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THE QUALITY OF GRAPE MUST AND WINE IN THE BUZIAS AREA, UNDER THE CONDITIONS OF CLIMATE CHANGE

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Abstract

The study was conducted in a vineyard in the Buziaș-Silagiu area between 2023 and 2024. The vineyard has now reached full maturity after being established in stages between 2012 and 2018. The planting configuration consists of a row spacing of 2.2 meters and a vine spacing of 1 meter within rows, resulting in a planting density of 4,545 vines per hectare. The study aimed to evaluate how the grape varieties cultivated in the vineyard utilize the area's natural resources and how these factors influence the quality of both grape must and the resulting wine. Six grape varieties, representing the largest cultivated areas within the vineyard, were analyzed: red wine varieties: Cabernet Sauvignon, Merlot, and Fetească Neagră; white wine varieties: Chardonnay and Fetească Albă; aromatic wine variety: Muscat Ottonel. Observations and analyses focused on the biochemical composition of the must, monitoring key parameters, assessing the evolution of the must during alcoholic fermentation, and evaluating the primary characteristics of the final wine. The Buziaș-Silagiu viticultural area has a long-established tradition and is well-suited for cultivating both white and red wines, as well as aromatic varieties. Despite the challenges posed by climate change, factors such as solar radiation, effective temperature accumulation, and precipitation levels remain relatively balanced, exerting a positive influence on vine growth and the overall quality of the wines produced.

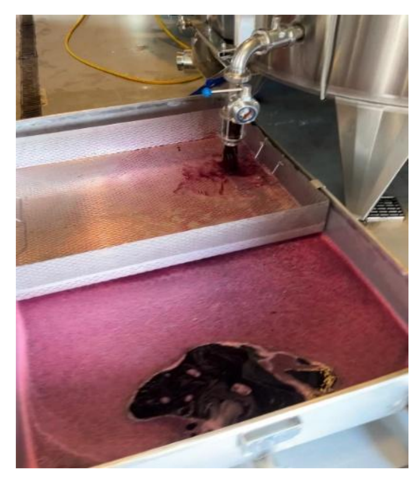
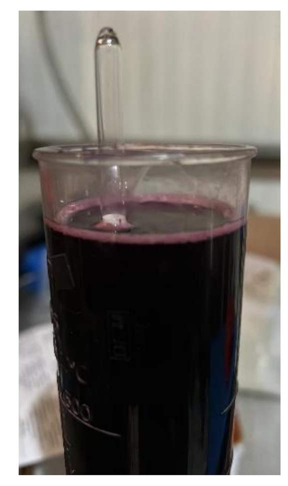
The quantitative assessment of yield was conducted at harvest maturity by measuring the total grape yield per vine and extrapolating to a per-hectare basis. The sugar content of the must was determined using a digital refractometer (°Brix), which measures the refractive index of the grape juice. This method provides an accurate estimation of soluble solids, primarily sugars, present in the must, and is commonly used as a standard parameter to assess grape ripeness and potential alcohol content in the resulting wine (OIV, 2022).

