Influence of grapevine age on general physicochemical and phenolic parameters of Rabigato (*Vitis vinifera* L.) white variety: Results from three vintages

António M. Jordão[1, 2,*], Hugo Lourenço[3], Riccardo Brancaleone[4, 5], Ana C. Correia[1], Daniela Fracassetti[4], and Jorge M. Ricardo-da-Silva[5]

[1]Instituto Politécnico de Viseu, Escola Superior Agrária, Viseu, Portugal
[2]Centro de Química de Vila Real (CQ-VR), Laboratório de Química Alimentar e do Vinho, Vila Real, Portugal
[3]Adega Cooperativa de Freixo de Numão, Portugal
[4]Università degli Studi di Milano, Department of Food, Environmental and Nutritional Sciences, Milan, Italy
[5]LEAF - Instituto Superior de Agronomia, Universidade de Lisboa, Portugal

Abstract. The preservation of the old vine heritage, combined with the fact that old vines could present greater resistance to biotic and abiotic factors, has led to an increase in research studies about the contribution of vine age on grape and wine quality. Thus, the main goal of this work was to evaluate the potential influence of grapevine age on several general physicochemical and phenolic parameters during grape maturation of a Rabigato white grape variety. Therefore, grapes from two adjacent vineyards, with an age difference of 30 years (one with 20 years and the other with 50 years, at the beginning of this study) were studied. At technological maturation, the results obtained for the three consecutive vintages studied (2019 to 2021), and for the general physicochemical parameters analysed, do not seem to indicate a clear differentiation between the grape musts obtained from the younger and the older vineyards. However, for grape phenolics, the results suggest that vine age could be a potential factor on phenolic content, nevertheless not totally confirmed by the results at technological maturation during the three consecutive vintages considered. With this work we will contribute to expand the knowledge about the potential impact of the vine age on grape composition.

1 Introduction

Grapevines are long-lived perennial plants, with one such vine documented as more than 400 years old [1]. Nevertheless, despite vine plant has a long longevity, it is not uncommon presently to see vineyards uprooted only two to three decades after planting. In fact, between the 10 and 30 years, the grapevine has the maximum of production, however, until then, the plant is under enormous biotic and abiotic stress situations that increase its adaptability [2]. After some decades, grapevine productivity tends sometimes to decline, leading to a decrease in the economic value, and at the same time problems with maturation and resistance to some diseases may begin to emerge [3, 4]. These changes may simply be to replant them with cultivars that better adequate wine consumption trends. However, in the last years despite these productive points, a tendency to protect the old vineyards has occurred. Thus, the preservation of the old vine heritage, combined with the fact that old vines could present greater resistance to biotic and abiotic factors, and due to the trend of producers to consider wines obtained from old vines to be of superior quality, has led to an increase in research studies about the potential contribution of vine age on grape and wine quality. In addition, the production of these wines is highly valued due to marketing strategies that focus on showing the qualities of the wines that are produced from old vines. However, nowadays we don't have a global knowledge of the grape qualities of the old vines that could explain the difference between the wines. Some authors reported that its high value is due to the better attention in the winemaking process and the viticultural techniques and not the because of the grapevine age [5].

Therefore, in this context, it will be interesting to evaluate the potential impact of vine age on grape composition and their evolution during ripening. In this way, it will be possible to take advantage of potential specific grape composition obtained from old vines that could determine the production of wines with specific and valuable characteristics. In addition, the few published works about this topic have used red varieties as their object of study [5, 6], while studies where white varieties are evaluated in general are much scarcer [2].

Thus, the main goal of the present work was to evaluate the potential influence of grapevine age on the main general physicochemical and phenolic parameters during grape maturation of an autochthonous Portuguese white grape variety (Rabigato cv.).

2 Material and methods

2.1 Plant material and location

This work focused on the Portuguese Rabigato white grape variety (*Vitis vinifera* L.). Thus, grapes from two adjacent vineyards, with an age difference of 30 years (one with 20 years and the other with 50 years, at the beginning of this study), located in the Vila Nova de Fóz Coa - Douro wine region (North of Portugal) were studied. Samples of 100 berries (in duplicate) were picked randomly from fifty different plants of each vineyard. Each grape was collected from all possible locations with difference in height and exposure to sunlight. All grape samples were kept frozen

* Corresponding author: antoniojordao@esav.ipv.pt

at -20°C until processing. This studied was conducted during three consecutive vintages (2019 to 2021).

