Scientific Papers. Series B, Horticulture. Vol. LXVIII, No. 2, 2024
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

PHYSICO-CHEMICAL COMPOSITION OF DIFFERENT GRAPE VARIETIES FROM PIETROASA VINEYARD

Mihai FRÎNCU[1*], Corina DUMITRACHE[2], Andrei Cătălin PETRE[1*], Iuliana Diana Bărbulescu[3], Răzvan Ionuț TEODORESCU[2]

[1]Research Center for Studies of Food Quality and Agricultural Products, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania
[2]Faculty of Land Reclamation and Environmental Engineering, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania
[3]Faculty of Biotechnologies, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania
*Equal contribution

Corresponding author email: corina_dumitrache17@yahoo.com

Abstract

The objective of this study was to evaluate the quality aspects of grapes harvested prior to the commencement of the 2023 winemaking campaign at Pietroasa Winery. Grape samples from eight distinct varieties - Busuioacă de Bohotin, Tămâioasă Românească, Riesling Italian, Alb Aromat, Fetească Regală, Fetească Neagră, Merlot, and Cabernet Sauvignon - were collected during the harvest season at Pietroasa. This paper details the analysis of key quality indicators, including fruit weight, shape index (SI), firmness, total soluble solids (Brix), total titratable acidity (TTA), pH, dry matter content (DM), total polyphenols content (TPC), and antioxidant activity (AA), all of which are critical to assessing wine quality. It synthesizes current research on grape quality, highlighting the significant antioxidant capacity attributed to polyphenol content and suggesting avenues for future research on wine production at Pietroasa Winery. In conclusion, the study reaffirms the suitability of the Pietroasa region for vinification, attributed to its terroir which ensures the production of grapes of high quality, resulting in wines with desirable and distinctive aromatic profiles.

Key words: *quality, grape, wine, polyphenols, antioxidant activity*

INTRODUCTION

Grapes are among the most cultivated plants on Earth, largely due to their direct human consumption as fresh fruits, raisins, and juices, as well as for wine production. They thrive globally across various climates due to their remarkable adaptability. Their adaptability to different climatic conditions and soils, along with their significant cultural and economic importance, place them at the forefront of global agricultural crops. Additionally, the genetic diversity of grapevines plays a crucial role in their widespread adaptability and cultivation success. This diversity allows grapevines to flourish in a broad range of environmental conditions, from temperate to arid climates and enables the production of a wide variety of grape types, each with unique flavors and uses. However, this genetic wealth also poses significant challenges in terms of conservation and sustainable cultivation practices. Efforts to understand and harness grapevine genetic resources can lead to the development of new grape varieties that are more resistant to diseases, pests, and climate variability, ensuring the long-term viability of grape cultivation for economic and cultural purposes (Valente et al., 2022; Smith et al., 2015; Sabir, 2018)

According to FAOSTAT, worldwide, grape production in the last reported 5 years ranged between 70 and 80 million tons (Figure 1), resulting in the production of 25-29 million tons of wine.

In Europe, grape production in the last reported 5 years ranged between 25 and 30 million tons (Figure 2), resulting in the production of 15-18 million tons of wine. Regarding Romania's situation, in the last 5 reported years, grape production was around 1 million tons, resulting in the production of 0.38-0.53 million tons of wine. An exception to this was in 2018 when wine production was only 0.12 million tons (Figure 3).