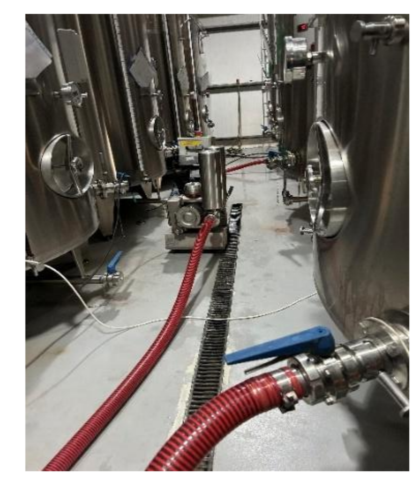
- Introduction

Located in the southwest of Romania, the Banat wine region boasts a long-standing and distinguished tradition in viticulture, supported by its unique pedoclimatic conditions. The region's moderate continental climate, with hot summers, mild winters, balanced rainfall, and diverse soil types (including rendzinas and luvisols), creates a favourable environment for grapevine cultivation and the production of premium wines [6;17]. The viticulture of Banat, and particularly of Buziaș, is not merely a rural economic activity but a cultural symbol that reinforces local identity and supports rural development. Knowledge of vine cultivation and winemaking is passed down through generations and celebrated through festivals such as the "Wine Fair of Banat" held in Buziaș. These events contribute to tourism and strengthen the social fabric of the region [23]. Buziaș vineyards cultivate both international and indigenous grapevine varieties, with an increasing focus on quality-driven viticulture. Among the red wine varieties, Cabernet Sauvignon, Merlot, and Fetească Neagră are prominent, appreciated for their structure, complexity, and aging potential. For white wines, Chardonnay and Fetească Albă are cultivated for their balanced acidity and aromatic finesse. Additionally, Muscat Ottonel, an aromatic white variety, is grown for producing expressive, floral wines [7]. The combination of traditional practices with modern vineyard management techniques - such as controlled irrigation, density optimization (e.g., 4,545 vines/ha), and precision viticulture - has contributed to the region's continued evolution. Moreover, Buziaș's vineyards have shown adaptive resilience in the face of climate change. Studies report that the region maintains favourable levels of solar radiation and thermal accumulation, which are crucial for phenolic maturity and sugar-acid balance in grapes [14].This study aims to assess how these grape varieties utilize the environmental resources of Buziaș and how pedoclimatic conditions influence must composition and wine quality. By analyzing biochemical indicators during fermentation and final wine traits, the research contributes to a better understanding of varietal expression and oenological potential within the Buziaș terroir. The findings were expected to support sustainable viticulture and enhance the visibility of Banat wines in global markets.

- Material and method

The research was conducted between 2023 and 2024 in a vineyard located in the Buziaș–Silagiu viticultural area. The vineyard was established in successive stages between 2012 and 2018 and has now reached full maturity. The planting configuration consists of 2.2 meters between rows and 1 meter between vines within the row, resulting in a planting density of 4,545 vines per hectare. The study aimed to evaluate how the grape varieties included in the vineyard's varietal assortment utilize the natural resources of the area, as reflected in the quality of both the grape must and the resulting wine. Six grapevine varieties, representing the largest cultivated areas within the vineyard, were selected for analysis. These include three red wine cultivars: *Cabernet Sauvignon, Merlot*, and *Fetească Neagră*; two white wine cultivars: *Chardonnay* and *Fetească Albă*; and one aromatic variety: *Muscat Ottonel.* Observations and measurements were carried out on the biochemical composition of the must, by monitoring key parameters, the evolution of the must during alcoholic fermentation, and the main characteristics of the final wine obtained.



Results and discussions

The quality of grape must is essential for producing high-quality wines that are well-balanced and possess distinctive organoleptic attributes capable of meeting consumer expectations. Must quality is primarily determined by the biochemical composition of the grapes, including sugar content, acidity, phenolic compounds, and aroma precursors [13]. However, it is also significantly influenced by factors such as the timing of harvest, the duration between harvest and grape processing, and, importantly, the precision and quality of the winemaking process. Optimal harvest time is crucial, as it ensures a favourable balance between sugar accumulation and acid degradation, both of which affect potential alcohol content and freshness of the wine [15]. Additionally, pre-fermentation practices, such as cold soaking, must clarification, or the use of sulphur dioxide, can further impact the must's composition and the final sensory attributes of the wine [27]. Environmental and viticultural factors - including climate, soil type, vine management, and vintage variation—also play a vital role in must quality [29]. In particular, rising temperatures due to climate change have led to accelerated sugar accumulation, which may result in high-alcohol wines unless mitigated by adaptive vineyard and winery practices [10; 19]. Taken together, these elements demonstrate that grape must quality is not a static characteristic, but the result of dynamic interactions among grape biochemistry, environmental conditions, and technological interventions in the vineyard and winery.

