JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 41-49
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

The impact of Merlot grapes harvesting time on berry composition

Eleonora NISTOR[1], Alina DOBREI[1*], Simion ALDA[2], Marcel DANCI[3], Gabriel CIORICA[4], Alin DOBREI[1*]

[1]University of Life Sciences “King Michael I” from Timișoara, Faculty of Engineering and Applied Technologies, Department of Horticulture, e-mail: nisnora@yahoo.com, ghitaalina@yahoo.com, alin1969tmro@yahoo.com
[2]University of Life Sciences “King Michael I” from Timișoara, Faculty of Engineering and Applied Technologies, Department of Forestry, e-mail: aldasimion@yahoo.com
[3]University of Life Sciences “King Michael I” from Timișoara, Faculty of Engineering and Applied Technologies, Department of Genetic Engineering, e-mail: marcel_research@yahoo.com
[2]“Victor Babeș” University of Medicine and Pharmacy, Timişoara, Romania, email: gciorica@gmail.com

*Corresponding author: alin1969tmro@yahoo.com, ghitaalina@yahoo.com

Manuscript received: 15 May 2024; revised: 29 May 2024; accepted: 4 June 2024

Abstract
The study took place between 2020 and 2022 during the wine harvest season with the aim to analyse and compare the physical and chemical characteristics of Merlot grapes from three vineyards in the western of Romania region: Miniș, Recaș and Buziaș. Twenty-five vines were randomly selected at each site with comparable vineyard management techniques to collect samples. The experimental layout was randomly assigned, with three treatments and three replications for each individual test. The research investigated three phases of berry growth, each marked by unique biochemical alterations. Four hundred berries were chosen at random from clusters on every vine in every replication. Different sampling dates were used to collect grapes for basic analyses, which involved berry weight, seed and skin weight, soluble solids, total acidity, tannins and pH. The findings showed changes in the physico-chemical characteristics of the berries from veraison and before harvest. This development was marked by a rise in the amount of soluble solids, skin and berry weight and pH, which was associated with a reduction in seed weight and total acidity. These results emphasize the importance of the harvest time in determining the content and quality of Merlot grapes, depending on where the vineyard is located and how it is managed. This highlights the need for further research to clarify the factors that lead to the presence of quality compounds in grapes.

Key words: grapevine, pH, seed, skin, sugar, total acidity

Introduction

Merlot is a type of red wine grape that is known for its flexibility, grown in regions ranging from Europe to North or South America, as well as Australia and New Zealand. Wines can be enjoyed either in their youthful and tasty stage or after they have matured gracefully [24]. An outstanding characteristic of the type is its early maturation, making it well-suited for various climates and growing environments, spanning from cold to warm climates. However, the finest and most intricate wines are produced in areas characterized by moderate temperatures and well-drained soils [8]. Incorporated with Cabernet Sauvignon or Cabernet Franc in blends, it contributes depth, balance, softness, and fruity scents of plums, raspberries, blackberries, or black cherries to the wines. Aging in oak barrels can result in flavours such as vanilla, chocolate, or cedar being present [9]. Despite the recent trend of prioritizing quantity over quality in this variety, winemakers are still dedicated to maintaining its popularity by using selective harvesting to produce high-quality wines [19].

The Merlot cluster is well structured, with a pyramidal shape and one or two wings. Its structure makes it particularly resistant to diseases and favourable for the uniform ripening of the grapes [3]. The Merlot berries are round, regular, with a not too thick skin that tends towards blue-black, and covered with an abundant layer of wax bloom; its pulp is light, sweet, slightly acidic and herbaceous. It normally has two-three seeds per berry and the separation of the pedicel from the berry is easy. The pulp is sweet, with a balance of acidity and herbaceous notes, which contribute to the distinctive organoleptic profile of Merlot [21].

Cluster length can change slightly as the grapes ripen because of fluctuations in turgor pressure and the overall structural integrity of the cluster; the weight rises as the berries ripen because they accumulate sugars and water [4]. The increase in weight may level off or slightly decrease as ripening nears completion due to dehydration of the berries, particularly in hotter seasons and regions [5]. The number of berries in each cluster is typically determined in the early stages of the growing season during fruit set [1]. Nevertheless, certain clusters might experience a decrease in berries because of pests, diseases, or various environmental elements [23]. Berries left on the cluster following veraison generally increase in size and weight as they continue to ripen. The weight of the berries gradually rises from veraison to harvest as sugars and water accumulate in them [6]. The rise in berry weight plays a significant role in the overall increase in bunch weight as the berries ripen. Berry weight may reach its highest point before being harvested, especially if favourable conditions support water retention and sugar accumulation. The weight of the skin might remain relatively stable while the weight of the berry changes during ripening [12]. Yet, the skin could become thicker as the berry matures, impacting both its heaviness and composition. Seed weight typically reaches a steady state earlier during ripening and remains relatively constant from veraison to harvest. The seeds may harden as they mature, impacting tannin extraction in winemaking, especially with red grape types [15].

