THE IMPACT OF TERROIR ON THE PHYSICO-CHEMICAL SPECIFICITY OF INDIGENOUS AND INTERNATIONAL WHITE WINES CULTIVATED IN ROMANIA

IMPACTUL TERROIR-ULUI ASUPRA SPECIFICITĂȚII FIZICO-CHIMICE A VINURILOR ALBE AUTOHTONE ȘI INTERNAȚIONALE CULTIVATE ÎN ROMÂNIA

***BEDREAG (REBIGAN) Ioana Cristina*[1], *SCUTARAŞU Elena Cristina*[1,2], *CIOROIU Ionel-Bogdan*[2]*, *NICULAUA Marius*[2], *COTEA V. Valeriu* [1,2]**

*Corresponding author e-mail: bogdan.cioroiu@acadiasi.ro

Abstract.
This study examines the influence of terroir on the physico-chemical characteristics of white wines, focusing on both local and international varieties grown in Romania. The research compares Sauvignon blanc (SB) and Fetească albă (FA) wines from various Romanian viticultural regions, highlighting how the growing conditions, soil-climate characteristics, and vinification methods from 2019 and 2021 impacted the wines' properties. Physico-chemical parameters were assessed to establish quality benchmarks. Findings revealed a wide range of quality parameters, with alcohol strength varying from 11.04 % vol. alc. (FA, 2019) to 14.6 % vol. alc. (SB, 2021), volatile acidity ranging from 0.1 g/L acetic acid (FA, 2019) to 0.63 g/L acetic acid (SB, 2019), and reducing substances from 0.31 g/L (FA, 2019) to 12.00 g/L (SB, 2021). Total acidity ranged from 5.05 to 7.39 g tartaric acid/L, correlating with wine treatments and initial grape values.

Key words: terroir, Fetească albă, Sauvignon blanc, physico-chemical parameters

Rezumat.
Acest studiu analizează influența terroir-ului asupra caracteristicilor fizico-chimice ale vinurilor albe, concentrându-se pe soiuri locale și internaționale cultivate în România. Astfel, a fost analizată influența condițiilor de cultivare, a caracteristicilor pedo-climatice, precum și a metodelor de vinificare specific anilor 2019 și 2021 asupra calității vinurilor obținute din soiurile Sauvignon Blanc (SB) și Fetească Albă (FA) în diverse regiuni viticole românești. Parametrii fizico-chimici au fost evaluați pentru a stabili repere de calitate. Probele au prezentat caracteristici fizico-chimice diferite, cu o concentrație alcoolică variind de la 11,04 % vol. alc. (FA, 2019) la 14,6 % vol. alc. (SB, 2021). Aciditatea volatilă a prezentat valori între 0,1 g/L acid acetic (FA, 2019)

[1] "Ion Ionescu de la Brad" Iași University of Life Sciences, Romania
[2] Romanian Academy, Iasi Branch, Research Centre for Oenology, Iași

și 0,63 g/L acid acetic (SB, 2019), pe când conținutul total de substanțe reducătoare a fost între 0,31 g/L (FA, 2019) și 12,00 g/L (SB, 2021). Aciditatea totală a vinurilor analizate a înregistrat variații între 5,05 și 7,39 g/L acid tartric, corelându-se cu tratamentele vinului și valorile inițiale ale strugurilor.

Cuvinte cheie: Fetească albă, Sauvignon blanc, terroir, parametric fizico-chimici

INTRODUCTION

Terroir, the complete natural environment influencing wine production, significantly shapes a wine taste and flavor. It includes climate, soil, topography, and winemaking techniques, which interact to form a unique ecosystem.

Climate impacts wine through macro- and microclimatic variations, including temperature, rainfall, and sunlight [Vaudour et al., 2015]. Temperature affects the timing of vine growth stages and grape ripening, while sunlight impacts photosynthesis and the development of secondary compounds in grapes [Van Leeuwen et al., 2020].

Soil contributes via composition, fertility, and drainage, while topography affects sunlight exposure and water flow through factors like slope direction and altitude. Soil provides essential nutrients to vines, especially nitrogen (N), which plays a key role in yield, vine vigor, and the composition of ripe grapes. The water status of the vine depends on both soil characteristics and root depth (affecting soil water retention) and on climate (determined by rainfall and evapotranspiration). Vine water status, in turn, influences shoot growth, yield, grape maturation, and fruit composition [Van Leeuwen et al., 2020].

Winemaking particularities, such as yeast selection and fermentation methods, can further emphasize or soften terroir influences [Van Leeuwen et al., 2018]. In France, the concept of *appellation d'origine contrôlée* (AOC) legally defines wine regions, acknowledging the unique qualities each terroir brings to wine. According to the OIV (OIV/VITI 333/2010), "viticultural terroir" refers to an area unique combination of physical, biological, and viticultural knowledge, shaping wines with distinctive qualities [Brillante et al., 2020].