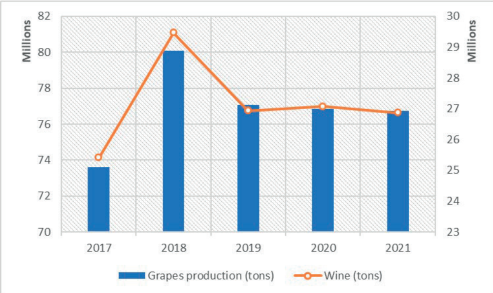

Figure 1. Grape and wine production - worldwide

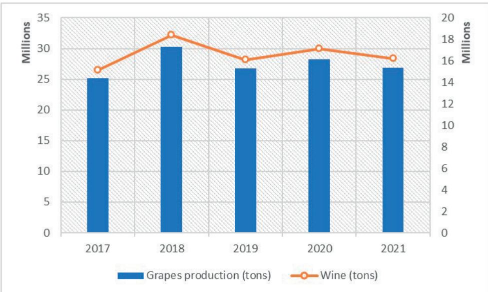

Figure 2. Grape and wine production – Europe

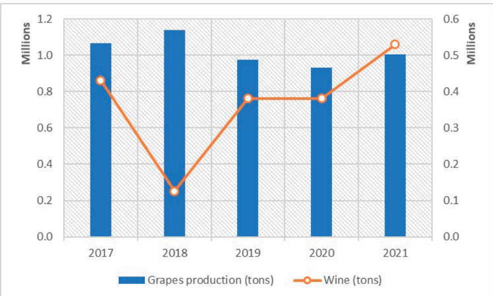

Figure 3. Grape and wine production - Romania

Grapes vary greatly in size, color, sugar content, and acidity, directly influencing the wine's aromatic and organoleptic profile (Steiner et al., 2021; Koundouras, 2018; Pérez et al., 2007). In this regard, analyzing and evaluating the quality characteristics of grapes are crucial for understanding their potential in the winemaking process. By determining these characteristics, a detailed picture of the quality and maturity of the grapes can be obtained, which will later be reflected in the quality of the resulting wines (Matthews et al., 2007; Gutiérrez-Escobar et al., 2021). Thus, carefully selecting grape varieties is crucial in winemaking to ensure the desired quality and sensory characteristics of wines (Grainger & Tattershall, 2016; Poni et al., 2018). Climatic factors have a significant effect on grape development. Increasing temperatures and altered precipitation patterns have been shown to influence the phenology and quality traits of *Vitis vinifera*, emphasizing the need for adaptive strategies in viticulture to sustain wine quality in changing climatic conditions (Van Leeuwen et al., 2019). Temperature plays a pivotal role in the accumulation of total soluble solids and affects total titratable acidity (TTA) and pH levels, where cooler conditions preserve acidity, contributing to the balance and taste profile of the wine. Also, drought conditions can increase dry matter and concentrate flavors, while moderate stress enhances total phenolic content (TPC) and antioxidant activity (AA), essential for wine's color, flavor, and health benefits (Biasi et al., 2019; Cozzolino et al., 2011; Soar et al., 2008; Grifoni et al., 2006). The grape variety's characteristics manifest in finished wines depend on many factors, the most important of which is the terroir soil and microclimate within the vineyard - viticultural management practices and the chosen winemaking technique (Goldammer, 2018; Trubek et al., 2010; Stevenson, 2005). An intriguing region from the perspective of terroir is the Pietroasa area in Buzău County, renowned for its terroir conditions that are conducive to viticulture. This includes volcanic soils and a microclimate that plays a significant role in cultivating high-quality grapes. These conditions are perfect for producing wines that are distinct and embody unique characteristics. Phenolic compounds, including tannins, flavonols, and anthocyanins that determine berry color, are produced and stored mainly in the skins and seeds of berries (Mollaamin, 2023; Li and Sun, 2017; Chira et al., 2011; Yilmaz and Toledo, 2003; Xu et al., 2011). The role of these compounds in enhancing the nutritional value of grape products and their potential health benefits, particularly as antioxidants, is a subject of ongoing research (Sabra et al., 2021).

These compounds are synthesized in the berry and concentrated in the fruit skin, and seeds when present (Teixeira et al., 2013).

The contributions of phenolic compounds to the nutritive value of grape products, and their potential health benefits as antioxidants, are currently active areas of investigation. (Dookozlia, 2020; Pirvu et al., 2011).

Despite the critical importance of understanding the physico-chemical properties of grape varieties for wine production, there exists a notable gap in the scientific literature addressing this subject, particularly within the unique context of the Pietroasa winery. This paper aims to assess the quality parameters (fruit weight, shape index, firmness, total soluble solids, total titratable acidity, pH, dry matter content, total phenolic content, and antioxidant activity) of eight grape samples from Pietroasa Winery to enhance a better understanding of their value in winemaking.