Cabernet Sauvignon grape must – 2023 vintage

Sample description and identification for analysis		
Analysis start date: September 27. 09.2023 Analysis completion date: September 27.09. 2023		
Physico-chemical analysis of the sample		
Parameter	Unit of measurement	Results
Total soluble solids (refractometric method)	g/L	232.30
Total acidity	g/L tartaric acid	6.45
Volatile acidity	g/L acetic acid	0.25
Total sugars	g/L	1.68
Reducing sugars	g/L	1.48
Malic acid	g/L	3.18
pH		3.31
Free sulfur dioxide (internal method, iodometric method)	mg/L	17.50
Total sulfur dioxide (internal method, iodometric method)	mg/L	80.00

Cabernet Sauvignon wine – 2023 vintage

Physico-chemical parameters	Unit of measurement	Results	Specific limits m=min; M=max	Date of analysis
Alcohol concentration	% vol. alcohol	14.37	m =11.0%	18.Jul.2024
Total acidity (as tartaric acid)	g/l	5.90	m =4.50 g/l	18. Jul.2024
Volatile acidity (as acetic acid)	g/L	0.58	M =1.20 g/L	18. Jul.2024
Total sulphur dioxide	mg/L	50.0	M =150.0 mg/L	18. Jul.2024
Free sulphur dioxide	mg/L	27.0	M =50.0 mg/L	18. Jul.2024
Glucose + Fructose	g/L	1.97	-	18. Jul.2024
Total sugars	g/L	2.56	-	18. Jul.2024
Non-reducing dry extract	g/L	30.01	m =17.0 g/L	18. Jul.2024
Total dry extract	g/L	32.0	-	18. Jul.2024
Relative density at 20°C	-	0.9937	-	18. Jul.2024
pH	-	3.56	-	18. Jul.2024
Energy value	Kcal/Kj/100 ml	86/361	-	18. Jul.2024
Carbohydrates – of which	g/100 ml	3.20		
Sugars		0.256	-	18. Jul.2024

Merlot grape must – 2023 vintage

Description and identification of the sample submitted for analysis		
Start date of analysis: September 25.09. 2023		
End date of analysis: September 25.09.2023		
Must analysis		
Determination	Unit of Measurement	Result obtained
Total sugar content (refractometric)	g/L	213.61
Total acidity (as tartaric acid)	g/L acid tartric	4.65
pH	-	3.42

Merlot grape wine – 2023 vintage

Physicochemical analysis results Parameter	Unit of Measurement	Results	Specific limits m=min M=max	Analytical date
Alcohol concentration	% vol	14.64	m = 11.01%	07.Nov.2024
Total acidity (as tartaric acid)	g/L	5.51	m =4.52 g/L	07.Nov.2024
Volatile acidity (as acetic acid)	g/L	0.76	M=1.202 g/L	07.Nov.2024
Total sulphur dioxide	mg/L	14.2	M=150.2 mg/L	07.Nov.2024
Free sulphur dioxide	mg/L	10.1	M =20.2 mg/L	07.Nov.2024
Glucose + Fructose	g/L	2.81		07.Nov.2024
Total sugars	g/L	3.46		07.Nov.2024
Non-reducing dry extract	g/L	27.68	m=17.2 g/L	07.Nov.2024
Total dry extract	g/L	30.51		07.Nov.2024
Relative density at 20°C	-	0.9927		07.Nov.2024
pH	-	3.56		07.Nov.2024
Energy value	Kcal/Kj/100 ml	88/366		07.Nov.2024
Carbohydrates – of which sugars	g/100 ml	3.03		07.Nov.2024
		0.346		

Grape must from the Fetească Neagră variety – 2023 vintage

Sample description and identification		
Analysis start date: September 24.09.2023		
Analysis end date: September 24.09.2023		
Must analysis results		
Determination	Unit of Measurement	Results
Total sugar content (refractometric)	g/L	216.0
Total acidity	g/L as tartaric acid	4.74
pH	-	3.60

