RJH Vol. V, 2024: 109-116
10.51258/RJH.2024.13

The influence of climatic factors on the quality of grapes in the vineyards Murfatlar and Iasi

V. Artem[1*], A. Ranca[1], C. Ciobanu[1], I. Dina[1], A. Nechita[2] and G. Zaldea[2]

[1]Research and Development Station for Viticulture and Oenology Murfatlar, Romania

[2]Research and Development Station for Viticulture and Oenology Iasi, Romania

*Corresponding author e-mail: artemvictoria@yahoo.com

ABSTRACT

The objective of the present study was to evaluate the influence of key climatic factors (temperature and precipitation) during the growing season on the ripening and chemical composition of grapes for white and red wines in two vineyards renowned for the quality of their wines: Murfatlar and Iaşi, over two consecutive years (2023 and 2024). The climatic variability, characterized by high air temperatures and prolonged periods without precipitations contributed to a forced ripening of the grapes, with harvesting taking place in 2024 one week earlier than in 2023 in both vineyards. The high temperatures during ripening accelerated the accumulation rate of sugars, resulting in concentrations exceeding 200 g/L for white wine grape cultivar and over 220 g/L for red wine grape cultivars in the Murfatlar wine center, and concentrations ranging between 192.6-206.0 g/L for white grape varieties and 200.7-221.0 g/L for red grape cultivar in the Copou Iasi wine center. The results obtained, analyzed statistically, highlighted significant differences in the primary metabolites of grape berries (sugars and organic acids), influenced by vineyard and climatic conditions over the two studied years. Maintaining traditional viticultural regions remains a challenge for producers, requiring various strategies to compensate for these imbalances and to produce high-quality, balanced wines.

Keywords: extreme temperatures, drought, grape ripening, sugars

INTRODUCTION

The gradual climate change is affecting the evolution of natural factors in viticultural ecosystems; summers are becoming warmer and drier, with long autumns and uneven precipitation, alternating between periods of excessive drought and short bursts of heavy rainfall. High temperatures during the active growing season promote the development of shoots, but when they exceed 35°C, combined with low precipitation levels, they contribute to the onset of heat stress, which has a negative impact on vine phenology. Grape berries are vulnerable to heat stress, which have repercussions on the synthesis of primary metabolites such as sugars (Pillet *et al*., 2012), organic acids (Sweetman *et al*., 2014), and amino acids (Lecourieux *et al*., 2017), as well as secondary metabolites (polyphenols, aromas) responsible for wine sensorial attributes. Water deficit can impact vegetative growth, flowering and berry development, although this depends on the phenological stage, as well as the severity and duration of the water deficit (Hardie *et al*.,

1976). One of the main objectives of wine grape producers throughout history has been to achieve full maturity, meaning the maximum concentration of soluble sugars at the highest berry weight. Recently, this objective has lost relevance, as an increasing number of consumers in the internal and international markets prefer lighter wines characterized by a moderate alcohol content (Ilina-Dumitru *et al*., 2024). The grape ripening process is an extremely complex phenomenon that involves a combination of environmental conditions, genetic characteristics, hormonal activity, pigment biosynthesis, and the metabolism of sugars, acids, and aroma compounds. Key indicators of grape quality include total soluble substances, total acidity, and their ratio. In the dynamics of grape ripening, an increase in sugar content is observed due to the synthesis and accumulation of glucose and fructose, while titratable acidity tends to decrease (Fernandez *et al*., 2015). The ratio of sugars to organic acids correlates with the quality of aromas and determines the optimal harvest time, as it is considered a quality index (Kafkas *et al*., 2007). Figure 1 highlights the effect of temperature fluctuations on the synthesis of primary metabolites (sugars and organic acids) and secondary metabolites (aromas and phenolics) in grape berries, and consequently, on wines.

