

# Varietal differences in the sugar content of red grapes at the onset of anthocyanin synthesis

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## Summary

**The aim of this work was to study the sugar content of grapes at the onset of anthocyanin synthesis, in eighteen red grape varieties for three years. Sugar content at start of anthocyanin synthesis was measured during three years in eighteen red grape varieties under the same climatic conditions within DOCa Rioja. There were significant differences between varieties with respect to sugar content of grapes at the onset of anthocyanin synthesis. Varieties with the lowest sugar content at the beginning of anthocyanin synthesis, every year, were 'Alicante Bouschet', 'Moristel' and 'Trepát' (between 7 and 9 °Brix) and varieties with the highest sugar content were 'Trousseau' and 'Grenache' (between 10 and 14 °Brix). The rest of varieties showed, every year, a sugar content ranging between 9 and 10 °Brix. The difference between the variety with higher sugar content at the start of anthocyanin synthesis ('Trousseau') and the variety with lower sugar content ('Alicante Bouschet') was about 6 °Brix for the three years. On the other hand, there was no relationship between the sugar content at the onset of anthocyanin synthesis and the date on which this anthocyanin synthesis occurred. The sugar content at the start of anthocyanin synthesis for each variety in different years is much more stable than the dates that this synthesis occurs. Therefore, in the study of varieties regarding their cycle, it would be very interesting to take into account not only the phenology or the date on which the veraison occurs but also the berry sugar content at the onset of anthocyanins synthesis.**

**Key words:** grape varieties; DOCa Rioja; sugar content; anthocyanins synthesis.

## Introduction

In warm climatic conditions, the sugar content of red varieties could easily reach more than sufficient levels for obtaining high quality wines but, however, not the case with colour. This decoupled sugar:anthocyanin accumulation is mainly attributed to the different temperature ranges for optimal activity of the enzymes that produce sugars (18 to 33 °C) and that produce pigments (17 to 26 °C) (ILAND and GAGO 2002, SADRAS *et al.* 2007). Temperatures above 30 °C

can inhibit the synthesis of anthocyanins (MORI *et al.* 2007). Some previous work demonstrated that elevated temperature could reduce anthocyanin:sugar ratio in berries leading to unbalanced wines (SADRAS and MORAN 2012). Several studies showed an earlier stage of development in vine phenology during the last years in many wine growing regions (JONES *et al.* 2005, DUCHENE and SCHNEIDER 2005). Consequently, berry ripening is taking place during a warmer period (WEBB *et al.* 2007, 2008). Many studies proposed temperature indices aimed at determining the main changes in variety profile in different viticultural zones (KENNY and HARRISON 1992, SCHULTZ 2000, STOCK *et al.* 2005).

Several viticultural strategies can be used to mitigate this negative effect of climate warming. The ultimate goal is to obtain more balanced grapes of good quality but with lower SC. Some potential viticultural strategies or techniques are: reducing leaf area (STOLL *et al.* 2009, INTRIERI and FILIPPETTI 2009, MARTÍNEZ DE TODA and BALDA 2013), increasing yield (KLIEWER and DOKOOZLIAN 2005), irrigation at ripening period (COOLEY *et al.* 2005), double harvest (BALDA and MARTÍNEZ DE TODA 2013) and minimal pruning (MARTÍNEZ DE TODA *et al.* 2015).

The search of new grape varieties characterized by low berry sugar content and, at the same time, by optimal grape flavor and color requires long-term and well elaborated studies (CLINGELEFFER 2007). On the other side, the selection among existing genotypes to produce low-alcohol wines has also been considered. SADRAS and MORAN (2012) demonstrated that the decoupling between anthocyanins and sugars was more likely to be caused by a delayed onset in the accumulation of anthocyanins, rather than relative changes in rates. In connection with this information it will be very interesting to study the possible varietal differences in sugar content at the time that the synthesis of anthocyanin begins. Namely, if or not there are differences among varieties in the sugar content at the start of anthocyanins synthesis.

The aim of this work was therefore to determine the sugar content of grapes at the onset of anthocyanin synthesis, in eighteen red grape varieties for three years.

## Material and Methods

**Plant material:** The study was conducted during the years 2013-2015, in the Germplasm Bank of Minority Varieties of La Rioja, located in the institutional property

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of the Government of La Rioja "The Grajera" in Logroño (42° 26'50.81" N, 2° 30'05.79" O and 450 meters above sea level), inside Rioja appellation, North of Spain.

