ARTICLE IN PRESS

JOURNAL OF FUNCTIONAL FOODS XXX (2013) XXX–XXX

Available at www.sciencedirect.com

ScienceDirect

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

Choice of time of harvest influences the polyphenol profile of globe artichoke

*Gaetano Pandino, Sara Lombardo, Antonino Lo Monaco, Giovanni Mauromicale**

Dipartimento di Scienze delle Produzioni Agrarie e Alimentari (DISPA), University of Catania, via Valdisavoia 5, 95123 Catania, Italy

A R T I C L E I N F O

Article history:
Received 29 April 2013
Received in revised form
25 August 2013
Accepted 3 September 2013
Available online xxxx

Keywords:
Globe artichoke
Solar radiation
Temperature
Flavonoids
Caffeoylquinic acids
HPLC

A B S T R A C T

The quantity and composition of polyphenols in plant tissue were determined by a combination of genotype, growing environment and post-harvest processing procedures. To establish the influence of solar radiation and air temperature on the polyphenol content of globe artichoke, field-grown plants of the re-flowering cultivar 'Violetto di Sicilia' were successively harvested once a month over the period November through April. The polyphenol profile of the various parts of the plant was responsive to harvest time, both quantitatively and qualitatively. The combination of low air temperature and solar radiation level experienced during February in particular enhanced the total polyphenol content in the leaves, floral stem and bracts (reaching, respectively, 12.44, 18.10 and 15.38 g kg^{-1} dry matter). However, the polyphenol content of the receptacle was more strongly influenced by the level of solar radiation, and reached 9.46 g kg^{-1} dry matter during April. Qualitative differences were also documented with respect to the identity of the predominant individual polyphenol compounds present. The growing environment represented by the combination of air temperature and solar radiation was a major determinant of the polyphenol content of the globe artichoke plant.

1. Introduction

The herbaceous perennial globe artichoke [*Cynara cardunculus* L. var. *scolymus* (L.) Fiori], cultivated for its immature inflorescences (heads or *capitula*), is native to the Mediterranean Basin. Its annual global production of approximately 1.5 million metric tonnes (MMT) is dominated by Southern Europe, and in particular by Italy where it is grown over some 50 kilohectar (kha) (FAO, 2012). In the other parts of the world, Egypt (9 kha), China (9 kha), Peru (7 kha), Argentina (4 kha) and the USA (3 kha, mainly in California) are main producers (FAO, 2012). Globe artichoke provides a dietary source of vitamin C, several minerals (potassium, sodium, phosphorus and iron), fibre, inulin and polyphenols (Lombardo, Pandino, Ierna, & Mauromicale, 2012; Pandino, Lombardo, & Mauromicale, 2011a, 2011b). Its inclusion in the diet has been shown to be beneficial to human health and well-being, specifically resulting from its contribution to reducing the incidence of cardiovascular disease and certain forms of cancer (Holst & Williamson, 2008). Polyphenols have been implicated in various aspects of plant growth, reproduction and response to both abiotic stress and pathogen challenge (Beckman, 2000). They are represented in the globe artichoke by caffeoylquinic acids and flavones (Lattanzio, Kroon, Linsalata, & Cardinali, 2009; Schütz, Kammerer, Carle, & Schieber, 2004), both of which exhibit antioxidant activity and act as scavengers of reactive oxygen species (ROS) (Fukumoto & Mazza, 2000; Pietta, 2000). The commercial importance of natural antioxidants is based on the potential safety problems associated with the addition of synthetic antioxidants to extend the shelf life of various processed foods, as well as by a growing public interest in the relationship between diet and health

* *Corresponding author.* Tel.: +39 095 234409; fax: +39 095 234449.
E-mail address: g.mauromicale@unict.it (G. Mauromicale).
1756-4646/$ - see front matter
http://dx.doi.org/10.1016/j.jff.2013.09.001

(Shahidi, 1997). Polyphenols are important determinants of food flavour, texture, colour and sensory perception (Shahidi, 1997). Their quantity and spectrum of chemical structures are known to be modulated by both genotype and various aspects of the growing environment, and also by the conditions prevailing during post-harvest storage and the way in which the crop is then processed (Deng et al., 2013; Dewanto, Wu, Adom, & Liu, 2002; Schmidt et al., 2010). Despite the known contribution made by the environment, at least in certain other crops (Connor, Finn, McGhie, & Alspach, 2005; McDougall, Martinussen, Junttila, Verrall, & Stewart, 2011), the focus of research directed at the polyphenol content of globe artichoke has to date stressed the influence of genotype (Fratianni, Tucci, De Palma, Pepe, & Nazzaro, 2007; Lombardo et al., 2012). Specifically, very little attention has been paid to the effect of harvest time (Pandino, Lombardo, Williamson, & Mauromicale, 2012), and no systematic attempt has as yet been made to detail the importance of the weather prevailing during the harvesting season, which for re-flowering cultivars in the Mediterranean environment can extend from November to May. In this study, we document the fluctuation in polyphenol profile as influenced by solar radiation and temperature. The cultivar tested was the leading re-flowering Italian cv. 'Violetto di Sicilia', a plant which is harvested in the Mediterranean environment from November to April.