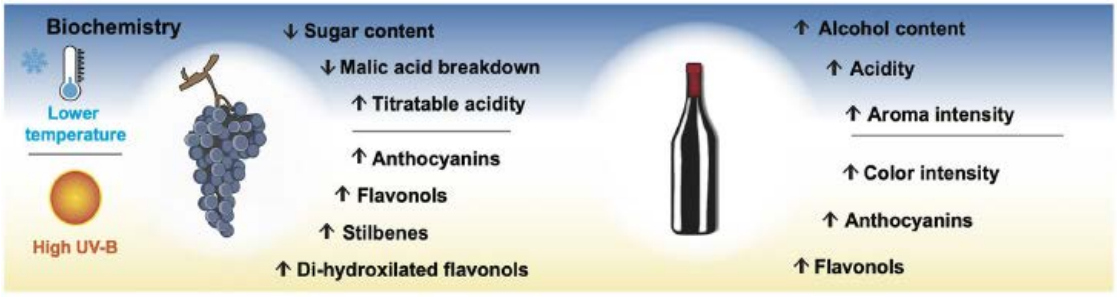

Figure 1. The effect of temperatures on the biochemistry of grape berries (Arias *et al*., 2022)

Climatic variability resulting from rising air temperatures and prolonged periods of precipitation absence generated over time effects on grapevine development and grape composition, namely: (i) the onset of flowering and veraison phases occurs earlier; (ii) accelerated grape ripening in terms of sugar accumulation, which, in turn, leads to the higher alcohol content in the wine; (iii) faster depletion of organic acids in the must and increased pH values, which trigger high microbiological instability of the must during pre-fermentation; (iv) as a result of excessive temperatures, the aromatic profile may atypically shift towards over-ripening; (v) technological ripening (which occurs earlier) and phenolic ripening (which occurs later) are decoupled, with negative effects on the aromatic and phenolic profile, especially for red grape cultivars (vi) increased frequency of berry withering, extending to damage caused by sunburn (Pallioti *et al*., 2014). Although the grapevines can adapt over time, the immediate consequences are inevitable, namely: a shortened phenological development period, plants that are less prepared for the cold season and more sensitive to extreme temperatures, forced ripening of grapes, and an advance of harvest dates with the berries being poorer in terms of their natural components (Lorenzo *et al*., 2013). As a result of global warming, maintaining traditional viticultural regions remains a challenge for producers, requiring various strategies (optimizing a complex set of agrotechnical measures, vineyard and winemaking practices) to compensate for these imbalances and to produce wines that are both qualitatively and physico-chemically balanced and organoleptically pleasing.

This study aimed to highlight the changes and impact of key climatic factors (temperatures and precipitations) on the ripening and composition of grapes in two wine centers from

Murfatlar and Iasi vineyards. The research is useful for winemakers in order to assess the advantages and risks of these climatic changes, so they can adapt their viticultural practices and maintain the typicity of white and red wines from the two studied wine regions, given the fierce competition in the wine industry and the increasing consumer demand for quality wines that reflect the terroir.

MATERIALS AND METHODS

The study was conducted on white wine grape cultivars 'Chardonnay', 'Sauvignon blanc', and 'Columna' for both wine regions. Regarding red wine grape cultivars, 'Fetească neagră', 'Pinot noir' and 'Mamaia' were studied for the Murfatlar vineyard, and 'Fetească neagră', 'Cabernet sauvignon' and 'Arcaş' for the Iasi wine region. All the mentioned cultivars are authorized for producing quality wines with a Controlled Designation of Origin. Data were analyzed over two consecutive years, 2023 and 2024.
The vineyards in the Murfatlar and Iasi wine centers were established after 2009 on Berlandieri x Riparia rootstock, selection Oppenheim 4, clone 4 (SO4-4). The rows are N-S oriented, with a planting distance of 2.2 m between rows and 1.2 m within rows, resulting in a density of 3,787 plants/ha. The training system is a bilateral cordon with a trunk height of 0.8 m. Climatic parameters (maximum and minimum temperature and precipitation) were recorded with an iMetos 3.3 weather station (Murfatlar) and a AgroExpert weather station (Iasi). Grape must sugar (g/L) equated according to the total soluble solids content (refractometeric method) and total acidity (g/L as tartaric acid) and pH were determined using the standard methods specified in the OIV Compendium of International Methods of Wine and Must Analysis. Data were expressed as the mean ± standard deviation. One-way analyses of variance of means (ANOVA) and the mean differences of the various samples were compared by a post-hoc test (Duncan multiple mean comparison test). A difference of $p < 0.05$ was considered as significant.