From veraison to harvest, grape ripening includes a range of intricate physiological transformations, with a specific emphasis on the build-up of sugars in the berry. The main process of sugar build-up in berries is the movement of glucose and fructose from the leaves to the berries through the phloem [7]. The sugars are moved from the leaves and stored carbohydrates in the vine to the berry, which raises the overall content of total soluble solids (TSS) [25]. Different enzymes, like invertase, are involved in transforming sucrose (brought from the leaves) into glucose and fructose, which build up in the berries. As these enzymes become more active during ripening, it becomes easier for sugar to accumulate. As the berries mature, they experience metabolic transformations, including the decomposition of organic acids (like malic and tartaric acids) and a simultaneous rise in sugars [14]. This procedure results in a reduction in acidity and a boost in sweetness, enhancing the taste profile of the grapes. Throughout ripening, the content of sugars, specifically glucose and fructose, gradually rises [20]. The build-up of sugar is an important factor in determining grape quality and impacts the flavour of the wine produced. Sugar levels in berries increase until they are fully mature, and the decision on when to harvest them depends greatly on the desired sugar-to-acid ratio for their intended purpose, such as making wine [21]. The choice to collect the crop depends on attaining the ideal sugar level (measured in ºBrix) suitable for the planned purpose, along with considering other factors like acidity, pH, and flavour enhancement. As the harvest nears, the sugar accumulation may decrease, causing the berries to soften further and the flavours to intensify [10]. The change in acidity and pH during grape ripening, from veraison to harvest, is a result of organic acids breaking down and sugars accumulating. These adjustments are carefully watched in order to identify the best time to harvest for achieving the desired quality in the grapes and wine [13].

The aim of this paper is to evaluate the quality components and physical characteristics of Merlot grape berries and clusters during the ripening process in three vineyards from west of Romania: Recaș, Miniș and Buziaș-Silagiu. Specifically, the study focuses on assessing the changes in sugar, titratable acidity (TA), and pH levels in the berries, as well as examining berry weight, and cluster characteristics such as length and weight. Additionally, the study aims to investigate seed weight and its potential influence on grape quality. Through a comprehensive analysis of these parameters, the paper seeks to understand the ripening dynamics of Merlot grapes and provide insights that could contribute to optimizing vineyard management practices for improved grape quality and winemaking outcomes.

Material and Method

a)Experimental location and sampling

The research took place from 2020 to 2022 in three vineyards located in the western areas of Romania. Recaș is located at 45°48'5.00"N; 21°30'48.00"E, Miniș at 46° 8'6.0678"N; 21°36'16.275"E, and Buziaș-Silagiu at 45º37' 00''N; 21º37' 00''E. The Merlot vines were 9 years old in Miniș, 12 years old in Recaș, and 8 years old in Buziaș-Silagiu. The vines were planted with a spacing of 2 m between rows and 1.2 m within rows, totalling 4,169 vines per hectare. Vines were trained in espalier and pruned using the Guyot method. Random samples were collected from 25 vines in each location with comparable vineyard management techniques. The experimental setup was randomized with three replications for each independent trial. The research assessed the Merlot berries development and the biochemical alterations from veraison to harvest. Four hundred berries were randomly selected from clusters on each vine in every replication. Different sampling dates were used to harvest grapes for basic analyses, including cluster length and weight, berry weight, seed and skin weight, soluble solids, total acidity, and pH.

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 41-49
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

b) Laboratory analysis

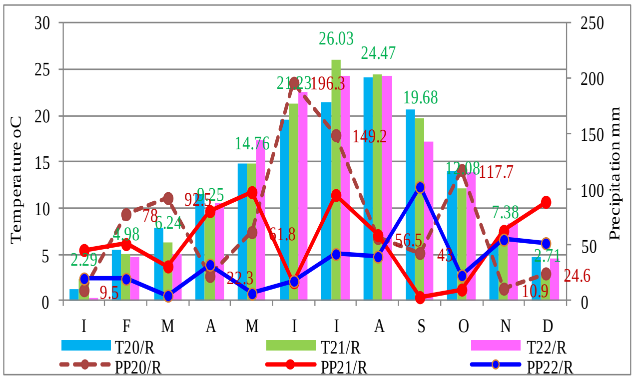
Sugar level was measured at weekly intervals, beginning at veraison and continuing until final harvest. The berries sugar content was determined with a Hanna Instruments portable digital refractometer, ranging from 0 to 85% Brix (HI96801). Berry samples' pH was assessed using an Automated Titration Equipment and Multi-Parameter Analysers – MT Series (MANTECH). The identical automated titration system was utilized to measure titratable acidity by titrate 5 mL berry juice sample to a pH endpoint of 8.2 using a 0.1 N NaOH solution. The acidity measured was expressed in terms of tartaric acid equivalents. The weight of each grape cluster was measured using a digital scale (SBS-PW-60/50) to determine grape production.

c) Climate in the vineyards area during 2020-2022 growing seasons

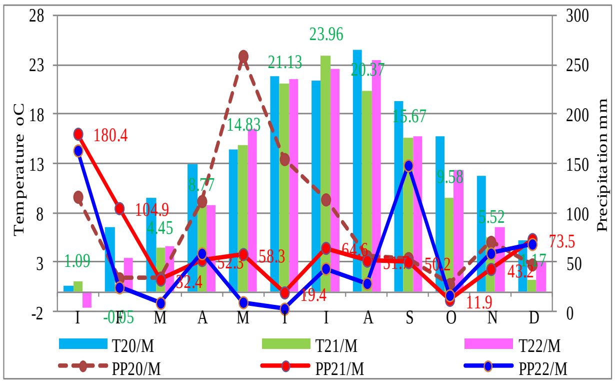
Temperature trends during the 2020-2022 growing seasons were typical for grapevine development, with peaks in summer and steady declines towards the fall and winter months. Precipitation levels varied across the years, which posed challenges such as disease pressure during wet periods or water stress during drier periods (Figure 1 – a, b, c).