2.2 Methodologies

General physico-chemical and phenolic parameters were measured directly during grape maturation from the must obtained after grape pressing. Thus, alcohol potential, pH and titratable acidity were analysed using the analytical methods recommended by the OIV [7]. Berry weight (including fresh skins and seeds weight), must volume and yield, were also analysed. In addition, several global phenolic parameters were analysed: total phenolic compounds [8], non-flavonoid, and flavonoid phenols [9].

2.3 Statistical analysis

The data are presented as mean of three vintages (2019 to 2021) and respective standard deviation. To determine whether there is a statistically significant difference between the data obtained for each data point during grape maturation between grapes collected from young and old vines, a *t*-student test ($p < 0.05$) was carried out. The statistical analysis was performed using SPSS software version 28.0 (SPSS Inc., Chicago, USA).

3 Results and Discussion

3.1 General physicochemical parameters evolution

The evolution of berries weight (including fresh skins, and seeds weight), must volume (all from 100 berries) and must yield throughout three consecutive vintages from Rabigato young and old vines during grape maturation is shown in Figure 1. The evolution of the weight of 100 berries, the corresponding must volume and yield obtained showed a tendency for a slight increase of the values during all grape maturation.

The average results obtained for these parameters during the three consecutive vintages, do not seem to indicate a clear differentiation between the grapes collected from the older and the younger vineyard (with 50 and 20 years at the beginning of the study, respectively) during all ripening. At technological maturation, similar tendency was also observed.

For grape skins and seeds weight (from 100 berries) in general, a tendency for a slight decrease of the values was detected during all ripening. However, for skins weight obtained from young vines, a slight increase of the values in last weeks of maturation was observed. However, at technological maturation, no significantly different values were observed between the grape skins and seeds weight from the older and the younger vineyard.

According to Riffle et al. [5] whether the differences in berry formation and ripening is either a function of vine age, a result of the effect of vine age on vine yield, or a combination thereof is an important distinction. In that case, these authors reported for grapes (Zinfandel cv) collected from young (5 to 12 years old) and old vines (40 to 60 years old) a ripening delay in the grapes from the old vines. Thus, young vines showed a progressed more slowly development during berry formation but a more