RESULTS AND DISCUSSION

Analyzing the evolution of the monthly average air temperatures over the two studied years presented in Table 1, a difference in the values of this parameter compared to the multi-annual average can be observed. As seen, in 2024, the recorded values at Murfatlar are significantly higher in July, 26.1°C and August, 28.5°C compared to Iasi, which recorded values of 22.7°C in July and 25.0°C in August. Similar differences of at least 2°C are observed in 2023 for the summer months between Murfatlar and Iasi. Observations indicate that for both vineyards, the average air temperatures were higher compared to the multi-annual average by 2.8°C to 4.4°C at Murfatlar and by 0.94°C to 2.84°C at Iaşi.

Table 1. The evolution of average monthly air temperatures for the two studied wine growing areas

Vineyard	Murfatlar			Iasi		
Month/ Temperature/Year	Average temperatures	2023	2024	Average temperatures	2023	2024
IV	10.5	10.8	16.2	10.8	8.1	14.2
V	16.2	17.4	16.6	16.5	16.2	16.7
VI	20.4	22.8	26.1	20.2	20.4	22.7
VII	22.6	26.8	28.5	22.0	23.0	25.0
VIII	22.6	26.9	26.1	21.4	24.6	24.4
IX	17.6	22.2	-	16.1	19.9	-
Average	18.3	21.2	22.7	17.8	18.7	20.6

Climatic variability, particularly of minimum and maximum air temperatures, as well as the lack of precipitation plays an important role in the biosynthesis of sugars and organic acids in grapes. The evolution of minimum and maximum temperatures recorded during the two studied viticultural years in the two vineyards, Murfatlar and Iasi, is illustrated in Figure 2.

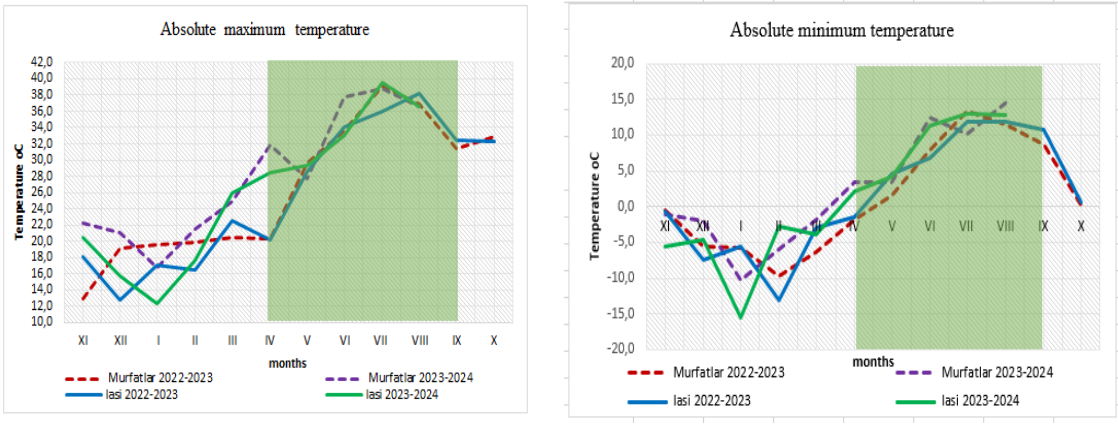

Figure 2. Evolution of maximum and minimum temperatures for the two vineyards

In the spring months, both vineyards show very large differences (on average 24.5°C) between minimum temperatures (-1.9°C to 3.4°C in April and 1.5°C to 4.6°C in May) and maximum temperatures (20.3°C to 31.9°C in April and 27.7°C to 29.7°C in May). Summer months (June, July, August) had minimum values ranging from 6.8°C to 13.4°C, with temperatures at least 2°C higher at Murfatlar (10.3°C to 14.5°C) compared to Iaşi (6.8°C to 12.8°C).

Regarding the evolution of maximum temperatures during the summer months, temperatures exceeding 30.6°C can be observed, with recorded temperatures reaching up to 39.1°C in July 2023 at Murfatlar and in the same month in 2024 at Iasi.

In September 2023, minimum temperatures dropped to a range of 8.6°C to 10.7°C, while maximum temperatures fluctuated within a relatively narrow range of 31.4°C to 32.4°C.

Among the ecological factors, water plays a crucial role, being the most important component of the vegetative organs of the vine, supporting numerous metabolic functions, participating in biochemical reactions, and facilitating the transport of substances and synthesized products.