In Recaș vineyards (Figure 1a) in 2020, budbreak happened sooner in the season because temperatures began rising gradually in January. The cool temperatures in early spring have extended the budbreak stage. Flowering and fruit set have benefited from the increased temperatures and precipitation levels in May and June, aiding in pollination and early fruit development. Veraison and ripening were positively influenced by the high temperatures in July and August, speeding up the ripening process. The cooler temperatures at the end of the season have impacted the harvest, helping grapes maintain acidity and reach equilibrium. In the same vineyards, budbreak have occurred slightly later in 2021 than 2020 due to cooler temperatures in early spring. Flowering and fruit set have been favourable given the warm temperatures in May and June, but the high precipitation levels in the same months have posed challenges of increased disease pressure. Veraison and ripening had progressed steadily with the warm temperatures in July, but the high precipitation in the same month had led to water stress, impacting berry concentration. Harvest has been affected by the relatively lower temperatures in September and October, and prolonging ripening and extending the harvest period. In 2022 growing season, budbreak have been later than in previous years due to very cool temperatures in early spring. Flowering and fruit set have been positively influenced by moderate temperatures and precipitation levels in May and June, supporting healthy growth and development. Veraison and ripening have progressed steadily, with the warm temperatures in July and August aiding in berry ripening. Harvest has been impacted by moderate temperatures towards the end of the season, allowing grapes to maintain acidity and delay harvest to achieve optimum ripeness.

The frosty weather in January 2020 caused a postponement in budbreak at Miniș vineyards (Figure 1b), but the mild temperatures in March have encouraged the growth of buds. High levels of precipitation during April and May, along with warm temperatures, provided ideal circumstances for blossoming and berry development. High temperatures in June and July supported veraison, while August and September continued to have favourable temperatures for the ripening process.

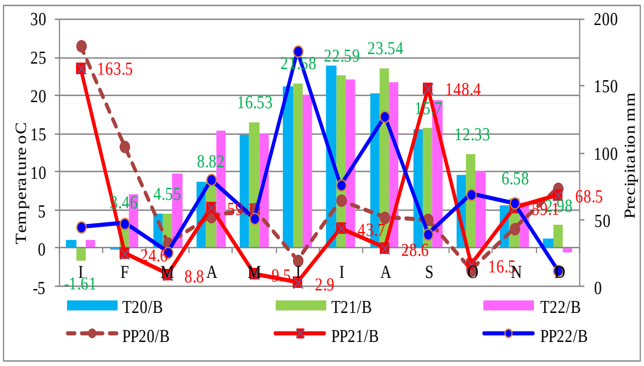


a)



b)

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(), 2024, 41-yy
www.journal-hfb.usab-tm.ro
ISBN: 2066-1797



c)

Figure 1. Temperature and precipitations during 2020-2022 growing seasons in Recaș, Miniș and Buziaș vineyards

T – temperature; PP – precipitations; (followed by the year of research, '20, '21,'22); R-Recaș; M-Miniș; B-Buziaș-Silagiu
a) Climate in Recaș vineyards (2020-2022)
b) Climate in Miniș vineyards (2020-2022)
c) Climate in Buziaș-Silagiu vineyards (2020-2022)

High temperatures during the summer season (June to August) helped increase sugar levels in the berries. Sufficient rain in March and light rainfall in August and September aided in the growth of berries and ensured proper acidity levels. Temperatures stayed at a low-level during January and February in 2021, causing a delay in budbreak. Weather conditions in April and May, along with consistent rainfall, helped the blooming and growth of berries. Berries were able to accumulate sugars in the summer months due to the elevated temperatures. The acidity levels in the berries were sustained with the help of mild rain in September and October. In the 2022 growing season, budbreak was postponed due to the winter's cold temperatures. Nevertheless, the temperatures during April and May, along with moderate rainfall, helped in the blooming and berry set. The acidity and pH levels of berries have been affected by above-average rainfall in September and moderate precipitation in October.

The climate conditions in the Buziaș vineyards (Figure 1c) during the 2020-2022 growing seasons have a significant impact on grapevine phenological phases and berry quality. In March 2020, temperatures helped initiate bud growth while temperatures in May and June supported flowering and fruit set. Moderate rainfall throughout the season provided enough moisture for balanced acidity levels in the berries. Climate in 2021 was favourable for sugar accumulation and to maintain balanced acidity levels. Temperature from winter months in 2022 growing season in Buziaș-Silagiu vineyards supported timely budbreak. The season featured moderate temperatures and rainfall throughout, which helped sugars accumulation and maintain balanced acidity levels.