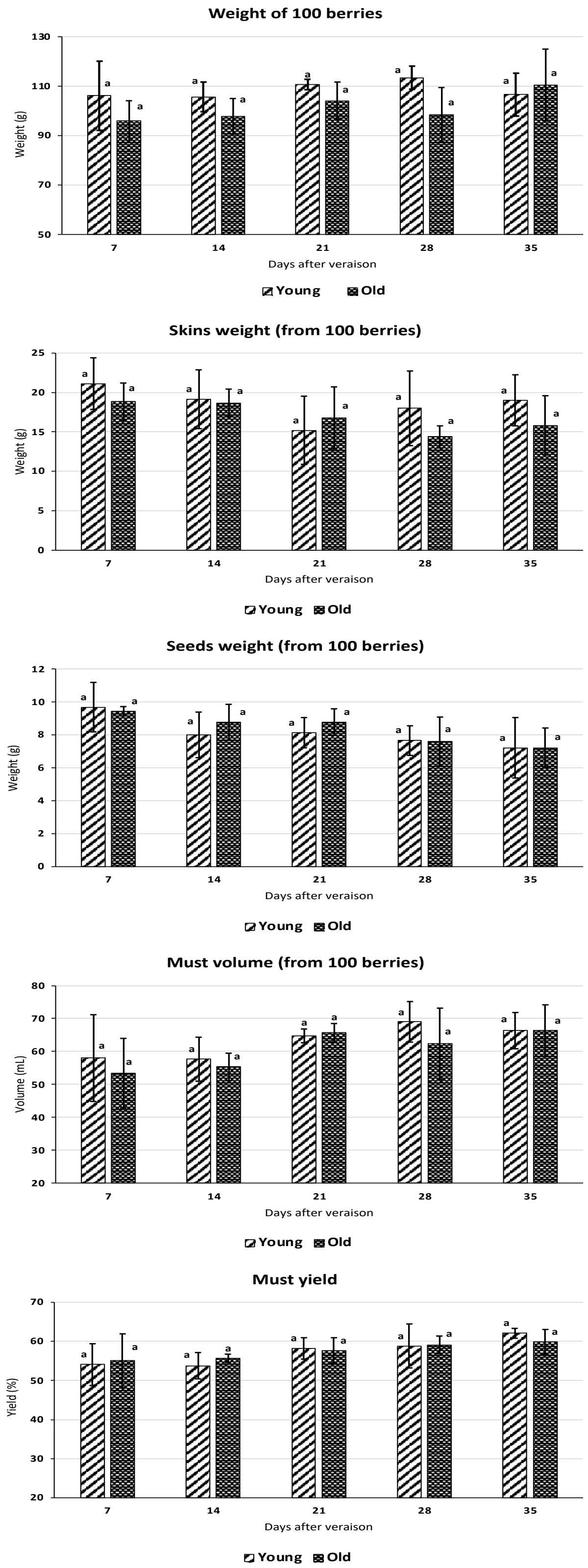

Figure 1. Evolution of berry weight (including fresh skins and seeds weight), must volume, and must yield throughout three consecutive vintages (averages values from 2019 to 2021) for young and old vines during grape maturation. Young - 20 years; Old - 50 years (at the beginning of the study). Data points for same harvest time showing the same letter are not significantly different ($p < 0.05$).

rapidly during berry ripening, resulting in young vines being harvested before old vines. However, these findings are contradictory to our results and previous studies which found little to no differences between young and old vines during grape ripening [6]. It is important to note that the apparent differences in the literature when we are comparing the performance from old and young vines may arise from the difficulty in finding adequate plant material and designing field experiments about vine age with comparable conditions. However, in our study both vineyards were two adjacent vineyards with very similar soil and climate conditions.

Average results from 2019 to 2021 for potential alcohol degree, pH, and titratable acidity during grape maturation are shown in Figure 2. For these three general physicochemical parameters quantified in Rabigato white grapes, similar evolution was detected in both grape samples collected from new and old vines. Thus, for potential alcohol it was not clear any significant differentiation between grape musts obtained from the older and the younger vineyards (with 50 and 20 years at the beginning of the study, respectively). At technological maturation the average values ranged between 11.1 and 11.2% (v/v), respectively for grape musts obtained from the old and young vines. Similar tendency was detected for titratable acidity, where at technological maturation the average values ranged between 5.47 and 5.87 g/L tartaric acid (from the young and old vines, respectively), and pH, where the average values ranged between 3.75 and 3.70 (from the young and old vine, respectively). Nader et al. [2] reported for a Riesling vineyard with identical planting material, but with three planting years ranging from 1971 to 2012, similar values of total soluble solids, titratable acidity, and pH, during two vintages (2016 and 2017). On the other hand, Sanmartin et al. [10] studied the chemical composition of Sangiovese grapes collected from old (41-42 years) and young (11-12 years) vines during two different vintages with very different climatic conditions. These authors reported that grape must collected from old vines showed significant higher total titratable acidity independently of the vintage. However, for sugar content, no statistical differences were obtained between grapes musts obtained from old and young vines during the two vintages considered.

Previously, also Reynold et al. [11] studied the impact of vine age in several grape must parameters from five *Vitis vinifera* cultivars (Cabernet Sauvignon, Pinot Meunier, Pinot Noir, Merlot, and Cabernet Franc) in vineyards of Ontario State (Canada), during two consecutive vintages (2002 and 2003). These authors reported for all cultivars, low ºBrix in grape musts obtained from old vines. In addition, grape musts from old vines of all five cultivars studied had also higher titratable acidity. Grape must pH was highest in old vines in Merlot and Pinot Noir, but musts from Cabernet Sauvignon and Pinot Noir had lower pH from young vines. These results once again support the great variability that we can find in grapes when we are studying the influence of vine age on the general physical-chemical composition.