This germplasm bank is composed of sixty-eight accessions of minority varieties that have been recovered in different areas of La Rioja (MARTÍNEZ DE TODA *et al.* 2004). For this study eighteen red varieties were selected (in 2013, data from the variety 'Morrastell Bouschet' were not shown because they were lost; the varieties "Unknown 1" and "Unknown 2" were named in this way because they have not been identified yet).

The vineyard was planted in 2004, with 25 copies per accession and was grafted on 110-R rootstock. The rows were East-West oriented along a 3 % sloping terrain. Plantation distance was 1.20 m between vines and 2.90 m between rows. The vines were trellised to a double horizontal cordon and pruned to twelve buds per vine on spurs of two buds each and the vineyard was subjected to the common viticultural practices of the region.

**Grape analysis:** Regular visits were conducted during the months of August and September to determine the phenological stage of 50 % of the berries showing synthesis of anthocyanins in each of the studied varieties. This determination was made visually over ten randomly selected clusters of ten different vines (choosing one cluster on each vine).

Once the stage of 50 % of the berries showing synthesis of anthocyanins was determined, we proceeded to the selection of berries. Each berry was collected at the slightest sign of color. Twenty berries per variety were selected on ten randomly selected clusters (two berries per cluster) and on ten different vines (one cluster per vine). In each of the twenty berries sugar concentration was determined (°Brix) with a digital refractometer.

**Statistical analysis:** Since there was interaction between variety and year on the analysis of variance of two factors, the final statistical analysis consisted, for each year, of the analysis of variance and mean separation by Student-Newman-Keuls test, using the statistical package SPSS 20.0 for Windows. Regarding the relationship between

sugar content at the onset of anthocyanins synthesis and date of this onset of synthesis a correlation analysis was made.

## Results and Discussion

Figs 1, 2 and 3 show the sugar content at the start of anthocyanin synthesis for the eighteen studied varieties and the date on which this onset of synthesis occurred, for 2013, 2014 and 2015, respectively.

In each of the years there were significant differences among varieties in sugar content of grapes at the onset of anthocyanin synthesis. Although there were some differences in different years, due to the different climatic and production conditions, a general tendency was observed in the behavior of varieties in this regard. Varieties with the lowest sugar content at the beginning of anthocyanin synthesis, every year, were 'Alicante Bouschet', 'Moristel' and 'Trepát' (between 7 and 9 °Brix) while the varieties with the highest sugar content were 'Trousseau' and 'Grenache' (between 10 and 14 °Brix). The rest of varieties showed, every year, a sugar content ranging between 9 and 10 °Brix. The difference between the variety with the highest sugar content ('Trousseau') and the variety with the lowest sugar content ('Alicante Bouschet') was about 6 °Brix for the three years.

SADRAS and MORAN (2012) demonstrated that the decoupling between anthocyanins and sugars was more likely to be caused by a delayed onset in the accumulation of anthocyanins, rather than relative changes in rates. In connection with this information, we can say that varieties with lower sugar content at the beginning of anthocyanin synthesis would be better adapted to climate warming because they are able to synthesize anthocyanins with lower sugar content and, as a result, its decoupling will be less.

With regard to the dates of the onset of anthocyanin synthesis, in 2013, most varieties reached this onset on similar dates except 'Moristel', 'Morate' and 'Vidadillo', which reached this onset later. In 2014, most varieties reached the onset of anthocyanin synthesis on similar dates except 'Tempranillo' and 'Portugieser Blau', which reached it earlier and

