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DATA NOTE

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The *LowSugarBerry* trait phenotyped at single fruit and population levels

Antoine Bigard^{1,2}, Luciana Wilhelm de Almeida^{3,4}, Dargie T. Berhe², Die Wu³, Hernán Ojeda², Anne Pellegrino³, Charles Romieu¹ and Laurent Torregrosa^{2,3*}

Abstract

Objective The grapevine is one of the most widely grown perennial crops worldwide. As for other species displaying clusters of small fruits, the development of single berries within a bunch is asynchronous and heterogeneous. Because of this, the study of water and solute accumulation kinetics and balance at the organ level cannot be directly extrapolated from populations of fruits. In order to have an original and reliable data sets on the accumulation of the main solutes and water in the grapevine fruits, from the onset of sugar importation to the end of phloem unloading, we analyzed the composition of populations of berries sorted according to their density and also single berry samples.

Data description Contents in primary and secondary metabolites and cations and water during fruit ripening in a panel of varieties displaying a range of metabolic features, including genotypes able to import water at low fruit osmotic potential. These original data sets are suitable to revisit some aspects of the accumulation of main solutes and water in the grapevine fruit and/or to perform comparative studies with other fleshy fruits.

Keywords Fleshy fruits, Growth, Water import, Metabolites, Soluble solids

Objective

Despite a diversity in the ontogenesis of the pericarp [1], fleshy fruits share mechanisms of growth based on osmotic gradient-mediated water imports. Grapevine fruit displays a consistent varietal diversity of solute concentration at the physiological ripe stage [2, 3], i.e., when phloem unloading in fruit stops [4, 5]. The balance between water imported into the fruit (i.e., the volume), which is driven by the osmotic force (i.e., the concentration in solutes) and tissue turgidity regulation

(i.e. cell skin and flesh plasticity) are crucial in determining the fruit final soluble solids' concentration. With rising air temperatures and increased climatic demand leading to higher grape sugar concentrations and therefore excessive alcoholic wines, identifying a target for genetic improvement is vital. One promising direction is the selection of varieties capable of producing berries at lower osmotic potential [2]. Given that grapevine is a perennial fruit crop, this trait stability across seasons and environmental constraints is essential.

However, as for other small fleshy fruits, the quantification of grape water and solute imports is challenging due to: (i) the asynchrony and heterogeneity of single berry development, which prevent the data extrapolation from the grape clusters to single fruits [6], (ii) the interplay of water budget and solute net accumulation mechanisms

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to determine the final metabolite concentrations and (iii) the difficulty of pointing final ripening stage.

The data sets detailed here was obtained from experiments designed at improving the quantification of solute and water accumulation during ripening, including the last green fruit stage and full physiological maturity [4, 6]. In the first set of experiments (2014 to 2018), an originality was the panel of varieties adopted, including 3 phenotypically-contrasted *Vitis vinifera* varieties (Grenache, Merlot and Morrastel) and 3 new *Muscadinia rotundifolia* x *V. vinifera* fungus-tolerant genotypes (G5, G7 and G14) displaying low sugar fruit concentrations. This phenotype, known as Sugarless or LowSugarBerry [5] is a promising option to mitigate excessive sugar concentration in juice or wine grapes under warming [7, 8]. The second experiment set (2019 to 2021), provides complementary observations for G5 and G14, and report original data sets on 4 new *Muscadinia rotundifolia* x *V. vinifera* deriving hybrids (Artaban, Floreal, 3176 N and 3159B) [7, 8], including a fine phenotyping of the plant water status during fruit development. This allows to elucidate the impacts of water availability on final fruit metabolites balance and LowSugarBerry trait stability under water deficit [9].

Data description

Plant material and sampling strategy

Fruit samples were collected throughout the ripening period. This period started with the onset of ripening when the berries are green and hard, at their maximum content and concentration in organic acids, and lasted until the phloem discharge stops, when water and solute quantities reach their maximum, just before shriveling. Experiments were conducted at the INRAE experimental center of Pech-Rouge (France) in plot 1 (43°8'32"N, 3°7'58"E), plot 2 (43°8'40"N, 3°8'07"E) and plot 3 (43°09'16"N, 3°6'44"E).

The [dataset1](#) [10] collected in 2014, corresponds to analyses of batches of 600 berries sorted by firmness and apparent density of G7, G14 and Merlot genotypes from 2 plots as partially reported [4]. The [dataset2](#) and [dataset3](#) was obtained in 2015, with the same protocol but with additional genotypes, Grenache and Morrastel. Sampling was divided into triplicates of 200 berries for some analyses [10]. Then, berries from each replicate were screened for apparent density and the osmotica analysis was performed on the major density groups of berries pooled to represent at least 80 out of the 200 berries and on the remaining pooled samples, which is displayed in [dataset4](#) [10]. The [dataset5](#) [10] was obtained with the six genotypes through single berry analyses in 2016 and 2017, as described in [5]. The [dataset6](#) and [7](#) (2019–2021) was obtained from plot 3, with 3159B, 3176 N, Artaban, Floreal, G14, and Syrah plants [10] under contrasting

Table 1 Overview of data files

DataSet ^o	File types (file extension)	Data repository and identifier (DOI or accession number)
DataSet1	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet2	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet3	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet4	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet5	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet6	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]
DataSet7	.csv	https://doi.org/10.6084/m9.figshare.28308986 [10]

irrigation treatments. In this set, plants were phenotyped individually for their water status and fruit metabolites content as described in [9, 11, 12].