2. Materials and methods

2.1. *Experimental field and management practices*

The field experiment was conducted during the growing season 2009–2010 on the Cassibile (South Italy), a typical area for globe artichoke cultivation in Italy. The local climate of the area is semiarid-Mediterranean, with mild winters and hot, rainless summers. The mean 30-year maximum monthly temperature ranges between 14.8 (January) and 30.6 °C (July) and minimum temperature between 7.8 (January) and 22.3 °C (August). The trial was carried out on an important re-flowering Italian commercial cultivar, namely 'Violetto di Sicilia', because it constantly produces *capitula* from November to April (Mauromicale & Ierna, 2000). The plant material was arranged in a randomized design with four replicates, consisting of twenty plants per plot. "Ovoli" (semi-dormant offshoots) were planted, on August, 0.8 m apart within a row and 1.2 m apart among close rows, adopting a plant density of 1.0 plant m^{-2}. Crop management (fertilization, irrigation, weed and pest control) were performed according to the standard commercial practice. In particular, a total of 220 kg N, 80 kg P_2O_5 and 150 kg K_2O per ha were applied, and drip irrigation was carried out when the accumulated daily evaporation reached 40 mm. Plant growth regulator used to speed up the ripeness of the heads, was not supplied to the plants during the crop cycle.

2.2. *Field sampling and sample preparation*

Five globe artichoke heads, including floral stem and leaves, per replicate, were monthly collected, during last week, from November 2009 to April 2010, at the marketing stage, when the length of central flowers ranged from 1.0 to 2.0 mm, and washed with tap water. Each head was separated into bracts and receptacle. They were then cut and blended using a domestic food processor (Kenwood multipro, Milan, Italy) at 0 °C. Finally, each sample was freeze-dried using a Christ freeze drier (Osterrade am Harz, Germany), divided into three replicates and stored at −20 °C until HPLC analysis.

2.3. *Meteorological data*

Meteorological data were monitored during the harvest time (from November to April) by a meteorological station (Mod. Multirecorder 2.40; EGT, Florence, Italy) sited within 250 m of the experimental field. Mean air temperature fell from 16.1 in November to 11.1 °C in January, and then rose from 12.8 to 17.8 °C between February and April; at the same time, the quantity of solar radiation rose from 725 to 1,904 J cm^{-2}, and the precipitation totaled 446 mm, of which 38% fell in January and 44% in March (Fig. 1A and B).

2.4. *Reagents and solvents*

Reagents and solvents were purchased from VWR (Leighton Buzzard, UK) and were of analytical or HPLC grade.

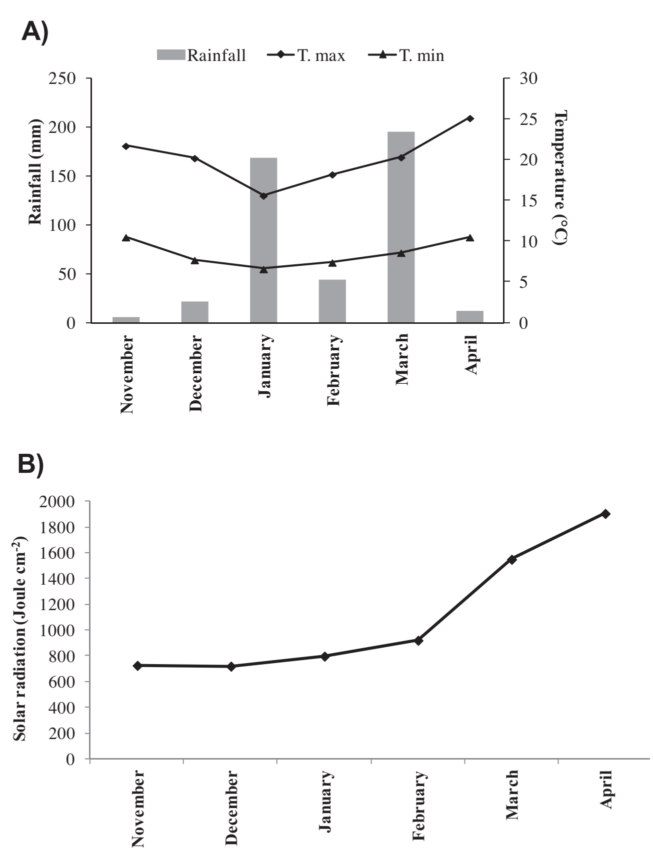

Fig. 1 – (A) Total rainfall and average monthly maximum and minimum temperatures at experimental filed during the globe artichoke harvest period. (B) Solar radiation at experimental filed during the globe artichoke harvest period.