This study examines how terroir affects the physico-chemical properties of Romanian white wines, analyzing local and international varieties to explore the environmental and human factors that contribute to each wine's unique characteristics.

MATERIAL AND METHOD

Representative samples were taken from the Fetească albă (FA) and Sauvignon blanc (SB) varieties. The study was conducted over two years, with sampling carried out in 2019 and 2021.

The geographic distribution follows vineyards and wineries across five major Romanian wine regions. In Dealurile Munteniei și Olteniei Wine Region, the Dealu Mare Vineyard (V) is represented by Vișinescu Winery (W), Davino W. and Ceptura W. Banat

Wine Region features the Dealurile Silagiului V. and Aramic W. For Colinele Dobrogei Wine Region, wines were sourced from the Sarica Niculițel V. and Murfatlar V., specifically Sarica Niculițel W. and Viișoara W. The Podișul Transilvaniei Wine Region includes samples from the Târnave V., Aiud V., Lechinta V. with Jidvei W., Domeniile Boieru W., and Jelna W respectevely. Dealurile Moldovei Wine Region is represented by the Dealu Bujorului V. and Panciu V., through Bujoru Viticulture Bujoru Viticulture and Winemaking Research and Development Station (SCDVV Bujoru) and Panciu W.

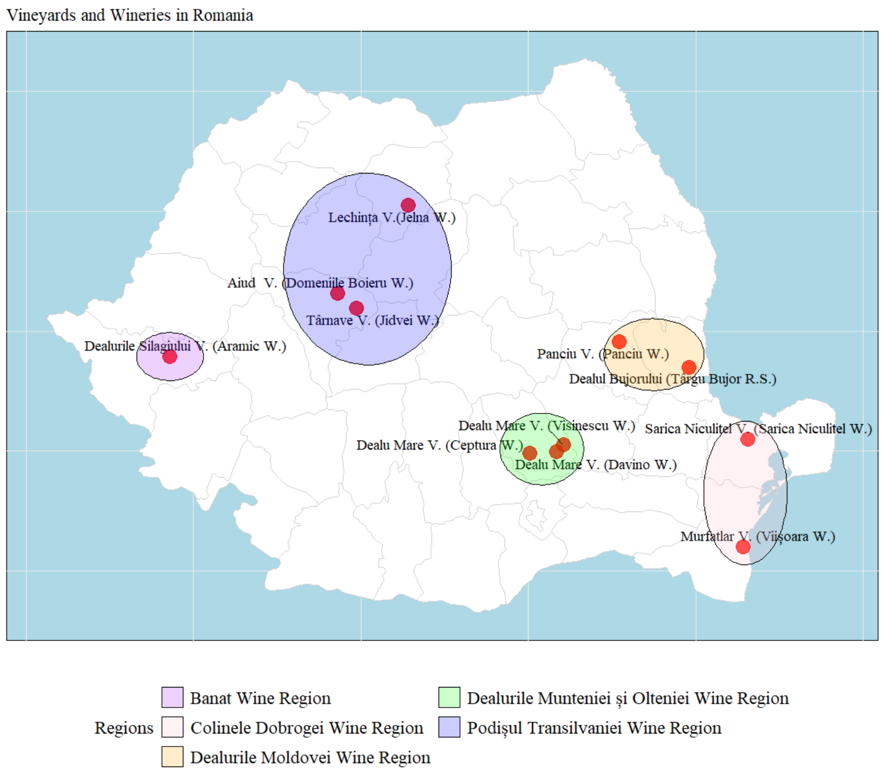

Fig. 1. Distribution of the analysed Vinyards and Wineries included in the study

To assess the physico-chemical characteristics of the wines, the following OIV-standardized methods were employed: reducing substances (g/L), total acidity (g/L tartaric acid), density and specific gravity at 20°C (g/mL), alcoholic strength by volume (%vol_alc), volatile acidity (g/L acetic acid), sulfur dioxide (free and total) (mg/L) [OIV, 2023].

RESULTS AND DISCUSSIONS

The physico-chemical characteristics are presented in table 1. The results exhibited a range of variations, from negligible differences in relative density to significant modifications with high variability. These changes may be influenced by oenological practices as well as specific characteristics determined by natural factors.

Figure 2 illustrates regional variations in the physico-chemical profiles of wines from diverse Romanian vineyards. Differences are noticeable when comparing wines from several regions which indicate terroir-specific influences, including vineyard location and winemaking techniques. The analysis of parameter variations based on the origin of wine samples involved testing the correlation between longitude (º) and latitude (º) as determining factors.

