Food Chemistry 139 (2013) 405–413

Contents lists available at SciVerse ScienceDirect

Food Chemistry

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

Comparison of biogenic amine and polyphenol profiles of grape berries and wines obtained following conventional, organic and biodynamic agricultural and oenological practices

Annalisa Tassoni *, Nunzio Tango, Maura Ferri

Department of Biological, Geological and Environmental Sciences, University of Bologna, Via Irnerio 42, 40126 Bologna, Italy

ARTICLE INFO

Article history:
Received 30 July 2012
Received in revised form 22 November 2012
Accepted 15 January 2013
Available online 29 January 2013

Keywords:
Biogenic amines
Antioxidant activity
Polyphenols
Polyamines
Grapevine

ABSTRACT

The bio-active compounds present in food and beverages have a high potential influence on the future health of humans. The levels of biogenic amines, anthocyanins, polyphenols and antioxidant activity were measured in white (Pignoletto) and red (Sangiovese) grape berries and wines from the Emilia-Romagna region (Italy) obtained following conventional, organic and biodynamic agricultural and oenological practices. No significant difference was shown among the samples coming from different agricultural and winemaking practices. Principal Component Analysis was also performed. Biogenic amine amounts were higher in red than in white berries, while in the wines an opposite trend was observed, with histamine, tyramine and putrescine being the most abundant in Pignoletto wines. Red grapes and wines were richer in anthocyanins and showed higher antioxidant activity than white ones. The total level of polyphenols was similar in red and white berries, but with different metabolite profiles depending on the grape variety.

1. Introduction

The bio-active nutraceutical and anti-nutraceutical compounds present in food and beverages have a potential influence on human health (or poor health), however, with very few exceptions, the molecular composition and complexity of foods cannot as yet be fully described.

Among the anti-nutraceutical compounds, amines are basic nitrogenous compounds synthesised by metabolic pathways in plant and mammalian cells that usually involve decarboxylation of precursor amino acids (Beneduce et al., 2010; Kusano, Berberich, Tateda, & Takahashi, 2008). The term "biogenic amines" includes decarboxylation products such as histamine (HIM), serotonine, tyramine (TYM), tryptamine (TRYPT), phenylethylamine but also aliphatic polyamines such as agmatine, putrescine (PUT), cadaverine (CAD), spermidine (SPD) and spermine (SPM).

In food and beverages, biogenic amines are formed by the enzymes from raw material or are generated by microbial decarboxylation of amino acids and in particular they are present in all those foods that are produced by fermentation processes such as cheese, wine, beer, sauerkraut (EFSA Panel on Biological Hazards, 2011). Some types of biogenic amines (such as HIM, TYM, TRYPT, PUT and CAD) are undesirable in food and beverages because, if absorbed at too high concentrations, they may cause headaches, respiratory distress, heart palpitation, hypertension or hypotension, and several allergenic disorders (EFSA Panel on Biological Hazards, 2011). Aliphatic polyamines, such as PUT, SPD and SPM, are essential for normal cell growth but also, at high concentrations, may sustain cancer cell proliferation (EFSA Panel on Biological Hazards, 2011). Therefore assessing the everyday dietary intake of biogenic amines could represent an important way of reducing their level in the body pool.

The identification of different amines in wine samples has been carried out in several investigations. More than twenty amines have been identified in wines and their total concentration has been reported to range from a few to about 50 mg/L, depending on many factors including the wine making conditions, must fermentation and ageing. HIM, TYM and PUT are the most significant biogenic amines encountered in wines (Beneduce et al., 2010; EFSA Panel on Biological Hazards, 2011; Mafra, Herbert, Santos, Barros, & Alves, 1999).

Over the last decade the beneficial influence on health of a moderate wine consumption has been increasingly investigated. The health-protective properties of grapes and wines are attributed to their antioxidant activities, i.e. their capability to eliminate reactive oxygen species (ROS). Consequently, numerous papers have focused on the determination of the antioxidant capacity of grapes and wines, as well as on the content of their polyphenols which are largely responsible for the antioxidant action (Minussi et al., 2003; Urquiaga & Lieghton, 2005).

Grape polyphenols, such as flavonoids (i.e. catechins and anthocyanins) and stilbenes (i.e. resveratrol (RESV)), are one of the most

* Corresponding author. Tel.: +39 051 2091280; fax: +39 051 242576.
E-mail address: annalisa.tassoni2@unibo.it (A. Tassoni).

0308-8146/$ - see front matter
http://dx.doi.org/10.1016/j.foodchem.2013.01.041

widespread groups of plant metabolites synthesised through the very complex phenylpropanoid pathway (Iriti & Faoro, 2004). Flavonoids and stilbenes occur both as glycosides and aglycones (Bavaresco, Fregoni, van Zeller de Macedo Basto Gançalves, & Vezzulli, 2009) and, after ingestion through daily diet, are absorbed by the small intestine mucosa increasing the antioxidant capacity of blood and aiding in the prevention of cancer and cardiovascular diseases (King, Bomser, & Min, 2006; Urquiaga & Lieghton, 2005). Among flavonoids, catechins are antioxidant metabolites particularly abundant in wines (Iriti & Faoro, 2004).

Great attention has been given to the stilbene family and in particular to RESV due to its healthy properties (Delmas, Lancon, Colin, Jannin, & Latruffe, 2006; King et al., 2006). Its mono-glucosylated derivatives piceid (PIC) and resveratroloside (RDE) are present at high levels in grape berries and wines and possess antioxidant activity comparable to free RESV but, due to the presence of the glucose residue, they have a more extended half-life and bioavailability (Regev-Shoshani, Shoseyov, Bilkis, & Kerem, 2003). In addition, piceatannol (PICEAT) is a naturally occurring derivative of RESV (with four –OH groups) synthesised in grape berries only during ripening (Bavaresco et al., 2003) and was shown to inhibit the proliferation of cancer cell lines via apoptosis and cell cycle arrest (King et al., 2006).

