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Assessment of technological maturity parameters and anthocyanins in berries of cv. Sangiovese (*Vitis vinifera* L.) by a portable vis/NIR device

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ABSTRACT

In grape berries the balance between technological parameters such as soluble solids and titratable acidity and phenolic maturity such as anthocyanins concentration, is a key factor for obtaining quality wines. Grapevine berries are commonly harvested on the base of technological maturity parameters determined by traditional analysis methods, often without considering properly phenolic maturity. We investigated the potential use of a portable and non-invasive device based on visible and near infrared (vis/NIR) spectroscopy (Cherry-Meter), which provides an Index of Absorbance Difference (I_{AD}) based on two wavelengths peaks (560 and 640 nm), to measure soluble solids concentration (SSC), titratable acidity (TA), firmness (DI) and anthocyanins (total and monomeric) in cv. Sangiovese grapes. Berries were separated in ten I_{AD} classes according to the Cherry meter data ranging from 0.4 to 1.8, and then analyzed for technological parameters and anthocyanins by using conventional methods. Linear and non-linear regression analysis showed that I_{AD} values were significantly correlated to SSC (R^2 = 0.92), TA (R^2 = 0.87), DI (R^2 = 0.89), and monomeric and total anthocyanin concentration (R^2 ranging from 0.68 to 0.97). A Principal Component Analysis (PCA) was applied to analyze relationship among I_{AD} classes, obtaining four different clusters based on increasing level of maturity defined by means of technological parameters and anthocyanins concentration. This is the first approach demonstrating that the use of I_{AD} values obtained from Cherry-Meter could be useful for monitoring both technological maturity parameters and anthocyanin concentration and composition of grape berries.

1. Introduction

Grapevines clusters are characterized by a high spatial and temporal heterogeneity of berry maturation in the vineyard (Bramley, 2005; Tuccio et al., 2011). The balance between technological maturity parameters and phenolic maturity plays a crucial role in wine quality (Conde et al., 2007; Kontoudakis et al., 2011). Technological maturity of grapevine berries normally precedes phenolic maturity (Ribéreau-Gayon et al., 2000) and this condition can be accentuated as a consequence of climatic conditions (Sadras and Moran, 2012) and agronomic practices such as heavy bunch thinning (Gatti et al., 2012).

Red grapevines (*Vitis vinifera* L.) berries are commonly harvested based on soluble solids concentrations (Brix) and titratable acidity. Nevertheless, these destructive methods can be carried out merely on a restricted amount of fruits, being sometimes poorly representatives of the vineyard and do not consider the grape phenolic maturity (Cozzolino et al., 2006; Kontoudakis et al., 2011; Urraca et al., 2015). Moreover, qualitative and quantitative analysis of anthocyanins, the main molecules providing the red/blue color of mature red grapevine fruits (Boulton, 2001), is frequently

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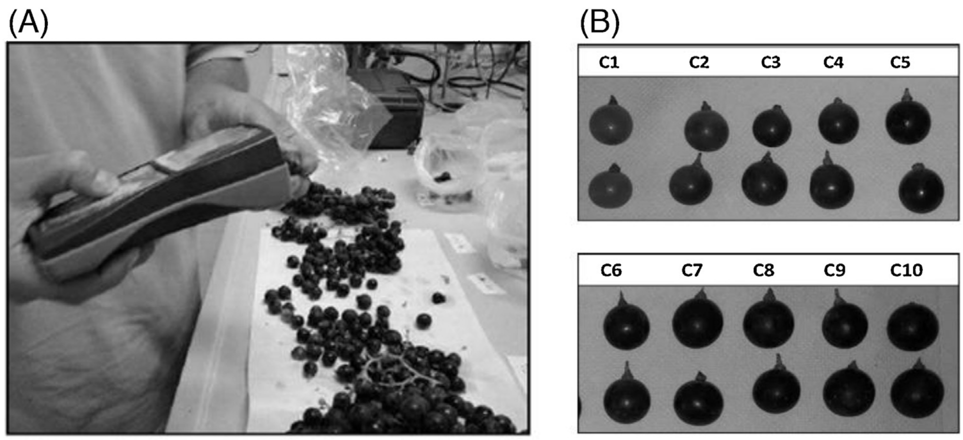

Fig. 1. I_{AD} measurements in grape berries using the Cherry-Meter device (A) and visual aspect of berries from the different I_{AD} classes, where C is the I_{AD} class (B).

performed by using time consuming, invasive and expensive techniques (Costa et al., 2009; Lorrain et al., 2013).