The data was analysed statistically using Addinsoft's XLSTAT software, version 2018.7.5. The linear model was applied to analyse variance and show the importance of vineyard area differences in vine growth, yield components, and berry composition. Duncan's multiple range test was employed to differentiate means at a confidence level of 95% ($p \leq 0.05$). Dunnett's t test showed significant variations between treatment and control averages, with $p \leq 0.05$.

Results and Discussion

To investigate the complex interactions among cluster and berry characteristics, including sugars, pH, and titratable acidity in Merlot wine grape juice across the three vineyards and growing seasons, a PCA diagram was applied to the dataset. Using PCA allows for the simultaneous assessment of the effects of vineyard location and growing season on the quality components of wine grape juice. PCA highlights the variables that contribute most to data variability, enabling the identification of which factors (sugars, pH, or titratable acidity) are most influential in determining grape juice quality.

In the Principal Component Analysis (PCA) diagram (Figure 2), PC1 explain 73.77% of variance and PC2 26.23%) representing the two primary dimensions that capture most of the variability in the data among the following variables: cluster length (CL), cluster weight (CW), number of berries in the cluster (NB/C), berry weight (BW), skin weight (SkW), and seeds weight (SW) in the grapes and berries from Recaș, Miniș, and Buziaș vineyards, during the 2020-2022 growing seasons. Among variables, cluster weight had the highest influence on variability of PC1.

During the analysis of Recaș vineyards, it was found that the berry weight in 2022 was significantly lower than in previous seasons. However, the findings indicated positive results for cluster length and weight, as well as the number of berries and berry weight in both the 2020 and 2021 growing seasons. Conversely, there was a decrease in skin and seed weights in 2022, indicating smaller berries and potentially impacting their quality.

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 41-49
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

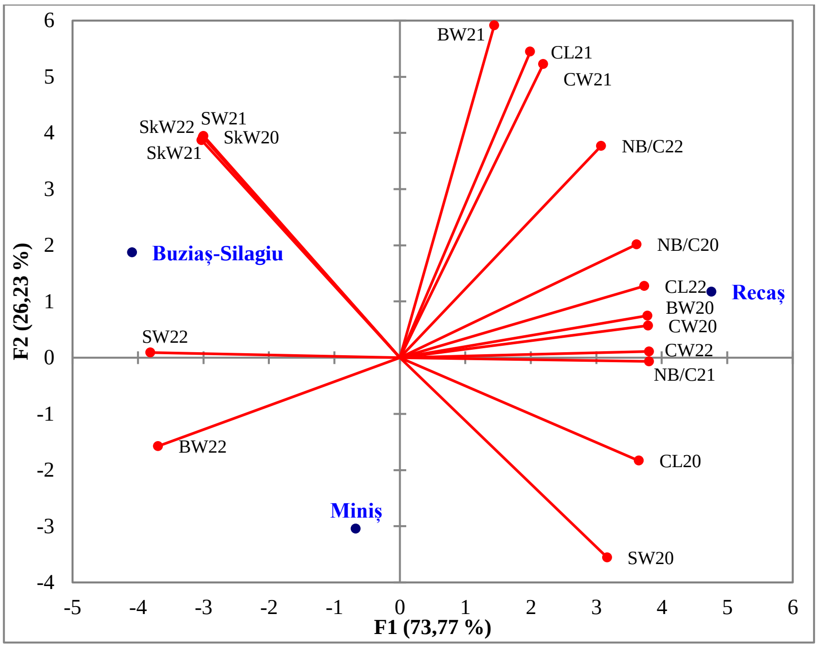


Figure 2. Principal Component Analysis (PCA) diagram for cluster and berry characteristics in Recaș, Miniș and Buziaș-Silagiu vineyards, during 2020-2022 growing seasons
Cluster length (CL), cluster weight (CW), number of berries in the cluster (NB/C), berry weight (BW), skin weight (SkW), seeds weight (SW) followed by the year 2020, 2021 and 2022

The results from Recaș differed from the findings at Miniș vineyards. In 2022, the berries were the smallest and lightest compared to the other seasons. Nevertheless, the clusters' length remained notably positive in 2020. This alteration could indicate changes in growing conditions or management practices that impact the berry development. A distinct pattern arose in the vineyards of Buziaș-Silagiu; grapes with thicker skins had a higher skin weight. The seeds were also larger and heavier, contributing to overall berry composition. This thicker skin impacted the texture and taste of the grapes and the resulting wines. The relationships and differences among the three vineyards over the three growing seasons are effectively emphasized by the PCA diagram. The findings highlight the intricate relationship among environmental factors, vineyard practices, and grape quality attributes including cluster traits, berry size, skin thickness, and seed weight.

In the principal component analysis (PCA) diagram (Figure 3), the first principal component (F1) accounted for 76.17% of the variability in the data, with pH being the most influential factor in driving this variability. The second principal component (F2) explained 23.83% of the variability, with titratable acidity having the highest influence within this component. The PCA diagram reveals that in Recaș, the highest pH level was observed in 2020 (with rainy May, June and July), while in Miniș, the highest pH was recorded in 2021. This occurred against a backdrop of consistently high titratable acidity across all three years of the study.