MATERIALS AND METHODS

Grape samples from eight different varieties were collected from the Pietroasa Winery vineyards during the 2022-2023 growing season: Busuioacă de Bohotin, Tămâioasă Românească, Riesling Italian, Alb Aromat, Fetească Regală, Fetească Neagră, Merlot, and Cabernet Sauvignon. Each grape variety was carefully selected to represent a diverse range of characteristics and flavors. Upon collection, the grapes were transported to the laboratory for analysis. Various parameters including fruit weight, shape index (SI), firmness, total soluble solids (Brix), total titratable acidity (TTA), pH, dry matter content (DM), Total phenolic content (TPC), and antioxidant activity (AA) were determined using standardized analytical methods.

Fruit weight

To determine the fruit weight, a representative sample of grapes from each variety was selected and separated from the stems. The grape berries were then weighed using a precision scale. Five replicates were performed, and the final value was represented by the mean of these measurements, in grams.

Shape index (SI)

For shape index determination, five grape berries were individually measured for their length (L) and width (W) using a digital caliper. The Shape Index (SI) was then calculated as the ratio of the length to the width (SI = L/W). This calculation provides a numerical value representing the elongation or roundness of the grape berry: a value less than 1 indicates more or less flattened fruits, a value greater than 1 indicates more or less elongated fruits, and a value equal to 1 indicates spherical fruits (Brewer et al., 2006).

Firmness

For firmness determination, a Turoni 53205 model was employed to measure the compressive force required to penetrate the grape berry. Each grape berry was carefully positioned on the analyzer's platform, and a standardized piston (3 mm) was used to apply a controlled force perpendicular to the berry's surface. The force required to penetrate the berry by a predetermined distance was recorded as the firmness value (Petre et al., 2021). This process was repeated 5 times, and the average firmness value was calculated and expressed as N (Newton).

Total soluble solids (Brix)

For total soluble solids (Brix) determinations, a hand refractometer was utilized to measure the sugar content in the grape juice. A small sample of grape juice was extracted from each grape variety and placed onto the prism of the refractometer (Petre et al., 2021). The refractometer measures the bending of light passing through the juice, which is directly correlated with the sugar concentration. The Brix value, expressed in degrees, represents the percentage of soluble solids in grapes.

Total titratable acidity (TTA) and pH

For total titratable acidity determination (TTA), the titration method was conducted using the TitroLine Easy apparatus. Initially, a homogeneous ground grape sample was titrated with a standardized solution of 0.1N NaOH using the method described by Petre et al., 2023. The titration process continued until a final 8.1 pH was reached. Additionally, the initial pH was recorded. The volume of 0.1 N NaOH solution required to reach this endpoint was recorded by the instrument. The TTA value, expressed as g tartaric acid/100 g of fresh fruit, was calculated based on the volume and concentration of the 0.1N NaOH solution used. The average TTA value was calculated based on the results of these three replicates.

Dry matter content (DM)

For the dry matter (DM) determination, a gravimetric method was employed. Specifically, 1 gram of homogeneous fresh sample was weighed into pre-weighed laboratory crucibles and then dried in a laboratory oven at 105°C, until a constant weight was achieved (Iliescu et al., 2019). The difference in mass before and after drying represented the dry matter, expressed as a percentage of the initial sample mass. This process was repeated for each grape variety, with three replicates for each.

Total polyphenol content (TPC)

The extraction of polyphenols was based on the method described by Barbulescu et al., 2022. Therefore, 1 gram of each grape sample was initially triturated with 10 mL of 70% MeOH, and the resulting mixture was left to incubate overnight in darkness at ambient temperature. Following this maceration period, the samples were homogenized on an orbital shaker for one hour. After the homogenization, the extraction process continued with stirring for an hour, 500 rpm, followed by centrifugation at 7000 rpm, 4°C, for 5 minutes. The supernatant was collected in 50 mL tubes, and the residual material underwent two successive extractions until a final extract volume of 30 mL was obtained. A standard solution of gallic acid was prepared to generate a standard curve ($y = 0.012x + 0.003$, $R^2 = 0.9982$). From the grape extract obtained, 0.5 mL of the extract with 2.5 mL of Folin-Ciocalteu reagent, followed by a 2-minute incubation at room temperature, approximately 21°C. In the subsequent step, 2 mL of a 7.5% sodium carbonate (Na_2CO_3) solution is added to this mixture, which is then incubated for an additional 15 minutes at 50°C. After the incubation, the absorbance was measured at a wavelength of 750 nm using a Specord 210 Plus UV-VIS spectrophotometer (Analytik Jena, Jena, Germany). The results were expressed as mg of gallic acid equivalents per gram of fresh weight (mg GAE/100 g fresh weight).