Variables

All variables are displayed in seven datasets that are listed in [Table 1](#).

Weight and volume

For each experiment, berries were weighed ([datasets1](#), [2](#), [5](#) and [6](#) [10]), and their volume measured using Dyostem^o or the Archimedes method [13].

Firmness monitoring

The firmness assessment was done by hand in [datasets1](#), [2](#) and [5](#) [10] as described in [2] and with a digital penetrometer in [dataset4](#) [10] as described in [5].

Osmolality assessment and dry matter content (DMC)

Osmolality was assessed using a Gonotec[™] Osmomat 3000 (osmometers.com) giving a value in milliosmol to represent a solute concentration in osmotic potential for [dataset1](#) [10]. DMC was performed on fresh juice and obtained as the sample weight after desiccation divided by the sample weight before desiccation times 100.

Total acidity, pH, Brix, primary metabolites, cation and yeast assimilable nitrogen (YAN) analysis

Total acidity converted in meq L⁻¹ [14] and pH were obtained using a TitroMatic KF 2 S 2B (crisoninstruments.com) by directly injecting berry juice for [dataset1](#) (2014), [2](#) (2015) and [6](#) (2019 to 2021) [10]. Brix and stored Brix (each sample was frozen, then a few days later defrosted, heated, vortexed and reanalyzed) were measured using a refractometer ([dataset1](#) and [2](#) [10]). Sugars (glucose and fructose), organic acids (malic and tartaric) and major cations (potassium, calcium, magnesium,

sodium and ammonium) were measured using HPLC as described in [4] for [dataset1](#) [10] and as described in [5] for [dataset5](#) and [6](#) [10]. YAN was measured in fruits from 2019 to 2021 experiments ([dataset6](#)) as described in [12].

Anthocyanins and total polyphenol index (TPI)

To obtain anthocyanin content ([dataset 1, 2](#) and [6](#) [10]), the same protocol as in [4, 9] was performed for all genotypes. For TPI ([dataset1, 2](#) and [6](#) [10]), the value of optical density (DO) at 280 nm obtained by the spectrometer was used as $TPI = \text{dilution} \times OD\ 280\ \text{nm}$.

Plant water status and phenology

In [dataset6](#) [10], plant water status was assessed as the accumulated predawn water potential from flowering to harvest as described in [11, 12]. Budburst, flowering, véraison and harvest (fruit physiological maturity at cluster level) were recorded in a subset of plants from 2019 to 2021 experiments ([dataset7](#) [10]).

Limitations

It should be pointed out that the genotype panel contains varieties that are in the process of being deployed and on which very little data exists. The data produced here, corresponding to seven years of experiments, enable assessing the actual contribution of genotype to the berry phenotypic variations including some environmental effects such as water deficit. Another potential limitation of the data concerns the first data set, plot 2, which was obtained from an experimental plot contaminated by the Grapevine Leafroll Virus (GLrV), known to limit sugar accumulation in grapes. In spite of this, the data are potentially valuable to study the effect of this virus on the composition of grapes, not only in terms of sugars but also of other major osmotica, organic acids, cations and secondary metabolites. A methodological limitation may also exist when comparing 2014–2015 (preparation from the whole berry) and 2016–2017 (seedless samples). Eventhough these differences did not affect the accuracy of the analyses carried out on primary and secondary metabolites, it may have led to some differences in the quantification of cations. Furthermore, in the second set of experiments conducted from 2019 to 2021 (plot 3), is important to point out source of variations that can apport limitations in the data: (i) age differences among the plants, as Syrah, 3176 N, and 3159B plants were three years older than G14, G5, Artaban and Floreal plants, which could influence vine development, fruit production, and overall physiological responses; (ii) differences in rootstock, as not all genotypes were grafted onto the same rootstock, potentially introducing variability due to different root system vigor, nutrient uptake, and environmental interactions; and (iii) the estimation of fruit physiological maturity was performed at the population level

by monitoring the growth of one cluster per plant. However, this stage is inherently a precise physiological point that occurs at the single berry level. As a result, when clusters reached their maximum volume and were harvested, the berries within each cluster were at different developmental stages: some were still actively accumulating sugars and water, others had reached physiological maturity, and others had already begun the shriveling process.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13104-025-07289-x>.

Supplementary Material 1
Supplementary Material 2
Supplementary Material 3
Supplementary Material 4
Supplementary Material 5
Supplementary Material 6
Supplementary Material 7

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Author contributions

L.T., H.O., A.B., A.P., L.W. and C.R. designed and supervised sampling collection and analysis. A.B., D.T. and L.W. collected and prepared the samples for HPLC analyses. A.B. managed the assessments of berry firmness. LT and AB conceived and drafted the manuscript. All authors reviewed the manuscript and attached data sets.

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Data availability

All tables have been deposited on the FigShare site and made available to the public using the doi references provided in the table.

Declarations

Ethics approval and consent to participate

N/A.

Consent for publication

N/A.

Competing interests

The authors declare no competing interests.

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