b] *Instituto Regional de Investigación Científica Aplicada (IRICA), Universidad de Castilla-La Mancha, Spain*

[c] *C.M.A. El Chaparrillo, Servicio de Investigación y Tecnología Agraria, Delegación Provincial de Agricultura, Ciudad Real, Spain*

Received 1 August 2005; received in revised form 30 September 2005; accepted 30 September 2005

Abstract

The olive tree is generally grown under rain-fed conditions. However, since the yield response to irrigation, even with low amounts of water, is great there is increasing interest in irrigated agriculture. The main goal of this study was therefore to optimize sustainable irrigation conditions in the Cornicabra olive cultivar grown in Castilla-La Mancha, a region where the aquifers are over-exploited, and to study the effect of different irrigation strategies on the composition and quality of Cornicabra virgin olive oil. Different irrigation treatments, based on regulated deficit irrigation (RDI), 100% ET_c, 125% ET_c, and rain-fed as control, were applied to a traditional olive orchard (cv Cornicabra) in a randomized complete-block design with four replications. The average olive production of the trees grown under rain-fed conditions was much lower, about 35%, than that obtained by applying the different irrigation treatments studied, between which practically no difference were observed. The total phenol content, which affected the sensory bitterness in the oils, decreased significantly as the amount of supplied water increased. This is very relevant, as high levels of phenols, typical of Cornicabra virgin olive oils, may decrease consumer preference. Notably, one of the RDI strategies produced olive oil similar in composition and quality to that obtained by 100% ET_c but with reduced water usage.

Keywords: Irrigation; Olive oil; Production; Composition; Quality; Phenols; Sensory

1. Introduction

The olive tree is the most extensive arboreous crop in Spain, the number one olive oil producing country in the world. More than 280,000 ha are grown in the region of Castilla-La Mancha, accounting for 15% of the Spanish olive crop. The most important olive cultivar grown in this region is the Cornicabra, which produces virgin olive oil characterised by high oxidative stability and unique sensory characteristics (intense bitterness), which are both due to high levels of phenolic compounds.

The olive tree is generally grown under rain-fed conditions, especially in Castilla-La Mancha, a region with limited water resources. Nevertheless, since irrigation increases the yield of the olive orchard, even with a low amount of water, there is increasing interest in irrigated agriculture. This has led to a situation in which some of the traditional olive groves, and the majority of the new ones, are being adapted to irrigation techniques. Proper agriculture practices must contribute to healthy olive fruit production, which is the best guarantee of high quality olive oil production. Irrigation, even in areas where water is limited, is therefore an advisable technique from the

* Corresponding author. Tel.: +34 902204100x3439; fax: +34 926 295318.

E-mail address: Giuseppe.fregapane@uclm.es (G. Fregapane).

0308-8146/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2005.09.075

point of view of both the production and quality of olive fruit, since high-quality olive oil cannot be obtained from olive fruit suffering from a high degree of water stress. Nevertheless, a satisfactory compromise between the amount of water applied and the improvement in the production and quality of the olive crop must be fully investigated.

There is scarce information available on the influence of irrigation on olive tree growth and production and on the composition and quality of the virgin olive oil obtained, especially in the case of the Cornicabra variety. Some recent research has shown differences in the chemical makeup and sensory characteristics of virgin olive oil from irrigated and rain-fed olive trees (Aparicio & Luna, 2002). The chemical components most influenced by irrigation are the phenolic compounds, which affect both the oxidative stability and the sensory characteristics, especially the bitterness attribute, showing in both cases an inverse relationship with the amount of water applied to the olive trees (D'Andria, Morelli, Martuccio, Fontanazza, & Patumi, 1996; Motilva, Romero, Alegre, & Girona, 1999; Motilva, Tovar, Romero, Alegre, & Girona, 2000; Tovar, Romero, & Motilva, 2001). This aspect is important in olive cultivars that produce virgin olive oils with high bitterness and pungency, such as, the Cornicabra variety in Castilla-La Mancha, and therefore just the right level of irrigation could enhance its sensory characteristics.