The use of non-destructive technologies to evaluate fruit quality and maturity parameters can represent a rapid and precise tool to estimate the harvest date (Costa et al., 2003, 2009; Tuccio et al., 2011; Urraca et al., 2015; Giovenzana et al., 2014). Hand-led visible/near infrared (vis/NIR) technologies have been assessed for the estimation of ripening level in fresh blueberries (Guidetti et al., 2009), fresh apricot (Camps and Christen, 2009), apple varieties (Beghi et al., 2013), and red grapes (Cerovic et al., 2008; Ben Ghozlen et al., 2010; Guidetti et al., 2010; Tuccio et al., 2011; Giovenzana et al., 2014). One of these technologies are the Cherry-Meter, a portable and friendly-use vis/NIR developed in 2005 at Bologna University (Italy). This device provides an Index of Absorbance Difference (I_{AD}), calculated on the basis of two wavelengths (560 and 640 nm), which correlates with several fruit chemical and biochemical parameters (Nagpala et al., 2013; Ribera et al., 2016). The, I_{AD} values have been used as suitable fruit harvest index in some cultivars of peaches (Ziosi et al., 2008; Bonora et al., 2013; Spadoni et al., 2016), plums (Infante et al., 2011; Infante, 2012), and apples (Nyasordzi et al., 2013). Lately, Cherry-Meter has been also used to estimate cherry maturity through the prediction of fruit skin total anthocyanin of cherry and blueberry fruits with encouraging results (Nagpala et al., 2013; Ribera et al., 2016).

The aim of this work was to perform a preliminary approach about the use of I_{AD} values as potential non-destructive predictor of soluble solids, titratable acidity, firmness and anthocyanins in cv. Sangiovese grapes.

2. Material and methods

2.1. Experimental site

The experiment was performed during 2014 growing season, in a mature vineyard, planted in 2003 with cv. Sangiovese (clone FEDIT 30 ESAVE; *Vitis vinifera* L.) grafted onto Kober 5BB and trained to spur pruned cordon (VSP). The vineyard was located in Tebano (Faenza, Emilia Romagna, Italy, 44°17′7″ N, 11°52′59″ E, 117 m a.s.l.), on a medium slope, with southeast-northwest and downhill-oriented rows. Vines were spaced 2.8 m × 1.0 m (3571 plants ha^{-1}). Starting in 2007, the vineyard is managed (irrigation, fertilizers supply and phytosanitary managements) and certified as organic in accordance with European Commission Regulation No. 834 (EC, 2007).

Table 1
Index of Absorbance Difference (I_{AD}) range of grapevine fruits from the ten different I_{AD} classes.

I_{AD} classes	I_{AD} range
1	0.4–0.5
2	>0.5–0.6
3	>0.6–0.7
4	>0.7–0.8
5	>0.8–0.9
6	>0.9–1.0
7	>1.0–1.2
8	>1.2–1.4
9	>1.4–1.6
10	>1.6–1.8

2.2. Berry sampling

At August 28th (beginning of blooming period started on May 22th), about 1.5 kg berry sample was collected from ten randomly selected mature (full-production) plants. Due to berries from clusters normally ripen in a heterogeneous form, it was possible obtain fruits with different coverage level of skin red-blue color at date in which fruit was collected. It is important to stress that; overall, the 2014 vegetative season was marked by average temperatures well below seasonal normal and high rainfall during summer. Such climatic conditions hampered fully ripening of berries, consequently the monitored vines displayed high heterogeneity in cluster composition, which enabled sampling of different berry ripening levels from one cluster on one sample date. Thus, grapes from fully-green to fully-blue were harvested. Berries were stored at 4 °C for I_{AD} data acquisition and technological maturity parameters determination, or at −80 °C for quali-quantitative anthocyanins analyses.

2.3. Cherry-Meter analysis

The Index of Absorbance Difference (I_{AD}) of all fruits (fresh whole berries) was measured by using the Cherry-Meter (T.R. Turoni S.r.l., Forlí, Italy; Fig. 1). Based on the Lambert-Beer's law, the I_{AD} is calculated through differences between two wavelengths peaks (560 and 640 nm) and the reference value at 750 nm (Noferini et al., 2009). The instrument consists of a light source of six LEDs located around a photodiode. For the I_{AD} calculation, the light remitted from the fruits is measured by the central photodiode, then converted by an "Adc converter" ("analog to digital converter") and elaborated by a micro-controller (Costa et al., 2010). Because the I_{AD} obtained with Cherry-Meter has been correlated significantly to ripening stages and levels of anthocyanins (Nagpala et al., 2013), this devise was selected.