Fetească Neagră wine – 2023 vintage

Analytical parameters	Unit of Measurement	Results	Specific limits m=min; M=max	Analysis date
Alcohol concentration	% vol	14.44	m=11.0%	06.Nov.2024
Total acidity (as tartaric acid)	g/l	6.02	m=4.5 g/l	06. Nov.2024
Volatile acidity (as acetic acid)	g/l	0.35	M=1.2 g/l	06. Nov.2024
Total sulphur dioxide	mg/l	17.0	M=150.0 mg/l	06. Nov.2024
Free sulphur dioxide	mg/l	6.0	m=20.0 mg/l	06. Nov.2024
Glucose + Fructose	g/l	0.32		06. Nov.2024
Total sugars	g/l	0.92		06. Nov.2024
Non-reducing dry extract	g/l	30.36	m=17.0 g/l	06. Nov.2024
Total dry extract	g/l	30.7		06. Nov.2024
Relative density at 20°C	-	0.9931		06. Nov.2024
pH	-	3.72		06. Nov.2024
Energy value	Kcal/Kj/100 ml	86/358		06. Nov.2024
Carbohydrates – of which sugars	g/100 ml	3.06 / 0.092		06. Nov.2024

Chardonnay Grape Must – 2023 vintage

Sample description and identification		
Analysis start date: 07 September 2023		
Analysis completion date: 07 September 2023		
Must analysis – physicochemical parameters		
Parameter	Unit of Measurement	Results
Total sugar (refractometric)	g/L	209.2
Total acidity	g/L (as tartaric acid)	5.65
pH	-	3.24

The quality of grape must is essential for producing high-quality wines that are well-balanced and possess distinctive organoleptic attributes capable of meeting consumer expectations. Must quality is primarily determined by the biochemical composition of the grapes, including sugar content, acidity, phenolic compounds, and aroma precursors [13]. However, it is also significantly influenced by factors such as the timing of harvest, the duration between harvest and grape processing, and, importantly, the precision and quality of the winemaking process. Optimal harvest time is crucial, as it ensures a favourable balance between sugar accumulation and acid degradation, both of which affect potential alcohol content and freshness of the wine [15]. Additionally, pre-fermentation practices, such as cold soaking, must clarification, or the use of sulphur dioxide, can further impact the must's composition and the final sensory attributes of the wine [27]. Environmental and viticultural factors - including climate, soil type, vine management, and vintage variation—also play a vital role in must quality [29]. In particular, rising temperatures due to climate change have led to accelerated sugar accumulation, which may result in high-alcohol wines unless mitigated by adaptive vineyard and winery practices [10; 19]. Taken together, these elements demonstrate that grape must quality is not a static characteristic, but the result of dynamic interactions among grape biochemistry, environmental conditions, and technological interventions in the vineyard and winery.

The 2023 Cabernet Sauvignon grape must from the Buziaș–Silagiu area (Table 1) exhibited a total soluble solids concentration of 232.30 g/L, aligning with optimal harvest parameters for this variety, which typically range between 24–26.5 °Brix (approximately 230–265 g/L). The must's total acidity was measured at 6.45 g/L (as tartaric acid), and the pH was 3.31, both within the desirable range for red wine production, where pH values between 3.3 and 3.6 are considered favourable. The volatile acidity was low at 0.25 g/L (as acetic acid), indicating minimal microbial spoilage and a clean fermentation profile. The malic acid concentration stood at 3.18 g/L, suggesting a significant potential for malolactic fermentation, which can enhance wine stability and complexity. The free and total sulphur dioxide levels were 17.50 mg/L and 80.00 mg/L, respectively, within acceptable limits to ensure microbial stability without adversely affecting the wine's sensory attributes. These parameters collectively suggest that the 2023 vintage Cabernet Sauvignon must possess a balanced composition conducive to producing high-quality wines with good aging potential.