Grapes from Buziaș-Silagiu exhibited the highest accumulation of sugars, along with moderate to high levels of pH and titratable acidity. In contrast, grapes from Recaș were characterized by high pH levels in 2020 and moderate sugar accumulation compared to the levels found in Buziaș-Silagiu and Miniș, against a backdrop of low titratable acidity. This suggests a distinctive profile for grapes from Recaș in terms of pH and sugar accumulation, while grapes from Buziaș-Silagiu were marked by their higher sugar content. Banjanin et al. [2] found in the grape juice of Merlot variety cultivated in Serbia, during 2016-2017 growing seasons, total acidity ranging between 5.75 and 7.4 g/l (H_2SO_4). The pH values ranged from 3.18 to 3.32, which are quite similar to those found in the present study. Sugar content with close values (between 20.8 and 22.4 g/l) in Merlot grape juice, also cultivated in the Recaș vineyards, between 2016 and 2018 was found by Nistor et al. [18]. The titratable acidity reported was found between 3.6 and 5.6 g/l H_2SO_4 with pH values ranging from 3.34 to 3.63. In Brazil, Panceri et al. [19] conducted a chemical characterization of the Merlot variety and found titratable acidity levels in the berry juice at 6.08 g/l and pH at 3.40. Hilbert et al. [11] after application of nitrogen treatments on the Merlot variety during 2001 growing season, in France, reported an amount of sugars between 20.7 and 23.5 °Brix, pH levels from 3.59 to 375 and titratable acidity from 3.57 to 3.90.

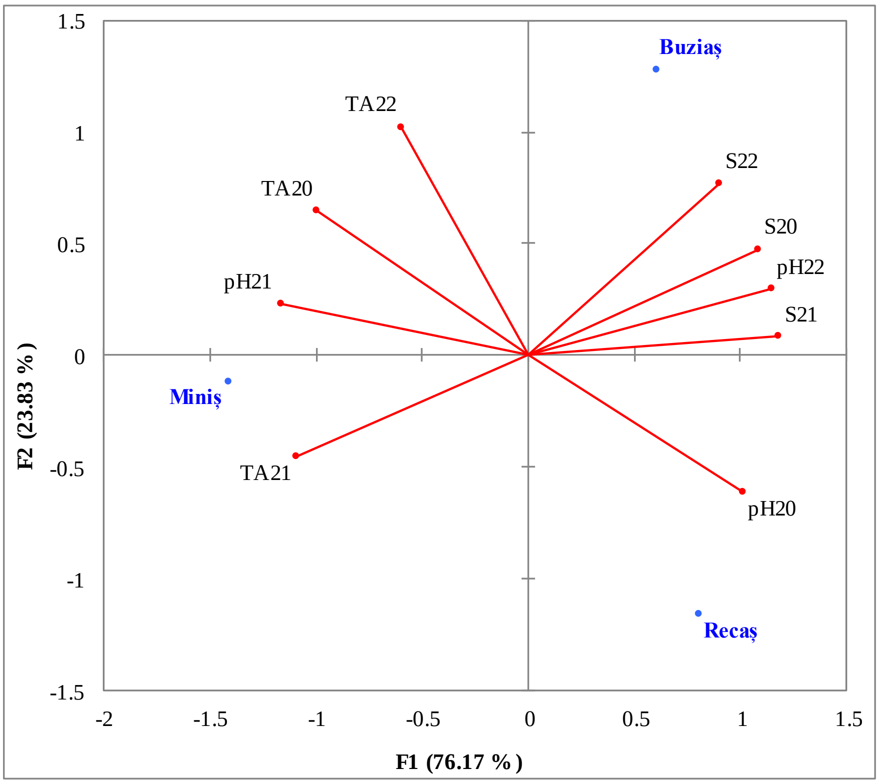


Figure 3. Principal Component Analysis (PCA) diagram for sugars, titratable acidity and pH, in Recaș, Miniș and Buziaș-Silagiu vineyards, during 2020-2022 growing seasons

Da Mota et al. [16] examined the maturation curves and fruit composition in Merlot grapes from Brazil in 2007 and 2008 and found sugar accumulation of 23.00 and 21.5 °Brix, and titratable acidity of 6.32 and 8.27 g/l (H_2SO_4), respectively. In a more recent study, Miele [17] investigated four Merlot clones and found pH levels in berry juice that were higher compared to those observed in the present study, ranging from 3.70 to 3.77. To investigate the potential relationship and dependencies within the dataset, Pearson correlation analysis was performed among variables (Table 1, 2, 3). There is a strong positive correlation between sugars and both skin weight (0.997) and seed weight (0.995) in Merlot berry juice from Recaș vineyards. This indicates that higher sugar content in the grape juice is closely associated with greater skin and seed weights. This relationship could imply that grapes with higher sugar levels tend to have more developed skins and seeds, which can impact the overall quality and characteristics of the juice. The correlation between sugars and titratable acidity is also high (0.977), suggesting a positive relationship. This indicates that as sugar content increases, so does the level of titratable acidity.