Interestingly the interaction between polyphenols and biogenic amines metabolic pathways has been pointed out. Catechins were shown to target some enzymes of biogenic amine biosynthetic pathways (Melgarejo, Urdiales, Sánchez-Jiménez, & Medina, 2010). In particular epigallocatechin gallate (EGCG) specifically reduces HIM and PUT production by inhibiting histidine decarboxylase (HDC) and ornithine decarboxylase activities, while enhancing the activity of SPD/SPM N^1-acetyltransferase (SSAT) enzyme that promotes polyamine catabolism (Kusano et al., 2008; Melgarejo et al., 2010; Nitta, Kikuzaki, & Ueno, 2007). Studies performed with Caco-2 colorectal cancer cells, related the presence of RESV and its natural derivative PICEAT, with the modulation of enzymes involved in the biosynthesis and catabolism of amines, confirming a possible chemopreventive effect of stilbenes (Wolter, Ulrich, & Stein, 2004).

Following previous considerations it should be useful to actively promote the production of functional beverages and foods, having a modified balance between amines and polyphenols, by using different agricultural management practices and processing methods. It is in fact well known that the amount and spectrum of nutrients and metabolites in food and beverages not only depends upon their processing and storage methods but also is largely influenced by the farming system with which the raw materials are produced. Several published papers aimed to compare the metabolite profile of several crops grown under conventional, organic and biodynamic agricultural practices. In general, organic products are perceived by the public as healthier and safer than those produced through conventional agriculture. There are fundamental differences in organic and conventional production practices, but limited information is available on how these influence the nutritional quality of food. Research data showed that some crops grown under organic farming practices contained more bioactive substances such as flavones, vitamin C, carotenoids and total polyphenols. Some studies confirmed better biological activity of organic products versus conventional due to the higher content of bioactive compounds (Asami, Hing, Barret, & Mitchell, 2003; Olsson, Andersson, Oredsson, Berglund, & Gustavsson, 2006). Conversely, other researches demonstrated no significant difference between general the metabolic profile, phenolic levels and nutritional values of buckwheat groats (Kalinova & Vrchotova, 2011), wheat grains (Zörb, Langenkämper, Betsche, Niehaus, & Barsch, 2006) and apples (Valavanidis, Vlachogianni, Psomas, Zovoilli, & Siatis, 2009) grown under conventional and organic farming.

Biodynamic farming is similar in many ways to the better-known organic agriculture. Both use composting and cover cropping instead of mineral fertilising, and ban pesticides, herbicides, hormones and other chemicals. The difference from organic agriculture, apart from philosophical and historical aspects, lies in the use of biodynamic preparations which contain specific herbs or minerals, treated or fermented with animal organs. These preparations are applied in homoeopathic form, generally as field sprays after dynamisation. The different types and aims of biodynamic preparations have been described and are supposed to lie in the improvement of soil and crop quality (Reeve et al., 2005). One study on wine grape quality showed no differences in leaf and grape analysis, and only in one year out of seven of vintage was a higher content of polyphenols and anthocyanins found in biodynamically-cultivated grape with respect to organically-cultivated plants (Reeve et al., 2005).

Up to now, no information is available about the variation of biogenic amine levels in crops, and in particular grape, grown by using different management systems.

The public opinion generally considers organic and biodynamic foods healthier than the conventional ones, however the scientific evidence is still poor and ambiguous. In this view, the present study aims to compare conventional, organic and biodynamic white and red grapes and the related wines, to ascertain whether the different agricultural practices and winemaking procedures, may directly influence the profiles and contents of biogenic amines and polyphenols, and the antioxidant capacity.

2. Materials and methods

2.1. Materials

Grape berries of *Vitis vinifera* var. Pignoletto (white, autochthonous variety) and Sangiovese (red, international variety) and the derived wines were collected in 2009 from producers of the Emilia-Romagna region (Italy). Pignoletto and Sangiovese grapevines were grown by using the following agricultural practices: conventional (Pignoletto from Vigneto San Vito, Monteveglio, Bologna and Sangiovese from Antonio Gallegati, Tebano, Faenza, Ravenna), organic (Pignoletto from Maria Bortolotti, Zola Predosa, Bologna and Sangiovese from Quinzân, Faenza, Ravenna) and biodynamic (Pignoletto from Vigneto San Vito, Monteveglio, Bologna and Sangiovese from Paolo Francesconi, Faenza, Ravenna).

The berries (white or red) were harvested during vintage time on the same day, picking bunches from different plants grown in different vineyard areas, and at different light/shadow exposure. About 10 kg of grape were collected for each vineyard, immediately frozen with liquid nitrogen and stored at −80 °C. The grapes were successively ground in liquid nitrogen and the powders, stored at −80 °C, were used for the following analyses. Wines were produced from grapes on site by the same producers/wineries according to the relative conventional, organic and biodynamic technical regulations (see winemaking parameters in Supplementary Table 1). The wines were collected from wineries at the end of the production process, immediately after bottling, centrifuged at 13,000*g* for 10 min to remove solid residues and immediately stored at −20 °C until analysis.

2.2. Quantification of biogenic amines

Free biogenic amines (tryptamine, histamine, tyramine, diamine-propane, cadaverine, putrescine, spermidine and spermine) analyses were performed (Tassoni, van Buuren, Franceschetti, Fornalè, & Bagni, 2000). The grape samples (about 0.2 gFW of powders) were homogenised in 10 volumes of 4% (v/v) cold