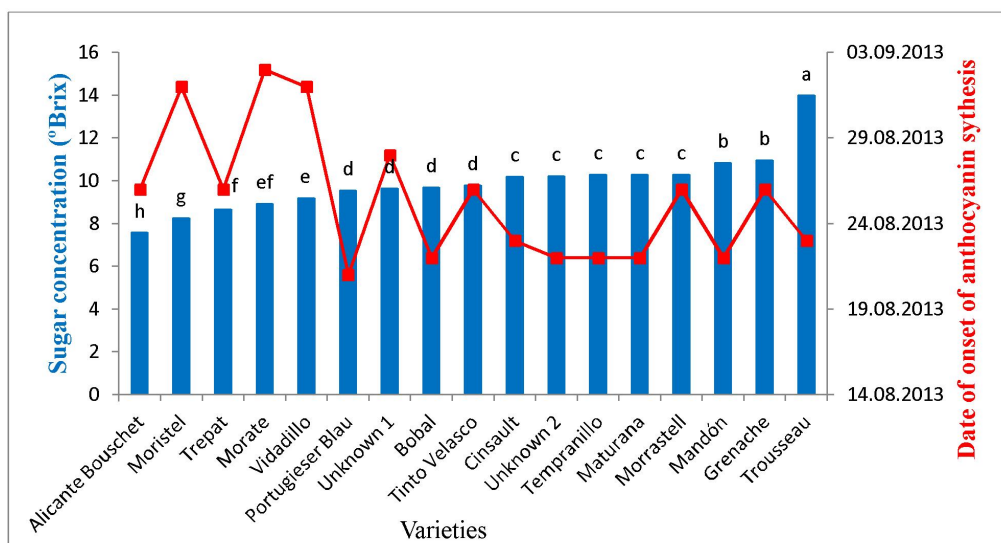


Fig. 1: Sugar concentration at the onset of anthocyanin synthesis and date of this onset of synthesis for different red varieties in 2013. Different letters represent significant differences according to the SNK test ( $P = 0.05$ ).

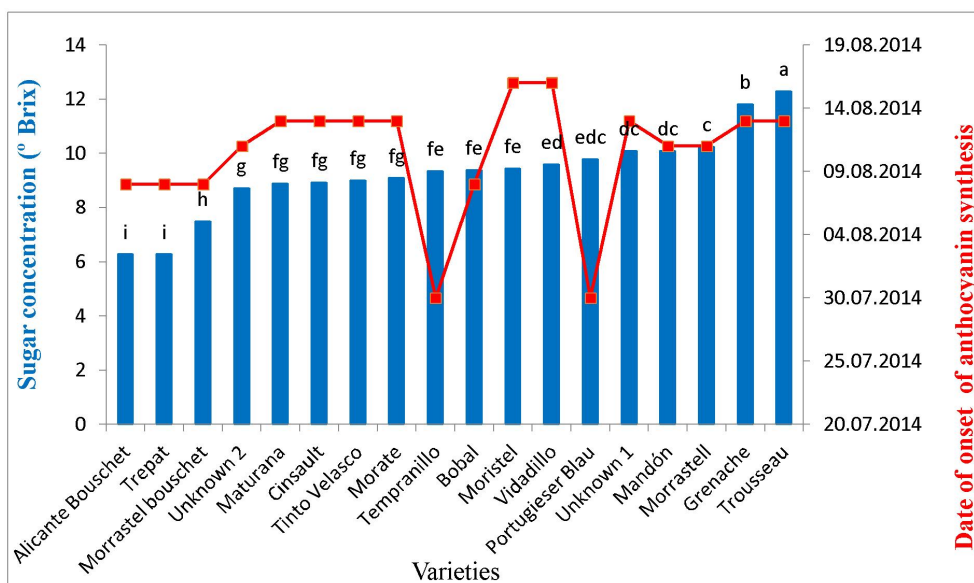


Fig. 2: Sugar concentration at the onset of anthocyanin synthesis and date of this onset of synthesis for different red varieties in 2014. Different letters represent significant differences according to the SNK test ( $P = 0.05$ ).