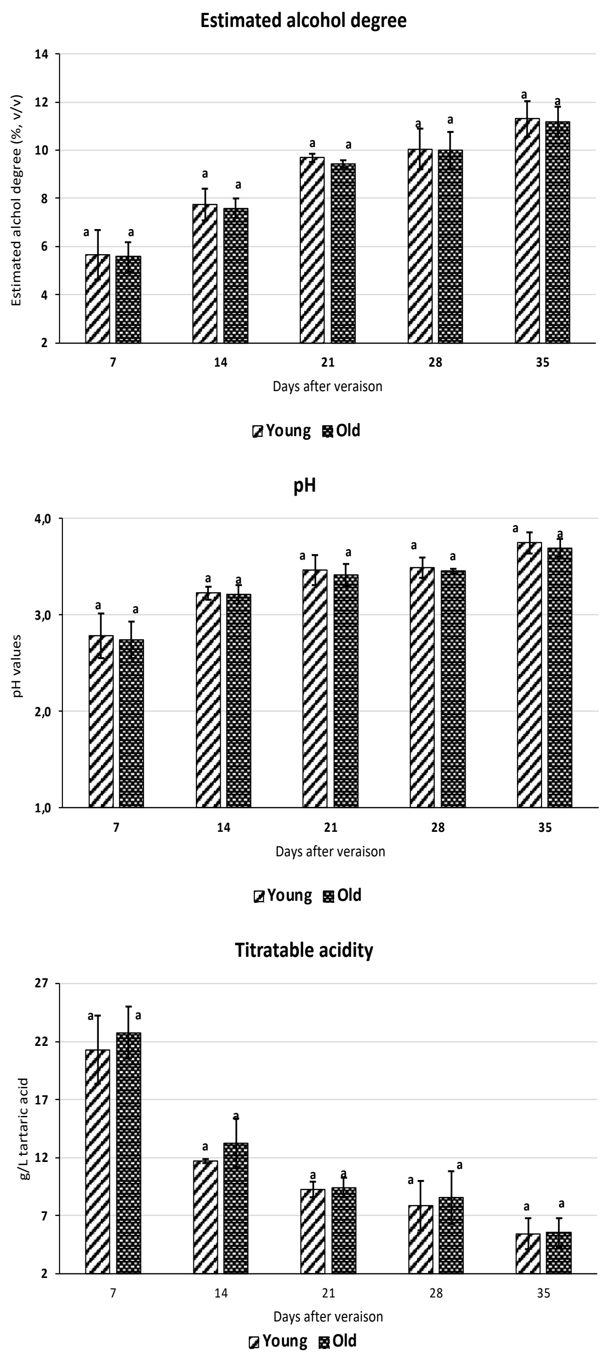

Figure 2. Evolution of estimated alcohol degree, pH, and titratable acidity throughout three consecutive vintages (averages values from 2019 to 2021) for young and old vines during grape maturation. Young - 20 years; Old - 50 years (at the beginning of the study). Data points for same harvest time showing the same letter are not significantly different ($p < 0.05$).

3.2 Global phenolic parameters evolution

The potential impact of vine age on the evolution of several global phenolic parameters during grape maturation throughout the three consecutive vintages is shown in Figure 3. For the general phenolic parameters studied in grape must (total phenols, flavonoid, and non-flavonoid phenols), similar evolution was observed in both grape samples collected from old and new vines. Thus, for these phenolic parameters, a tendency for an increase of the values was detected up to 21 or 28 days after véraison (for grapes from old and young vines, respectively), followed by a decrease until technical maturation.

Although the overall evolution was similar for both grape musts from the two vines, the results seem to indicate that the samples from the old vines can reach a maximum of phenolic compounds slightly earlier compared to that observed in grapes from the new vines. Instead, the subsequent decrease in phenolic content until technological maturation was slightly more accentuated in grape musts from the new vines compared to grape musts from the old vines. This tendency may eventually indicate a faster evolution of the phenolic content in the grapes from the younger vines compared to that detected in the grapes from the older vines. Probably a clear differentiation between technological and phenolic maturity in the new vines could be occur, being these more sensitive to the abiotic stress (eg. Radiation, salinity, flooding, water stress, temperature extremes) and consequently induce a more evident decrease on grape phenolic content. In this context, future studies on the potential influence of vine age on the biosynthesis of grapes phenolic compounds could be a topic to be developed in this area.