Antioxidant activity (AA)

Antioxidant activity (AA) was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay (Stan et al., 2020). This process entailed combining 0.2 mL of the extract with 2 mL of a 0.2 mM solution of DPPH in methanol, followed by a 30-minute incubation in darkness with homogenization. Subsequently, the absorbance of the resulting samples was measured at a wavelength of 515 nm. The results were expressed as mg Trolox equivalent/100 g FW (fresh weight) using a Trolox calibration curve ($y = 0.0238x + 0.0884$, $R^2 = 0.9985$).

Statistical analysis

Standard deviation was employed as the statistical analysis technique for all samples, quantifying the variation or dispersion from the mean value, based on either five or three replicates per sample.

RESULTS AND DISCUSSIONS

This study aimed to analyze 8 grape samples from Busuioacă de Bohotin, Tămâioasă Românească, Riesling Italian, Alb Aromat, Fetească Regală, Fetească Neagră, Merlot, and Cabernet Sauvignon varieties harvested from Pietroasa Winery. These analyses are crucial for assessing the qualitative aspects of the grapes, as they directly impact the potential quality and characteristics of the wines that can be further produced.

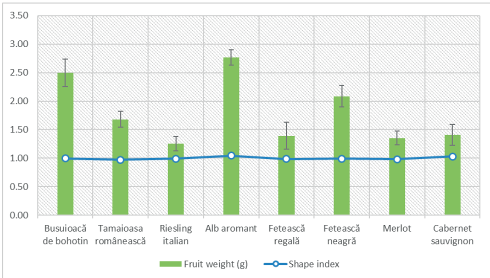

Figure 4. Fruit weight and shape index for analyzed samples

The fruit weight varied among the analyzed samples (Figure 4). The highest average grape weight was observed for the Alb Aromat variety, at 2.77 g, while the lowest average grape weight was recorded for the Riesling Italian variety, at 1.26 g. Regarding the shape index, the samples exhibited values ranging between 0.97 and 1.05, which are characteristic of spherical-shaped grapes. This indicates a consistent shape across the samples, with most grapes exhibiting a round or spherical morphology.

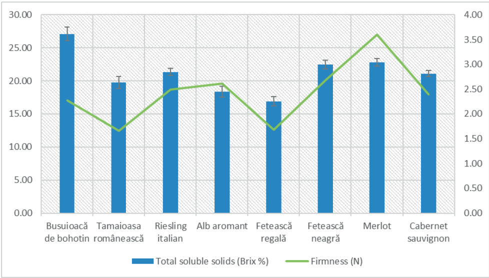

Figure 5. Brix and firmness values of the analyzed samples

For the Brix values (Figure 5) the highest value was recorded for the Busuioacă de Bohotin variety, reaching 27.10%, while the lowest value was observed for the Fetească Regală variety, at 16.92%. The values obtained for the Merlot (22.78%) and Cabernet Sauvignon (21.10%) varieties are confirmed by Karoglan et al. in 2014, with 23.20% Brix for Merlot and 21.20% Brix for the Cabernet Sauvignon variety. A value of 20.5 % was also mentioned by Stănuș et al., in 2019 for the Fetească Regală variety. Regarding firmness, the highest value was measured for the Merlot variety, reaching 3.60 N, while the lowest firmness was observed for the Tămâioasă Românească variety, at 1.66 N.

These results reveal significant variability in sugar concentration (Brix) and firmness among the grape samples analyzed. The wide range of Brix values indicates variations in sugar levels across the samples, which can have implications for the potential alcohol content and taste profile of the wines produced from these grapes.

Additionally, the variation in firmness suggests differences in berry structure, which can influence extraction during winemaking processes and ultimately impact the texture and mouthfeel of the resulting wines.