The precipitation regime, represented as the number of rainy days classified into three categories based on quantity (>0.1 mm; >5 mm; >10 mm), is shown in Table 2. It can be observed that for Murfatlar in 2023 the highest number of rainy days was recorded, especially those with >0.1 mm (40 days) compared to Iasi, where there were 36 days, whereas in 2024, the number of rainy days decreased, with 35 days in Murfatlar and 26 days in Iasi. Regarding the number of days with rainfall >10 mm, Murfatlar recorded a maximum of 3 days in April 2023 and in April and August 2024, while Iasi had 6 days in the same month of April 2023 (Table 2).

Table 2. The number of days with rain for the two wine growing areas

Year/ Vineyard	2023						2024					
	Murfatlar			Iasi			Murfatlar			Iasi		
	No.of days with rain			No.of days with rain			No.of days with rain			No.of days with rain		
Month	>0,1	>5	>10	>0,1	>5	>10	>0,1	>5	>10	>0,1	>5	>10
IV	13	7	3	11	1	6	10	5	3	6	1	1
V	8	1	0	3	1	1	8	1	1	4	1	2
VI	7	1	1	6	3	0	4	1	0	4	1	3
VII	8	0	2	8	0	3	6	1	2	6	2	2
VIII	3	0	0	1	0	1	8	5	3	6	2	1
IX	1	0	0	6	0	0	-	-	-	-	-	-
Total	40	9	6	35	5	11	36	13	9	26	7	9

Analyzing the precipitation quantity recorded during the growing season (Figure 3), it can be observed an uneven distribution, alternating in 2023 between periods of pluviometric excess - April at Murfatlar and April and July at Iasi, as well as periods of deficit - May, June, July, August, September at Murfatlar and May, June, August, September at Iasi. The total precipitation recorded was 170.9 mm at Murfatlar and nearly double, at 349.3 mm at Iaşi, with values lower compared to the multi-annual average of 245.7 mm at Murfatlar and 384.3 mm at Iasi. In 2024 the total precipitation quantity recorded was 169.4 mm at Murfatlar and 250.0 mm at Iasi, with a decrease of 0.87% for Murfatlar and 28.42% for Iasi by comparison with 2023.

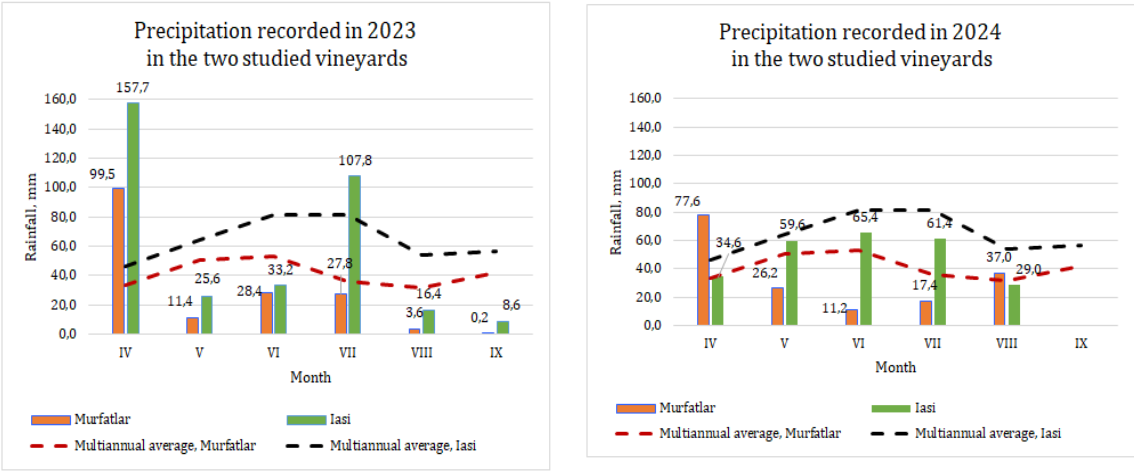

Figure 3. Precipitation for 2023 and 2024 compared to the multi-annual average

The analysis of the experimental data (Table 3), shows that the climatic variability of the two studied years for the two wine regions influenced the synthesis of primary metabolites (sugars and organic acids) in grapes. Thus, at harvest time, the sugar content was significantly higher at Murfatlar compared to Iasi, with higher values for red wine grape cultivars - over 220 g/L, with an average of 8.37% higher compared to Iasi. For white wine grape cultivars, sugars showed similar values, ranging from 200.3 g/L to 212.3 g/L at Murfatlar compared to 200.7 g/L to 206.0 g/L at Iasi. For white wine grape cultivars, sugar levels showed similar values ranging from 200.3 g/L to 212.3 g/L at Murfatlar compared to 200.7 g/L to 206.0 g/L at Iasi. Harvesting took place at Murfatlar from September 13 to September 29 in 2023 and between August 20 and September 16 in