Table 1. Correlation matrix (Pearson) for Merlot berry juice (sugar, titratable acidity and pH) from Recaș vineyards, during 2020-2022 growing seasons

Variables	S	TA	pH	CL	CW	NB/C	BW	SkW	SW
S	**1**	0.977	-0.987	-0.788	-0.878	**-0.999**	-0.876	0.997	0.995
TA	0.977	**1**	-0.931	-0.901	-0.960	-0.970	-0.754	0.991	0.993
pH	-0.987	-0.931	**1**	0.680	0.791	0.992	0.941	-0.972	-0.967
CL	-0.788	-0.901	0.680	**1**	0.986	0.767	0.393	-0.834	-0.845
CW	-0.878	-0.960	0.791	0.986	**1**	0.862	0.538	-0.913	-0.921
NB/C	**-0.999**	-0.970	0.992	0.767	0.862	**1**	0.891	-0.994	-0.991
BW	-0.876	-0.754	0.941	0.393	0.538	0.891	**1**	-0.835	-0.824
SkW	0.997	0.991	-0.972	-0.834	-0.913	-0.994	-0.835	**1**	**1.000**

SW	0.995	0.993	-0.967	-0.845	-0.921	-0.991	-0.824	**1.000**	**1**

Values in bold are different from 0 with a significance level alpha=0,05; s – sugar, TA- titratable acidity; CL- cluster length; CW- cluster weight; NB/C- number of berries in cluster; BW- berry weight; SkW – skin weight; SW- seeds weight.

This relationship is important for understanding how these two quality components interact, potentially impacting the overall flavour profile of the grape juice. Between sugars and the number of berries in the cluster the correlation is nearly perfect (-0.999), indicating a strong negative relationship. This suggests that clusters with more berries tend to have lower sugar content, which could be due to the distribution of available resources across a larger number of berries. The relationship between titratable acidity and pH is strongly negative (-0.931). This is a classic negative relationship, as pH and acidity levels are typically expected to move in opposite directions. This correlation is crucial for understanding the balance of acidity and pH in grape juice, which can influence taste and overall quality. There is a strong positive correlation between pH and the number of berries in the cluster (0.992). This suggests that clusters with more berries tend to have higher pH levels, which could influence the overall flavour and stability of the juice.

Table 2. Correlation matrix (Pearson) for Merlot berry juice (sugar, titratable acidity and pH) from Miniș vineyards, during 2020-2022 growing seasons

Variables	S	TA	pH	CL	CW	NB/C	BW	SkW	SW
S	**1**	0.715	0.992	0.431	-0.092	-0.411	-0.263	**1.000**	0.133
TA	0.715	**1**	0.624	-0.323	-0.762	-0.931	-0.862	0.702	0.788
pH	0.992	0.624	**1**	0.538	0.031	-0.296	-0.143	0.995	0.011
CL	0.431	-0.323	0.538	**1**	0.859	0.646	0.757	0.447	-0.837
CW	-0.092	-0.762	0.031	0.859	**1**	0.946	0.985	-0.074	**-0.999**
NB/C	-0.411	-0.931	-0.296	0.646	0.946	**1**	0.988	-0.394	-0.958
BW	-0.263	-0.862	-0.143	0.757	0.985	0.988	**1**	-0.245	-0.991
SkW	**1.000**	0.702	0.995	0.447	-0.074	-0.394	-0.245	**1**	0.115
SW	0.133	0.788	0.011	-0.837	**-0.999**	-0.958	-0.991	0.115	**1**

Values in bold are different from 0 with a significance level alpha=0,05; s – sugar, TA- titratable acidity; CL- cluster length; CW- cluster weight; NB/C- number of berries in cluster; BW- berry weight; SkW – skin weight; SW- seeds weight.

The most important correlations among the provided variables can be identified based on their Pearson correlation coefficients (Table 2). The most notable correlation is between sugars and skin weight, with a perfect positive correlation (1.000). This suggests that as sugar content in the grape juice increases, the weight of the skin also increases. This relationship indicates a direct influence of sugar content on the development and weight of grape skins, which may affect the overall quality and composition of the juice. There is a strong positive correlation between sugars and pH (0.992) suggesting a potential link between the ripeness of the grape and its pH level, which may influence the taste and stability of the grape juice. As sugar content increases, there is also a tendency for titratable acidity to increase, although not as strongly as the relationship between sugars and pH. A moderate positive correlation (0.702) was established between titratable acidity and skin weight, suggesting that higher acidity levels are associated with increased skin weight. This relationship may influence the flavour profile and astringency of the grape juice. Another strong positive correlation (0.985) was observed between cluster weight and berry weight, indicating that heavier clusters tend to have heavier berries. This relationship can impact juice extraction and overall grape quality. Finally, the moderate positive correlation (0.538) between cluster length and pH suggests that longer clusters tend to have higher pH levels. This relationship may influence the ripening process and the final acidity levels of the grape juice.