The data presented by Beauchet et al. (2020) reflected that sugar content from grapes and total acidity were strongly linked to Soil Annual Practices, (respectively, 26.60% of the contribution for sugar content and 19.61% for total acidity) and Structure Perennial Practices (20.07% for sugar content and 19.88% for total acidity). By the statistical analysis, they identified the main viticultural practices of the soil and climate variables related to the grape quality at harvest. The choice of harvest dates and locations is usually planned based on the color development of the grape bunches (Pothen & Nuske, 2016).

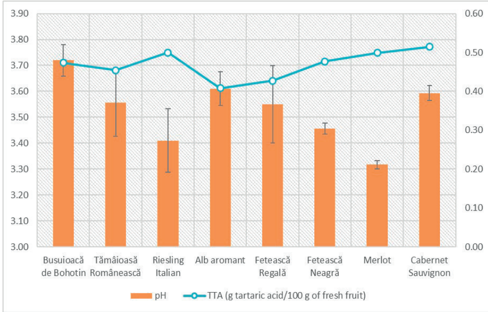

Figure 6. Total titratable acidity and pH of the analyzed samples

Variations in Total Titratable Acidity (TTA) and pH play a crucial role in shaping the sensory characteristics and overall quality of wines derived from different grape varieties (Pedneault et al., 2013). Higher acidity levels, typically indicated by lower pH values, contribute to wine freshness and longevity, while lower acidity levels, reflected by higher pH values, may lead to wines with a softer mouthfeel and smoother taste profile (Waterhouse et al., 2016).

In our analyzed grape samples, notable variations were observed in both TTA and pH levels (Figure 6). For TTA, the Cabernet Sauvignon variety exhibited the highest acidity levels, with a TTA of 0.51 g tartaric acid/100 g of fresh fruit, whereas the Alb Aromat variety displayed the lowest acidity levels, with a TTA of 0.41 g tartaric acid/100 g of fresh fruit. As for pH, the Busuioacă de Bohotin variety has the higher pH (3.72) while the Merlot variety exhibited the lowest value of pH (3.32).

Similar values were obtained also by Leila et al., in 2008 for the TTA and pH of the Cabernet Sauvignon, 0.67-0.85 g tartaric acid/100 g fresh weight for TTA and a pH between 3.49 and 3.77.

The highest dry matter content was recorded for the Busuioacă de Bohotin variety, reaching 28.44%, and the lowest was observed for the Fetească Regală variety, with a value of 18.07% (Figure 7). Dry matter content is an important parameter to know because a higher concentration of solid material in the grapes can influence factors such as mouthfeel, body, and potential alcohol content in the resulting wines. Conversely, a lower concentration of solid material in grapes may result in wines with a lighter body and potentially lower alcohol content.

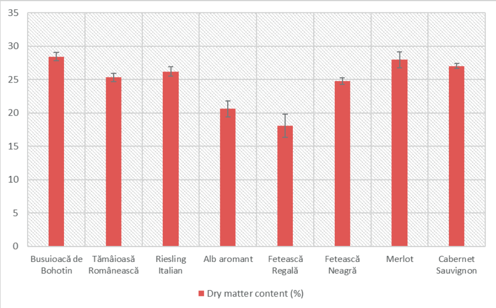

Figure 7. The dry matter content (%) of the analyzed samples

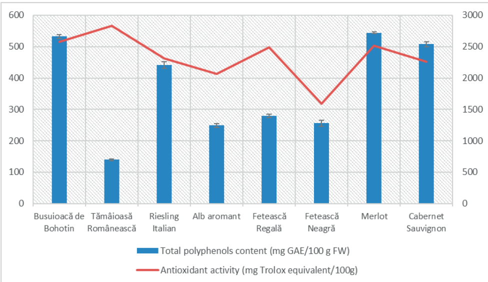

Figure 8. Total polyphenols content (TPC) and Antioxidant activity (AA) content of the analyzed samples

TPC and AA serve as crucial parameters, offering valuable insights into the antioxidant potential, health-promoting characteristics, and aging capabilities of wines derived from grapes. For the analyzed samples (Figure 8), in terms of TPC, the lowest value was recorded for the Tămâioasă Românească variety, with a value of 139.70 mg GAE/100 g sample, while the highest value was observed for the Merlot variety, reaching 543.73 mg GAE/100 g sample. Regarding AA, the lowest value was found for the Fetească Neagră variety, with a value of 1591.91 mg Trolox/100 g sample, while the highest value was observed for the Tămâioasă Românească variety, with a value of 2828.52 Trolox/100 g sample.