2024. It is noteworthy that the red wine cultivars were harvested before the white wine cultivars. At the Copou Iasi wine center, the white cultivars were harvested from September 23 to September 29 in 2023, and one week earlier in 2024. Similar studies have concluded that with increasing temperatures, the rate of sugar accumulation in grapes is accelerated, forcing wine growers to harvest earlier (Stanfield *et al*., 2024). Extreme temperatures during grape maturation reduce vine metabolism, resulting in high sugar concentrations and lower total acidity, which affects the taste balance and overall quality of the grapes (Husain *et al*., 2022).

Regarding the evolution of total acidity, this parameter recorded values ranging from 4.90 to 5.97 g/L of tartaric acid at Murfatlar and from 6.40 to 8.80 g/L of tartaric acid at Iasi, with higher values observed for red wine grape cultivars in this wine center. The most significant increase in pH was recorded for the 'Columna' *cv.* in 2024, due to reduced photosynthetic activity. Although the years 2023 and 2024 differed climatically, the average pH values fluctuated between 3.380 and 3.480 at Murfatlar and between 3.143 and 3.444 at Iasi, generally moderate values below 3.6 (Table 3), which is favorable for producing stable wines.

Table 3. The chemical characteristics of the musts obtained at the moment of harvest

Wine center	Harvest year	Type	Cultivar	Harvest date	Sugars (g/L)	Total acidity (g/L tartaric acid)	pH
Murfatlar	2023	white	Chardonnay	13.sept	227.8	5.03	3.184
			Sauvignon blanc	26.sept	207.0	4.90	3.607
			Columna	29.sept	202.0	5.66	3.350
		average			*212.3±13.7 abc*	*5.19±0.4 c*	*3.380±0.21 ab*
		red	Fetească neagr-	15.sept	224.3	5.66	3.321
			Pinot noir	17.sept	216.1	5.20	3.653
			Mamaia	19.sept	225.7	5.11	3.253
		average			*222.0±5.2 ab*	*5.32±0.29 c*	*3.409±0.21 ab*
	2024	white	Chardonnay	02.sept	210.8	5.97	3.238
			Sauvignon blanc	02.sept	196.4	5.20	3.420
			Columna	16.sept	193.8	4.90	3.675
		average			*200.3±9.2 c*	*5.36±0.55 c*	*3.444±0.22 a*
		red	Fetească neagră	20.aug	236.1	5.21	3.593
			Pinot noir	26.aug	228.2	5.04	3.360
			Mamaia	02.sept	219.2	4.90	3.486
		average			*227.8±8.4 a*	*5.05±0.15 c*	*3.480±0.11 a*
Iasi	2023	white	Chardonnay	29.sept	228.0	6.40	3.362
			Sauvignon blanc	28.sept	198.0	7.00	3.341
			Columna	23.sept	192.0	7.50	3.301
		average			*206.0±19.3 bc*	*6.96±0.55 b*	*3.335±0.03 ab*
		red	Fetească neagră	12.oct	201.0	7.1	3.114
			Cabernet Sauvignon	10.oct	195.0	8.8	3.235
			Arcaș	06.oct	182.0	8.2	3.081
		average			*192.6±9.7 c*	*8.03±0.86 a*	*3.143±0.08 b*
	2024	white	Chardonnay	06.sept	206	7.0	3.402
			Sauvignon blanc	06.sept	200	6.9	3.339

Wine center	Harvest year	Type	Cultivar	Harvest date	Sugars (g/L)	Total acidity (g/L tartaric acid)	pH
			Columna	09.sept	196	7,1	3,368
		average			*200,7±5,0 c*	*7,00±0,10 b*	*3,370±0,03 ab*
		red	Feteascp neagrp	20.sept	234	6,3	3,562
			Cabernet Sauvignon	20.sept	214	8,2	3,351
			Arcaş	10.sept	217	7,1	3,420
		average			221,7*±10,7 ab*	7,20*±0,32 ab*	3,444*±0,08 a*