The strong relationship between sugars and titratable acidity (0.984), in Merlot grape juice from Buziaș-Silagiu vineyards, suggests that both parameters may be closely linked during the ripening process of the grapes, with higher sugar levels accompanying higher acidity (Table 3).

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(), 2024, 41-yy
www.journal-hfb.usab-tm.ro
ISBN: 2066-1797

Table 3. Correlation matrix (Pearson) for Merlot berry juice (sugar, titratable acidity and pH) from Buziaș-Silagiu vineyards, during 2020-2022 growing seasons

Variables	S	TA	pH	CL	CW	NB/C	BW	SkW	SW
S	**1**	0.984	0.015	-0.824	-0.444	0.463	-0.340	-0.508	-0.900
TA	0.984	**1**	0.193	-0.710	-0.277	0.614	-0.167	-0.346	-0.963
pH	0.015	0.193	**1**	0.553	0.889	0.893	0.935	0.854	-0.450
CL	-0.824	-0.710	0.553	**1**	0.873	0.120	0.813	0.906	0.495
CW	-0.444	-0.277	0.889	0.873	**1**	0.588	0.994	**0.997**	0.008
NB/C	0.463	0.614	0.893	0.120	0.588	**1**	0.676	0.528	-0.804
BW	-0.340	-0.167	0.935	0.813	0.994	0.676	**1**	0.983	-0.105
SkW	-0.508	-0.346	0.854	0.906	**0.997**	0.528	0.983	**1**	0.080
SW	-0.900	-0.963	-0.450	0.495	0.008	-0.804	-0.105	0.080	**1**

Values in bold are different from 0 with a significance level alpha=0,05; s – sugar, TA- titratable acidity; CL- cluster length; CW- cluster weight; NB/C- number of berries in cluster; BW- berry weight; SkW – skin weight; SW- seeds weight.

The negative relationship (-0.900) between sugars and seeds weight may imply that higher sugar levels in grapes result in smaller seeds, which could be associated with advanced ripening. Between titratable acidity and seeds weight, there is a very strong negative correlation (-0.963) indicating that higher acidity levels are associated with lower seed weight. This relationship could suggest that as grapes become more acidic, they may also have smaller seeds. The relationship between cluster weight and skin weight (0.997) can affect the phenolic content and astringency of the grape juice. There is also a very strong positive correlation (0.983) between berry weight and skin weight, indicating that heavier berries tend to have thicker skins. This relationship can impact the extraction of phenolic compounds during winemaking.

Conclusions

Identifying the key factors affecting grape juice quality can lead to improved quality control measures and targeted interventions to optimize wine production. Data analysis for data collected from the three vineyards, demonstrates the impact of vineyard location and growing season on the quality components of wine grape juice, showcasing how cluster weight, berry weight, skin weight, and seed weight influence the overall grape quality. PCA allows for the exploration of the relationships between the variables and their interactions across vineyards and seasons. This can lead to a better understanding of the influence of terroir and climate on grape juice quality. Strong correlations provide valuable insights into the interactions between different grape and juice characteristics. Understanding these relationships can help in making informed decisions in vineyard management and winemaking practices to optimize the quality of the grape juice and the resulting wine. By understanding the key factors that influence grape juice quality in different vineyards and growing seasons, winemakers and viticulturists can make informed decisions about vineyard management and winemaking practices.

References

[1] Aquino, A., Diago, M. P., Millán, B., & Tardáguila, J. (2017), *A new methodology for estimating the grapevine-berry number per cluster using image analysis*. Biosystems engineering, 156, 80-95.
[2] Banjanin, T., Lisov, N., Petrović, A., Ranković-Vasić, Z., Blesić, M. (2019), *The quality of grape and wine of Merlot and Blatina varieties in the agroecological conditions of the Trebinje vineyar*d, VIII International symposium on agricultural sciences AgroReS 2019, Book of proceedings, pp. 69-75.
[3] Bubola, M., Rossi, S., Váczy, K. Z., Hegyi, Á.I., Persic, M., Zdunić, G. & Radeka, S. (2023), *Modification of cv. Merlot berry composition and wine sensory characteristics by different leaf area to fruit ratios.* Applied Sciences, 13(9), 5465.
[4] Bubola, M., Persic, M., Rossi, S., Bestulić, E., Zdunić, G., Plavša, T., & Radeka, S. (2022), *Severe shoot trimming and crop size as tools to modulate cv. merlot berry composition*. Plants, 11(24), 3571.
[5] Candar, S. (2024), *understanding the impact of artificial stress on the morphological characteristics of cv'Merlot'berry and cluster.* Applied Fruit Science, 66(1), 257-267.
[6] Candar, S. (2023), *How abiotic stress induced by artificial wounding changes maturity levels and berry composition of Merlot (Vitis vinifera L.).* European Food Research and Technology, 249(10), 2611-2623.