CONCLUSIONS

The results obtained in this study showed variations among the analyzed grape varieties, highlighting notable differences in antioxidant potential and health-promoting characteristics of the wines. Merlot stands out for its highest phenolic content, while Tămâioasă Românească excels in antioxidant activity.

The analyzed samples demonstrated consistency in the shape index, showing an almost spherical morphology across the grape varieties. However, there were notable differences in TTA and pH among the varieties, with Cabernet Sauvignon exhibiting higher acidity, and Merlot showing lower pH values, which impact their sensory profiles and aging potential.The outcomes of our study contribute to a deeper comprehension of the physico-chemical attributes of eight grape varieties, including fruit weight, shape index (SI), firmness, total soluble solids (Brix), total titratable acidity (TTA), pH, dry matter content (DM), total polyphenol content (TPC), and antioxidant activity (AA), which are crucial in the wine production process.

The Pietroasa region is traditionally recognized for producing distinctive wines, thanks to its terroir, which influences grape quality and contributes to the wine's unique and appealing aroma.

ACKNOWLEDGEMENTS

This work was supported by the project 7PFE/2021 “Circular economy in USAMV farms - whole use of by-products resulting from fermentation processing”, Program 1 – Development of the national research-development system, Subprogram 1.2 - Institutional performance - Institutional development projects - Projects to finance excellence in RDI.

REFERENCES

Barbulescu I.D., Cîrîc A.I., Begea M., Matei P.M., Moisac A., Niță A., Frîncu M., Baniță C.D., Teodorescu R.I., Tudor V., Dumitrache C. (2022). Tămâioasă Românească and Busuioacă de Bohotin grapes - valuable sources for wine production, *Scientific Papers. Series B, Horticulture*. Vol. LXVI, No. 2, PP171-176.

Beauchet S., Cariou V., Renaud-Gentié C., Meunier M., Siret R., Thiollet-Scholtus M. and Jourjon F. (2020). Modeling grape quality by multivariate analysis of viticulture practices, soil and climate, *OENO One*, 3, 601-622, DOI:10.20870/oeno-one.2020.54.3.106.

Biasi, R., Brunori, E., Ferrara, C., & Salvati, L. (2019). Assessing impacts of climate change on phenology and quality traits of *Vitis vinifera* L.: The contribution of local knowledge. *Plants,* 8(5), 121. https://doi.org/10.3390/plants8050121.

Brewer, M. T., Lang, L., Fujimura, K., Dujmovic, N., Gray, S., & van der Knaap, E. (2006). Development of a controlled vocabulary and software application to analyze fruit shape variation in tomato and other plant species. *Plant Physiology*, 141(1), 15–25. doi:10.1104/pp.106.077867.

Chira, K., Lorrain, B., Ky, I., & Teissedre, P.-L. (2011). Tannin composition of cabernet-sauvignon and merlot grapes from the Bordeaux area for different vintages (2006 to 2009) and comparison to tannin profile of five 2009 vintage Mediterranean grapes varieties. *Molecules*, *16*(2), 1519–1532. https://doi.org/10.3390/molecules16021519.

Cozzolino, D., Cynkar, W.U., Dambergs, R.G., Gishen, M. and Smith, P. (2011) Grape (*Vitis vinifera*) compositional data spanning ten successive vintages in the context of abiotic growing parameters. *Agriculture Ecosystems & Environment* 139, 565–570.

Dookozlia N.K. (2020). Grape berry growth and development, Chapter 5, book Estimating grape maturity by sensory analysis - grape maturity series, https://store.extension.iastate.edu/product/Estimating-Grape-Maturity-by-Sensory-Analysis-Grape-Maturity-Series.