For the Cabernet Sauvignon variety, the long and warm autumn favoured a particularly advantageous accumulation of quality-related compounds, despite the fact that this is one of the latest ripening cultivars among red wine grapes. The must was well-balanced, with a favourable sugar-to-acidity ratio, indicating a high aging and development potential. The excellent quality of the must, together with a carefully managed vinification process, allowed for the production of a base wine with very good characteristics. This wine shows high versatility in terms of maturation and development, allowing it to be refined into various wine categories - ranging from dry to semi-dry wines, and from fruit-forward styles to those matured with oak chips or in barrels [12].

In Merlot variety (Table 3), although genetically this variety ripens earlier than Cabernet Sauvignon, the sugar concentration in the must was lower. This outcome is attributed to Merlot's slightly reduced capacity to optimally exploit the natural resources of the Buziaș–Silagiu area. Nevertheless, the must still presented a balanced composition, with a favourable sugar-to-acidity ratio and good potential for vinification.

Resulted values are within the typical ranges for Merlot grape musts. For instance, studies have reported sugar contents around 221.5 g/L, total acidity values ranging from 6.7 to 8.3 g/L, and pH levels between 3.0 and 3.6 for Merlot musts. The pH value of 3.42 is also within the desirable range for red wines, which is generally between 3.3 and 3.6 [25]. Maintaining appropriate pH and acidity levels is crucial for the stability and sensory attributes of the resulting wine. A pH within the optimal range helps inhibit microbial growth, enhances colour stability, and contributes to the overall balance of the wine. Furthermore, the sugar content indicates potential alcohol levels, which are essential for the body and mouthfeel of the wine [20]. The analytical profile of the 2023 Merlot must suggest favourable conditions for producing a balanced and high-quality red wine.

The total acidity was measured at 5.51 g/L (as tartaric acid), and the pH was 3.56. These values fall within the desirable range for red wines, contributing to the wine's freshness and stability. A study on Merlot wines reported pH values between 3.64 and 3.74, with total acidity ranging from 3.90 to 4.65 g/L, depending on the aging vessel used [26]. Volatile acidity is recorded at 0.76 g/L (as acetic acid), which is below the sensory detection threshold of 1 g/L, indicating proper fermentation and storage conditions. The low levels of free (10.1 mg/L) and total sulphur dioxide (14.2 mg/L) suggest minimal intervention, preserving the wine's natural profile [4]. Residual sugars (comprising glucose and fructose) total 2.81 g/L, classifying the wine as dry. This is consistent with other Merlot wines, where residual sugar levels ranged from 1.60 to 2.10 g/L after aging [22]. The non-reducing dry extract is 27.68 g/L, and the total dry extract is 30.51 g/L, indicating a wine with substantial body and mouthfeel. These values are comparable to those found in Merlot wines aged in various vessels, where dry extract levels ranged from 23.2 to 27.6 g/L [18]. The 2023 Merlot wine from the Buziaș–Silagiu region exhibits physicochemical parameters that are in line with high-quality Merlot wines from other regions, reflecting both the grape's potential and the effectiveness of the winemaking process.)

The data from table 5 are consistent with the typical ranges reported for Fetească Neagră grape musts [21]. For instance, studies have indicated that this variety can accumulate sugar levels between 230 and 240 g/L under optimal conditions, with total acidity values ranging from 4.5 to 5.7 g/L. The pH value of 3.60 aligns with the desirable range for red grape musts, which generally falls between 3.3 and 3.6. Maintaining appropriate sugar and acidity levels is crucial for the fermentation process and the development of the wine's sensory attributes. The sugar content directly influences the potential alcohol content of the wine, while the acidity and pH levels affect its freshness, stability, and colour [24]. The analytical profile of the 2023 Fetească Neagră suggests favourable conditions for producing a balanced and high-quality red wine.