The main goal of this study was therefore to optimize sustainable irrigation conditions in the Cornicabra olive cultivar grown in Castilla-La Mancha, a region where aquifers are over-exploited, and to study the effect of different irrigation strategies on the composition and quality of Cornicabra virgin olive oil. Different irrigation treatments (based on 100% crop evapotranspiration, ET_c, also known as the FAO method, 125% ET_c, two different regulated deficit irrigation strategies and rain-fed) were applied to a traditional olive orchard (cv Cornicabra) planted at 70 trees per hectare in a randomized complete-block design with four replications.

2. Materials and methods

2.1. Experimental olive orchard

The study was carried out during the 2003/2004 and 2004/2005 olive crop seasons in an experimental olive orchard of Cornicabra cv. maintained by Conserjería de Agricultura y Medio Ambiente (Department of Agriculture and the Environment), located in Almodóvar del Campo (Ciudad Real, Spain). About three hundred and twenty 50-year-old trees, spaced $12 \times 12\ m^2$, were used in a randomised complete block design with four different treatments and four replications. Each experimental unit consisted of 4×3 trees, where only the central ones were used for sampling. The experimental olive orchard was enclosed by two outer rows of irrigated olives. All of the agronomical treatments applied to the experimental olive orchard were identical, with the exception of the amount of water applied.

2.2. Irrigation treatments

Four treatments were applied two years before the commencement of this assay: rain-fed (RF), regulated deficit irrigation (RDI), FAO and 125 FAO. Rain-fed treatment was used as the control to compare the results obtained with the three irrigation treatments studied. In the FAO treatment, the water requirements were obtained using methodology proposed by the Food and Agriculture Organization of the United Nations, by subtracting the effective precipitation (41 mm in 2003 and 138 mm in 2004) from the crop evapotranspiration (ET_c), this latter term being calculated using the effective crop coefficient (K_c), the reference crop evapotranspiration (ET_o; 822 mm in 2003 and 801 mm in 2004) obtained from an agronomic weather station and a reductor coefficient (K_r) that depended on the size of the tree ($ET_c = K_c \times ET_o \times K_r$; Doorenbos & Pruitt, 1977). In 125 FAO treatment, an irrigation dosage 25% higher than the FAO treatment was applied. As for the regulated deficit irrigation (RDI), a maximum amount of 75 mm of water was established since, in many Spanish irrigated olive areas, there is a legal limitation of 100 mm, and two different strategies were evaluated. In 2003, water was applied throughout the entire season with different rates of application (10% FAO in May and June, 4% FAO in July and August and 18% FAO in September); however, in 2004, based on the results obtained during the previous crop season, water was applied only from the beginning of August, when the oil formation starts in the fruit, with the purpose of investigating which RDI treatment is more effective in reaching similar olive production and olive oil quality to that obtained by the FAO method but considerably reducing the total amount of water applied. In all irrigation treatments, olive trees were irrigated daily with eight compensating drippers (4 l/h) placed around the trees.

The total water applied in 2003 for the different irrigation treatments was: 56 mm for RDI, 148 mm for FAO and 206 mm for 125 FAO; and in 2004: 60 mm for RDI, 124 mm for FAO and 154 mm for 125 FAO. In order to fully describe the different irrigation strategies used, the water stress integrals (MPa × day; as defined by Myers, 1998), calculated from the midday steam water potential data, and the minimum potential values are reported. These values during 2003 were: 332 MPa d and −4.1 MPa (observed in the middle of September) for RF; 316 MPa d, −4.1 MPa (middle of September) for RDI; 218 MPa d, −2.3 MPa (middle of September) for FAO; 172 MPa d, −1.8 MPa (middle of September) for 125 FAO. The following experimental data were observed in 2004: 269 MPa d and −4.1 MPa (middle of October) for RF; 223 MPa d, −2.9 MPa (beginning of August) for RDI; 176 MPa d, −2.2 MPa (end of September) for FAO; 159 MPa d, −1.7 MPa (middle of October) for 125 FAO.