At technological maturation, the results suggest that vine age could be a potential factor to determine total phenolic and flavonoid phenols content. In that case, average values from the three consecutive vintages (2019 to 2021) showed that total phenols ranged from 498 (grape samples from younger vineyard) to 528 (grape samples from older vineyard) mg/L gallic acid equiv., while for flavonoid phenols the values ranged from 275 (grape samples from younger vineyard) to 326 (grape samples from older vineyard) mg/L gallic acid equiv. However, it is important to note that these differences were not statistically different. In fact, the results obtained allow us to consider that under the specific vineyard characteristics (including climatic conditions) and during the 3 vintages considered, the vine age did not induce a significant impact on global phenolic indexes of Rabigato variety.

Concerning the potential impact of vine age on grape phenolic composition, most of the published works reported results for red grape varieties, existing a very scare information available for white varieties. In that case, even for red grape varieties the results published are inconsistent. Reynolds et al. [11] reported higher total anthocyanins in old vine fruit in Merlot, but lower anthocyanin content in Pinot Noir, compared to young vine fruit. Alternatively, total anthocyanins in old vines were reportedly lower [10], or the same [12], relative to young vines in Sangiovese and Syrah berries, respectively. Recently, Riffle et al. [13] for Zinfandel cultivar reported that grapes from young vines tended to have higher berry anthocyanins and total phenolics than grapes from old vines during two consecutive vintages (2019 and 2020), despite this trend not being statistically different.

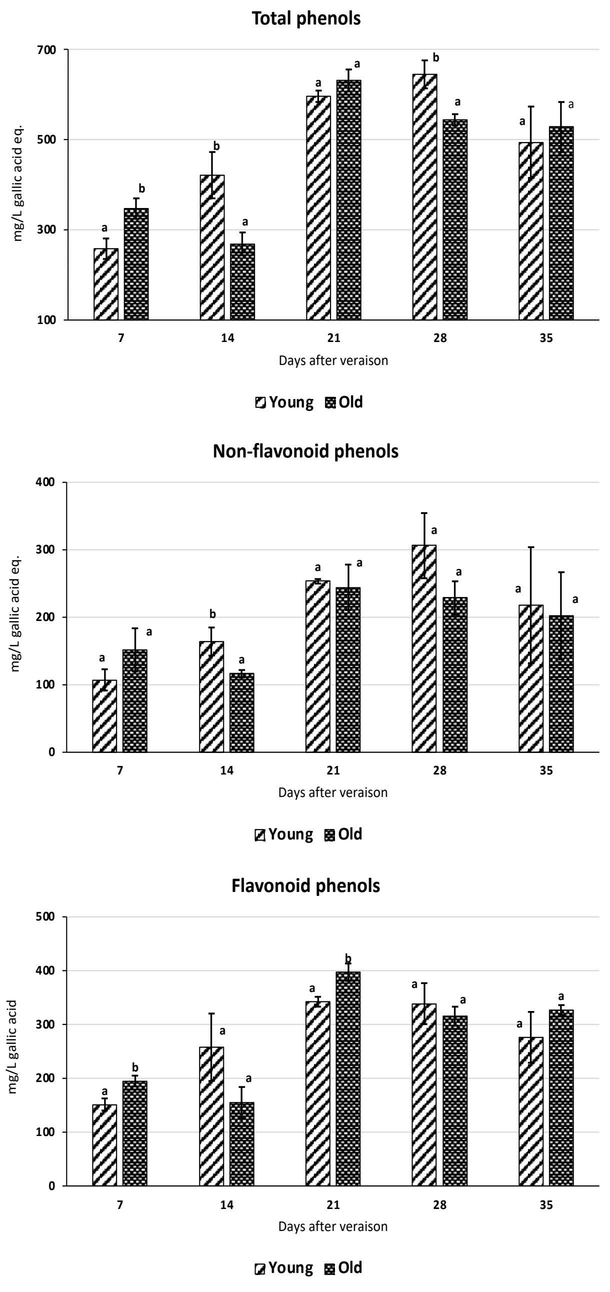

Figure 3. Evolution of global phenolic parameters throughout three consecutive vintages (averages values from 2019 to 2021) for young and old vines during grape maturation. Young - 20 years; Old - 50 years (at the beginning of the study). Data points for same harvest time showing the same letter are not significantly different ($p < 0.05$).