Goldammer, T. (2018). The Grape Grower's Handbook: A Guide to Viticulture for Wine Production. *Apex Publishers.*

Grainger, K., & Tattersall, H. (2016). *Wine production and quality, 2nd edition*. John Wiley & Sons.

Grifoni, D., Mancini, M., Maracchi, G., Orlandini, S. and Zipoli, G. (2006). Analysis of Italian wine quality using freely available meteorological information. *American Journal of Enology and Viticulture* **57**, 339–346.

Gutiérrez-Escobar, R., Aliaño-González, M. J., & Cantos-Villar, E. (2021). Wine polyphenol content and its influence on wine quality and properties: A Review. *Molecules*, *26*(3), 718. https://doi.org/10.3390/molecules26030718.

Iliescu, L. M., Stănică, F., Stan, A., Bezdadea-Cătuneanu, I. L., Mihai, C. A. (2019). Fruits physico-chemical parameters of some romanian kiwifruit hybrids influenced by different cold storage technologies. *Fruit Growing Research*, Vol. XXXV: 104-115.

Karoglan, M., Osrečak, M., Maslov, L., & Kozina, B. (2014). Effect of cluster and Berry thinning on Merlot and Cabernet Sauvignon wines composition. *Czech Journal of Food Sciences*, *32*(5), 470–476. https://doi.org/10.17221/598/2013-cjfs.

Koundouras, S. (2018). Environmental and viticultural effects on grape composition and wine sensory properties. *Elements*, *14*(3), 173–178. https://doi.org/10.2138/gselements.14.3.173.

Li, L., & Sun, B. (2017). Grape and wine polymeric polyphenols: Their importance in enology. *Critical Reviews in Food Science and Nutrition*, *59*(4), 563–579. https://doi.org/10.1080/10408398.2017.1381071.

Matthews, M.A. and Nuzzo, V. (2007). Berry size and yield paradigms on grapes and wines quality. *Acta Hortic.* 754, 423-436 DOI:10.17660/ActaHortic.2007.754.56.

Mollaamin, F. (2023). Phenolic compounds in black grape by the electronic and Thermochemical Studies. *Biointerface Research in Applied Chemistry*, *13*(2), 162. https://doi.org/10.33263/briac132.162.

Pedneault, K., Dorais, M., & Angers, P. (2013). Flavor of cold-hardy grapes: impact of berry maturity and environmental conditions. *Journal of agricultural and food chemistry*, *61*(44), 10418–10438. https://doi.org/10.1021/jf402473u.

Pérez-Lamela, C., García-Falcón, M. S., Simal-Gándara, J., & Orriols-Fernández, I. (2007). Influence of grape variety, vine system and enological treatments on the colour stability of young red wines. *Food Chemistry*, *101*(2), 601–606. https://doi.org/10.1016/j.foodchem.2006.02.020.

Petre A., Stan A., Popescu D, Frincu M., Ion V., Ciceoi R., Asanica A. (2021). Influence of pre and post-harvest conditions on quality indicators and microbiota of organic Aronia melanocarpa. *Scientific Papers. Series B. Horticulture,* Vol. LXV, Issue 2, Print ISSN 2285-5653, 69-76.

Petre A., Frincu M., Barbu (Stan) A., Lesnic A., Badulescu L., Asanica A. (2023). Quality assesment of organic 'PLAPINK' raspberry fruits under different storage conditions. *Scientific Papers. Series B, Horticulture*, Vol. LXVII, Issue 2, Print ISSN 2285-5653, 143-151.

Pirvu L, Barbulescu D., Nichita C., Nita S., Colceru Mihul S. (2011). Obtaining and chemical characterization of some vegetal extracts with corrosion-scaling inhibition properties. Part II. *Juglandis folium* and *Agrimoniae herba* extracts, *Romanian Biotechnological Letters,* Vol. 16, No. 1, pp 5937-5943.

Poni, S., Gatti, M., Palliotti, A., Dai, Z., Duchêne, E., Truong, T.-T., Ferrara, G., Matarrese, A. M., Gallotta, A., Bellincontro, A., Mencarelli, F., & Tombesi, S. (2018). Grapevine quality: A multiple choice issue. *Scientia Horticulturae*, *234*, 445–462. https://doi.org/10.1016/j.scienta.2017.12.035.