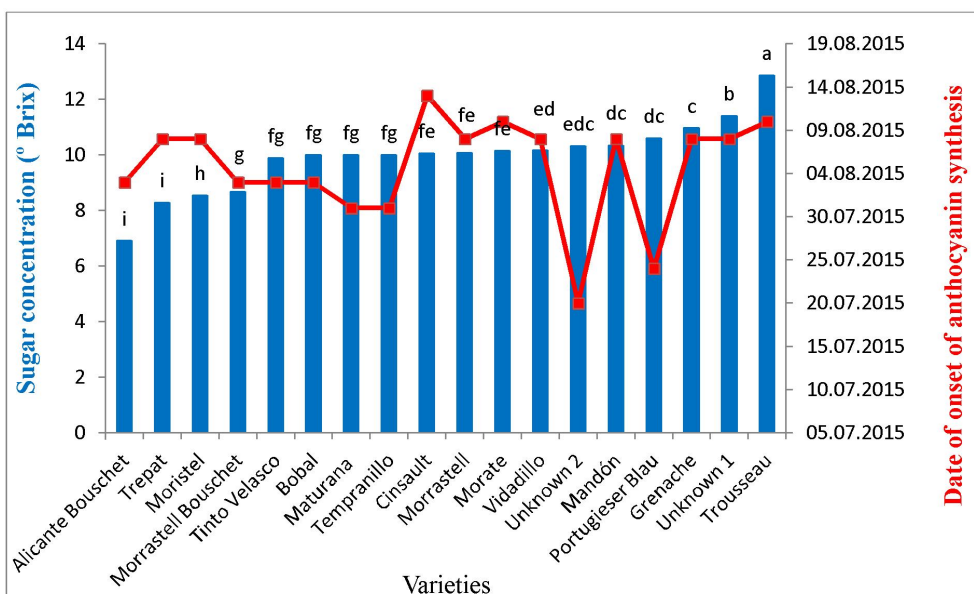


Fig. 3: Sugar concentration at the onset of anthocyanin synthesis and date of this onset of synthesis for different red varieties in 2015. Different letters represent significant differences according to the SNK test ( $P = 0.05$ ).

'Moristel' and 'Vidadillo', which reached it later. In 2015, in most varieties the onset of anthocyanin synthesis occurred on similar dates, except 'Portugieser Blau' and 'Unknown 2', in which it occurred before and 'Tempranillo', in which it occurred later.

Linear correlations between sugar content at the onset of anthocyanin synthesis and date of the onset of anthocyanin synthesis were weak and not statistically significant (data not shown), that is to say, there was no relationship between sugar content at the onset of anthocyanin synthesis and the date on which this onset of synthesis occurred. It should be remembered in this regard that, when studying or describing a variety, it is usually indicated the date of veraison but never the sugar content at the onset of anthocyanin synthesis is provided. Thus, to understand the behavior of a variety in a given environment and whether a variety is early or late it seems as interesting and crucial to know the

sugar content at the onset of anthocyanin synthesis as the date of veraison itself. Therefore, in the study of varieties regarding their cycle, it would be very interesting to take into account not only the phenology or the date on which the veraison occurs but also the berry sugar content at the onset of anthocyanin synthesis.

Comparison of results between different years show that the sugar content at the start of the synthesis of anthocyanins for each variety is much more stable than the dates on which this synthesis occurs. That is, the dates on which the onset of anthocyanin synthesis occurs for a given variety vary greatly from year to year, depending on environmental conditions, but the sugar content at the onset of anthocyanin synthesis of each variety remains practically constant each year.

Knowing the sugar content in the beginning of anthocyanin synthesis is particularly important because, although we have not shown the data, there is a trend in which varieties

with lower sugar content at this time also have a lower sugar content in the end of the ripening; in this sense, 'Grenache' and 'Trousseau' can easily reach 24 °Brix at the end of ripening, while 'Alicante Bouschet' and 'Trepát' can hardly reach 18 °Brix (MARTÍNEZ DE TODA *et al.* 2004).

### Conclusions

There were significant differences among varieties in the sugar content of grapes at the onset of anthocyanin synthesis. Varieties with the lowest sugar content at the beginning of anthocyanin synthesis, every year, were 'Alicante Bouschet', 'Moristel' and 'Trepát' (between 7 and 9 °Brix) while the varieties with the highest sugar content were 'Trousseau' and 'Grenache' (between 10 and 14 °Brix). The rest of varieties showed, every year, a sugar content ranging between 9 and 10 °Brix. The difference between the variety with highest sugar content ('Trousseau') and the variety with lowest sugar content ('Alicante Bouschet') was about 6 °Brix for the three years.

In relation to climate decoupling between anthocyanins and sugars, varieties with lower sugar content at the beginning of anthocyanin synthesis would be better adapted to climate warming and its decoupling will be less.

There was no relationship between sugar content at the onset of anthocyanin synthesis and date on which this synthesis occurred. Thus, to understand the behavior of a variety in a given environment and whether a variety is early or late it seems as interesting and crucial to know the sugar content at the onset of anthocyanin synthesis as the date of veraison itself. Therefore, in the study of varieties regarding their cycle, it would be very interesting to take into account not only the phenology or the date on which the veraison occurs but also the berry sugar content at the onset of anthocyanin synthesis.

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