Finally for Riesling white cultivar, Nader [14] reported a tendency to higher flavonol content in grapes collected in vines planted in 2014 and 2015 compared to the content obtained in grapes from vines planted in 1971 and 1995. However, according to this author, these differences could be related with absence of cover crop in vines planted in 2014 and 2015 which led to greater exposure of clusters to light. Lastly, it will be important to note that the potential differences on grape and wine quality between the use of young and old vines could be a consequence of multiple interactions between the vineyard conditions, winemaking techniques, and vineyard and cellar flora.

4 Conclusions

The results obtained in this work using Rabigato *Vitis vinifera* L. white variety during the three consecutive vintages considered, and for the parameters studied, do not seem to indicate a clear differentiation between the grape musts obtained from the older and the younger vineyard. This work has permitted to expand the knowledge about the potential impact of a white grapevine age on some chemical parameters during grape ripening.

This research started in 2019 will continue over the next years to obtain an adequate overview of the impact of vine age on grape composition and at the same time, reduce the potential influence of some variables, such as vintage or harvest date in the relative values of the parameters evaluated.

Acknowledgments

IPViseu, CQ-Vr (FCT-UIDB/00616/2020) and LEAF for financial support.

References

1. D. Grigg, D. Methven, R. de Bei, C. Rodríguez López, P. Dry, C. Collins, Aust. J. Grape Wine Res. **24**, 75 (2017)
2. K.B. Nader, M. Stoll, D. Rauhut, C.-D. Patz, R. Jung, O. Loehnertz, H.R. Schultz, G. Hilbert, C. Renaud, J.-P. Roby, S. Delrot, E. Gomès, Eur. J. Agron. **104**, 1 (2019)
3. B. Ezzili, Bull. Off. Int. Vigne Vin **65**, 161 (1992)
4. J. Kaplan, R. Travadon, M. Cooper, V. Hillis, M. Lubell, K. Baumgartner, Wine Econ. Policy **5**, 127 (2016)
5. V. Riffle, N. Palmer, L.F. Casassa, J.C. Dodson Peterson, Plants **10**, 311 (2021)
6. V. Zufferey, D. Maigre, Revue Suisse Vitic. Arboric. Hortic. **39**, 257 (2007)
7. OIV, *Recueil des méthodes internationales d'analyse des vins et moûts* (Ed. Officielle, Paris, 2016)
8. P. Ribéreau-Gayon, Y. Glories, A. Maujean, D. Dubourdieu, *Handbook of Enology. The Chemistry of Wine Stabilization and Treatments* (Wiley & Sons Ltd., Chichester, England, 2006)
9. T.E. Kramling, V.L. Singleton, Am. J. Enol. Vitic. **20**, 86 (1969)
10. C. Sanmartin, F. Venturi, I. Taglieri, G. Ferroni, G. Scalabrelli, N. Narkabulova, G. Andrich, A. Zinnai, Agrochimica **61**, 154 (2017)
11. A.G. Reynolds, E.G. Pearson, C. De Savigny, J. Coventry, J. Strommer, Int. J. Fruit Sci. **7**, 85 (2007)
12. D. Grigg, *An investigation into the effect of grapevine age on vine performance, grape and wine composition, sensory evaluation and epigenetic characterization*. Thesis, University of Adelaide, Adelaide, Australia (2017)
13. V.L. Riffle, J.A. Arredondo, I. Monaco, C. Appel, A.A. Catania, J.C.D. Peterson, L.F. Casassa, Am. J. Enol. Vitic. *In press* (2022)
14. K.B. Nader, *Grapevine age: Impact on physiology and berry and wine quality*. PhD Thesis, Université Bordeaux, France and Hochschule Geisenheim University, Germany (2018)