*Mean values ± standard deviation (n=3). Letters represent significance of p<0.05 difference between variants. The difference between any two values followed by at least one common letter is insignificant. Significance: *p<0.05, **p<0.01, ***p<0.001, ns= not significant.*

CONCLUSIONS

Climate change represents a major challenge for viticulture due to the variability of climatic factors (temperature and precipitation) that affect both the physiology and biochemistry of the vine, altering the phenology and composition of grape berries. Research on the impact of climatic factors on vine phenology and grape quality must continue to better understand the relationship between climate and grape development, in order to test the plants' ability to adapt to new conditions and to find the best measures to ensure the sustainability and ongoing success of grape production and the entire wine industry.

ACKNOWLEDGEMENTS

This study was funded by ASAS Bucharest and MADR Bucharest under projects PB-627/01.02.2023: Modern Technologies for Enhancing the Oenological Potential of Romanian Grape. Cultivars to Increase Their International Competitiveness and PB 3310/08.12.2022: Integrated Technological Solutions for Vineyard Cultivation Adapted to Climate Change to Ensure the Profitability of Vineyards in the Northeast of the Country.

REFERENCES

1. Arias L. A., Berli F., Fontana A., Bottini R., and Piccoli P. (2022). Climate change effects on grapevine physiology and biochemistry: benefits and challenges of high altitude as an adaptation strategy. Frontiers in Plant Science, vol. 13: 835425, pp: 1:14
2. Ilina-Dumitru A.M., Manolescu A.E., Sumedrea D.I., Florea A.C., and Cosmulescu S.N. (2024). Climate influence on the phenology of table grapes in Stefanesti, Romania. ISHS Acta Hortic., 1385: XIII International Conference on Grapevine Breeding, Genetics and Management, 181–188. 1385
3. Fernandes J.C., Cobb F., Tracana S., Costa G.J., Valente I., Goulao L.F., and Amaîncio S. (2015). Relating water deficiency to berry texture,skin cellwall composition and expression of remodeling genes in two *Vitis vinifera* L. varieties. J. Agric. Food Chem., 63, 3951–3961.
4. Hardie W. J., and Considine J. A. (1976). Response of grapes to water-deficit stress in particular stages of development. Am. J. Enol. Vitic. 27, 55–61.
5. Hussain Shah M., Rafique R., Rafique T., Naseer M., Khalil U., and Rafique R. (2022). Effect of climate change on polyphenols accumulation in grapevine; IntechOpen: London, UK.

6. Kafkas E., Kosar M., Paydas S., Kafkas S., and Baser K.H.C. (2007). Quality characteristics of strawberry genotypes at different maturation stages. Food Chem. 100, 1229–1236.
7.Lecourieux F., Kappel C., Pieri P., Charon J., Pillet J., and Hilbert G. (2017). Dissecting the biochemical and transcriptomic effects of a locally applied heat treatment on developing Cabernet sauvignon grape berries. Front. Plant Sci. 8.
8. Lorenzo M.N., Taboada J.J., Lorenzo J.F., and Ramos A.M. (2013). Influence of climate on grape production and wine quality in the Ríasaixas, north-western Spain. Reg. Environ. Chang, 13, 887–896.
9. Palliotti A., Tombesi, S., Silvestroni O., Lanari V., Gatti M., and Poni S. (2014). Changes in vineyard establishment and canopy management urged by earlier climate-related grape ripening: A review. Sci. Hortic.,178, 43–54.
10. Pillet J., Egert A., Pieri P., Lecourieux F., Kappel C., and Charon J., (2012). VvGOLS1 and VvHsfA2 are involved in the heat stress responses in grapevine berries. Plant Cell Physiol. 53.
11. Sweetman C., Sadras V. O., Hancock R. D., Soole K. L., and Ford C. (2014). Metabolic effects of elevated temperature on organic acid degradation in ripening *Vitis vinifera* fruit. J. Exp. Bot. 65.
12. Stanfield R.C., Forrestel E.J., Elmendorf K.E., Bagshaw S.B., and Bartlett M.K. (2024). Phloem anatomy predicts berry sugar accumulation across 13 wine-grape cultivars. Front. Plant Sci. 15, 1360381.
13. OIV (International Organization of Vine andWine). Compendium of International Methods of Wine and Must Analysis; OIV: Paris,France, 2019; Volume 1.