The physicochemical parameters of the 2023 vintage Fetească Albă wine (Table 10) align with established profiles for this Romanian white grape variety. The alcohol content of 12.79% vol., is consistent with the typical range for Fetească Albă wines, which often exhibit alcohol levels between 12% and 13% vol., depending on ripeness and regional conditions. The total acidity measured at 5.87 g/L (as tartaric acid) falls within the expected range for this variety. For instance, a study on Fetească Albă wines from the Dealu Bujorului vineyard reported total acidity values around 5.90 g/L. The pH value of 3.36 is also typical for Fetească Albă wines, which generally exhibit pH levels between 3.2 and 3.6 [9]. Volatile acidity, primarily due to acetic acid, was found to be 0.29 g/L, well below the sensory threshold of 0.8–1.0 g/L beyond which vinegar-like aromas become perceptible. This low level indicates a clean fermentation process without significant microbial spoilage. The total sulphur dioxide content of 89.0 mg/L and free sulphur dioxide of 18.0 mg/L are within acceptable limits for dry white wines, ensuring microbial stability without compromising sensory qualities [5]. Residual sugar content, as indicated by glucose and fructose levels totalling 0.58 g/L and total sugars at 0.71 g/L, classifies this wine as dry. This is consistent with other Fetească Albă wines, which reported a residual sugar content of 0.31 g/L. The non-reducing dry extract measured at 18.22 g/L reflects the concentration of non-volatile substances contributing to the wine's body and mouthfeel. Similar values have been observed in Fetească Albă wines from various Romanian regions. The relative density at 20°C of 0.9904 aligns with expectations for dry white wines, indicating proper fermentation and alcohol content. The energy value of 74 Kcal/309 KJ per 100 ml is typical for wines of this alcohol and sugar content.

The analytical parameters of the 2023 Muscat Ottonel wine (Table 12) as presented in Table 12 align closely with findings from recent studies on this grape variety. The alcohol content of 14.03% vol., is notably higher than the 11.00% vol., reported for Muscat Ottonel wines from the Dealu Bujorului vineyard in Romania, suggesting regional and vintage variations. The total acidity of 5.45 g/L (as tartaric acid) is consistent with values observed in other Muscat Ottonel wines, such as the 5.55 g/L reported for wines from the Blaj region. The volatile acidity measured at 0.41 g/L (as acetic acid) falls within the typical range for this variety, aligning with the 0.32 g/L reported in similar studies [9]. Regarding sulphur dioxide levels, the total SO_2 content of 134.0 mg/L and free SO_2 of 48.0 mg/L are within acceptable limits for white wines, ensuring microbial stability and preservation. The residual sugar content of 6.39 g/L classifies this wine as semi-dry, offering a balanced palate that complements its aromatic profile. The non-reducing dry extract of 18.14 g/L indicates a wine with substantial body and mouthfeel, which is desirable in quality white wines. The pH value of 3.25 contributes to the wine's freshness and stability, aligning with the pH range of 3.27 to 3.62 observed in Muscat Ottonel wines from various Romanian vineyards.

Conclusions

The viticultural area under study is a region with a longstanding tradition and clear potential for cultivating both white and red wines, as well as aromatic varieties. Even in the context of global warming, parameters such as insolation, effective temperatures, and precipitation levels remain balanced, exerting a positive influence on vine cultivation and the quality of the wines produced. The varietal assortment within the vineyard where the research was conducted is well-balanced, comprising both indigenous and international grape varieties, covering all major wine categories (red, white, and aromatic). This diversity enables the winery to meet a wide range of consumer preferences and demands, offering significant flexibility for adapting to a dynamic and volatile wine market. All three red wine varieties studied yielded favorable results, producing quality wines capable of diverse evolutions - from dry to semi-dry wines, from fruit-forward styles to full-bodied, matured, aged, or even barrel-aged wines. A special remark must be made regarding the Romanian varieties. Both Fetească Neagră and especially Fetească Albă demonstrated excellent performance in terms of quality. The resulting wines were remarkable and highly appreciated by the majority of tasters, as evidenced by the growing market demand for wines from these two varieties. The quality of the Muscat Ottonel wine further reinforces the belief held by many viticulturists and consumers that this viticultural area possesses exceptional natural conditions for producing aromatic wines, particularly those made from the Muscat Ottonel variety.

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