Pothen Z., Nuske S., (2016), Automated Assessment and Mapping of Grape Quality through Image-based Color Analysis, *IFAC-PapersOnLine.*

Sabir, A. (2018). Sustainable viticulture practices on the face of climate change. *Agricultural Research & Technology: Open Access Journal*, *17*(4). https://doi.org/10.19080/artoaj.2018.17.556033.

Sabra, A., Netticadan, T., & Wijekoon, C. (2021). Grape bioactive molecules, and the potential health benefits in reducing the risk of heart diseases. *Food Chemistry*: X, 12, 100149. https://doi.org/10.1016/j.fochx.2021.100149.

Smith, S., Bubeck, D., Nelson, B., Stanek, J., & Gerke, J. (2015). Genetic diversity and modern plant breeding. *Sustainable Development and Biodiversity*, 55–88. https://doi.org/10.1007/978-3-319-25637-5_3.

Soar, C.J., Sadras, V.O. and Petrie, P.R. (2008). Climate drivers of red wine quality in four contrasting Australian wine regions. *Australian Journal of Grape and Wine Research* **14**, 78–90.

Stan, A., Butac, M., Ion, V. A., Cătuneanu, I., Frîncu, M., & Bădulescu, L. (2020). Post-harvest technologies influences in organic 'Tita' plums quality. *Scientific Papers. Series B, Horticulture*, 64(2), 105-112.

Stănuș, M., Petcov, D. Z., Dobrei, A., Dobromir, D., & Dobrei, A. (2019). Research concerning the identification, ampelographic description and quality properties of some local grapevine varieties from Alba County. *Journal of Horticulture, Forestry and Biotechnology*, 23(3), 63-67.

Steiner, M., Grace, J. B., & Bacher, S. (2021). Biodiversity effects on grape quality depend on variety and management intensity. *Journal of Applied Ecology*, *58*(7), 1442–1454. https://doi.org/10.1111/1365-2664.13899.

Stevenson, T. (2005). The Sotheby's wine encyclopedia. DK Publishing (Dorling Kindersley).

Teixeira, A., Eiras-Dias, J., Castellarin, S., & Gerós, H. (2013). Berry Phenolics of grapevine under challenging environments. *International Journal of Molecular Sciences,* 14(9), 18711–18739. https://doi.org/10.3390/ijms140918711.

Trubek, A., Guy, K.M. and Bowen, S. (2010). Terroir: a French conversation with a transnational future. *Contemporary French & Francophone Studies* 14, 139–148.

Valente J., Symington C., Leal da Costa P., Rogerson F.S., Silva R. and Alves F. (2022). Adaptability of grapevines to climate change: characterization of phenology and sugar accumulation of a large range of grape varieties, under hot climate conditions. *XIVth International Terroir Congress.* https://ives-openscience.eu/wp-content/uploads/2023/02/S8-A2_ValenteJ-final-version.pdf

Van Leeuwen, C., Destrac-Irvine, A., Dubernet, M., Duchêne, E., Gowdy, M., Marguerit, E., Pieri, P., Parker, A., de Rességuier, L., & Ollat, N. (2019). An update on the impact of climate change in viticulture and potential adaptations. *Agronomy*, 9(9), 514. https://doi.org/10.3390/agronomy9090514

Volume 49, Issue 16, 2016, Pages 72-78.

Waterhouse, A. L., Sacks, G. L., & Jeffery, D. W. (2016). *Understanding Wine Chemistry*. https://doi.org/10.1002/9781118730720.

Xu, Y., Simon, J. E., Welch, C., Wightman, J. D., Ferruzzi, M. G., Ho, L., Passinetti, G. M., & Wu, Q. (2011). Survey of polyphenol constituents in grapes and grape-derived products. *Journal of Agricultural and Food Chemistry*, *59*(19), 10586–10593. https://doi.org/10.1021/jf202438d.

Yilmaz, Y., & Toledo, R. T. (2003). Major flavonoids in grape seeds and skins: antioxidant capacity of Catechin, Epicatechin, and gallic acid. *Journal of Agricultural and Food Chemistry*, *52*(2), 255–260. https://doi.org/10.1021/jf030117h.