JOURNAL of Horticulture, Forestry and Biotechnology
Volume 28(1), 2024, 41-49
https://jhfb.ro/index.php/jhfb
Print ISSN: 2066-1797
Online ISSN: 3045-1876

[7] Diago, M.P., Tardaguila, J., Aleixos, N., Millan, B., Prats-Montalban, J.M., Cubero, S., & Blasco, J. (2015), *Assessment of cluster yield components by image analysis.* Journal of the Science of Food and Agriculture, *95*(6), 1274-1282.
[8] Dobrei, A., Posta, G., Danci, M., Nistor, E., Camen, D., Mălăescu, M., & Sala, F. (2016), *Research concerning the correlation between crop load, leaf area and grape yield in few grapevine varieties.* Agriculture and Agricultural Science Procedia, 10, 222-232.
[9] Dobrei, A.G., Dobrei, A., Nistor, E., Sala, F., Mălăescu, M., Drăgunescu, A., & Camen, D. (2015), *Research concerning the qualitative potential of the wines obtained from different grape-growing ecosystems.* JOURNAL of Horticulture, Forestry and Biotechnology. Volume 19(1), 103- 107.
[10]Hernández-Montes, E., Zhang, Y., Chang, B. M., Shcherbatyuk, N., & Keller, M. (2021), *Soft, sweet, and colorful: Stratified sampling reveals sequence of events at the onset of grape ripening.* American Journal of Enology and Viticulture, 72(2), 137-151.
[11]Hilbert, G., Soyer, J. P., Molot, C., Giraudon, J., Milin, M., & Gaudillere, J. P. (2015), *Effects of nitrogen supply on must quality and anthocyanin accumulation in berries of cv. Merlot.* VITIS-Journal of Grapevine Research, 42(2), 69.
[12]Karoglan, M., Osrecak, 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).
[13]Keller, M., Mills, L.J., & Harbertson, J.F. (2012*). Rootstock effects on deficit-irrigated winegrapes in a dry climate: vigor, yield formation, and fruit ripening*. American Journal of Enology and Viticulture, 63(1), 29-39.
[14]Kuhn, N., Guan, L., Dai, Z.W., Wu, B.H., Lauvergeat, V., Gomès, E., & Delrot, S. (2013), *Berry ripening: recently heard through the grapevine.* Journal of experimental botany, 65(16), 4543-4559.
[15]Matijašević, S., Popović, T., Glišić, M., Isajlović, S., Ranković-Vasić, Z., & Pržić, Z. (2020), *The influence of the berry size on the skin anthocyanins content of some black wine varieties.* Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, 49(1), 98-106.
[16]da Mota, R.V., Favero, A.C., Silva, C.P.C., Purgatto, E., Shiga, T.M., & de Albuquerque Regina, M. (2011), *Wine grape quality of grapevines grown in the cerrado ecoregion of Brazil*. OENO One, 45(2), 101-109.
[17]Miele, A. (2020), *Wine composition of Merlot and Cabernet Sauvignon vine clones under the environmental conditions of Serra Gaúcha, Brazil.* Food Science and Technology, 41, 116-122.
[18]Nistor E., Dobrei A.G., Dobrei, A., & Ciorica, G. (2019), *Studies on growth and yield components in Merlot, Pinot noir and Syrah varieties. Journal of Horticulture,* Forestry and Biotechnology, 23(1), 44-50.
[19]Panceri, C.P., De Gois, J.S., Borges, D.L., & Bordignon-Luiz, M.T. (2015), *Effect of grape dehydration under controlled conditions on chemical composition and sensory characteristics of Cabernet Sauvignon and Merlot wines.* LWT-Food Science and Technology, 63(1), 228-235.
[20]de Rosas, I., Deis, L., Baldo, Y., Cavagnaro, J.B., & Cavagnaro, P.F. (2022), *High temperature alters anthocyanin concentration and composition in grape berries of Malbec, Merlot, and Pinot Noir in a cultivar-dependent manner.* Plants, 11(7), 926.
[21]da Silva, A. P. G., Sabbatini, P., VanderWeide, J., & Medina-Meza, I. G. (2023). *Influence of early leaf removal on flavonoid accumulation and antioxidant capacity in Merlot (vitis vinifera l.)* Berry components. ACS Food Science & Technology, 3(9), 1457-1470.
[22]Suter, B., Destrac Irvine, A., Gowdy, M., Dai, Z., & van Leeuwen, C. (2021). Adapting wine grape ripening to global change requires a multi-trait approach. *Frontiers in Plant Science*, *12*, 624867.
[23]Xie, S., Tang, Y., Wang, P., Song, C., Duan, B., Zhang, Z., & Meng, J. (2018), *Influence of natural variation in berry size on the volatile profiles of Vitis vinifera L. cv. Merlot and Cabernet Gernischt grapes.* PLoS One, 13(9), e0201374.
[24]Wang, X., Shao, X., Zhang, Z., Zhong, X., Ji, X., Shi, X., & Wang, H. (2024), *Multi-nutrient fertilization-based analysis of fruit quality and mineral element composition during fruit development in Merlot wine grapevine*. Journal of Integrative Agriculture. vol.23, Issue 6. pp.1786-1804.
[25]Zarrouk, O., Brunetti, C., Egipto, R., Pinheiro, C., Genebra, T., Gori, A., & Chaves, M.M. (2016), *Grape ripening is regulated by deficit irrigation/elevated temperatures according to cluster position in the canopy.* Frontiers in plant science, 7, 214742.