Table 1

Physico – chemical characteristics for the wines from Fetească albă and Sauvignon blanc

Sp*	AS (% vol.)	TA (g/L)	VA (g/L)	F_SO_2 (mg/L)	T_SO_2 (mg/L)	RS (g/L)	Density (g/mL)
Feteasca alba (FA)							
L1	13.1±0.07	6.5±0.23	0.11±0.16	35±4.3	93±13.8	2.11±1.70	0.991±0.002
L2	13.6±0.30	6.6±0.12	0.44±0.08	26±4.5	123±9.2	2.03±0.70	0.991±0.001
L3	11.9±0.42	6.4±0.58	0.23±0.03	33±7.0	92±18	2.45±0.29	0.992±0.001
L4	11.7±0.95	5.7±0.93	0.26±0.06	47±3.5	99±8.8	2.04±2.44	0.992±0.001
L5	14.4±0.80	7.1±0.53	0.56±0.50	37±0.9	93±0.9	0.92±0.13	0.990±0.003
L6	12.5±0.42	5.8±0.78	0.44±0.15	28±4.2	155±7.1	3.80±0.00	0.991±0.003
L7	13.1±0.28	7.1±1.17	0.40±0.03	29±7.7	62±2.8	4.12±1.04	0.993±0.003
L8	12.9±0.71	5.7±0.43	0.26±0.04	57±4.3	107±12.3	3.06±1.02	0.993±0.001
L9	12.6±0.14	7.1±0.13	0.36±0.01	23±2.7	65±6.4	1.75±0.64	0.992±0.003
L10	13.5±0.60	6.1±0.80	0.28±0.72	38±5.1	51±0.5	0.38±0.20	0.989±0.005
Sauvignon blanc (SB)							
L1	13.5±0.64	6.2±0.13	0.28±0.10	42±7.8	135±12.8	1.16±1.09	0.991±0.002
L2	14.7±0.24	6.2±0.12	0.63±0.12	40±5.8	49±2.5	7.38±3.09	0.992±0.001
L3	12.4±0.28	6.6±0.02	0.30±0.03	30±7.8	79±5.2	2.38±1.59	0.992±0.002
L4	13.1±0.44	6.8±0.78	0.48±0.04	44±5.3	94±8.8	2.70±1.27	0.991±0.001
L5	13.6±0.20	7.1± 0.25	0.52±0.18	27±2.5	114±5.7	1.04±0.69	0.989±0.005
L6	14.0±0.14	6.1±0.78	0.57±0.08	32±0.7	141±12.7	8.70±4.67	0.992±0.001
L7	14.2±0.64	7.7±0.49	0.52±0.03	35±4.2	82±11.5	2.35±0.49	0.990±0.003
L8	13.5±0.52	6.5±0.36	0.36±0.13	57±2.5	111±13.5	3.28±0.52	0.992±0.003
L9	13.1±0.14	7.3±0.18	0.36±0.04	26±6.3	76±8.5	2.45±0.78	0.991±0.004
L10	13.0±0.52	6.7±0.46	0.28±0.08	38±10.2	60±14.5	0.35±0.70	0.989±0.002
L11	13.6±0.07	6.4±0.14	0.42±0.02	55±1.6	79±6.1	2.92±0.04	0.992±0.001

** (Sp - sample) L1 - Dealu Mare V. (Ceptura W.), L2 - Dealurile Silagiului V. (Aramic W.), L3 - Tarnave V. (Jidvei W.), L4 - Aiud V. (Domeniile Boieru W.), L5 - Lechinta V. (Jelna W.), L6 - Dealu Bujorului V. (SCDVV Bujoru); L7 - Panciu V. (Panciu W.); L8 - Dealu Mare V.(Visinescu W., Artizan Wine); L9 - Sarica Niculitel V. (Viisoara W.); L10 - Târnave V. (Jidvei W.); L11 - Dealu Mare V. (Visinescu W., Karakter Wine).*

AS - Alcoholic strength (% vol.); TA - total acidity (g tartaric acid/L); VA - volatile acidity (g acetic acid/L); F_SO_2 - Content of free SO_2 (mg/L); T_SO_2 - Content of total SO_2 (mg/L); RS - Residual sugars (g/L); Density (g/mL)

The analysis of reducing sugars and density across various Romanian vineyards shows a positive correlation, where higher sugar levels lead to increased density. For example, the Panciu V. has the highest reducing sugars for SB at 8.70±4.67 g/L, indicating a likely density above 0.992 g/mL. In contrast, Lechinta Vineyard (Jelna W.) has lower sugars (1.04±0.69 g/L for SB) and a density of 0.989 g/mL, reflecting that lower sugar content correlates with reduced density.

Some correlations between alcohol strength (Figure 2a), reducing sugars (Figure 2b) and geographic factors in FA and SB wines were considered. Generally, higher alcohol content is associated with lower reducing sugar levels [García-Martín et al., 2010]; for instance, Lechinta V. (Jelna W.) shows high alcoholic strength (14.4±0.80 % vol. for FA) alongside low reducing sugars (0.92±0.13 g/L). Latitude appears to impact alcohol content (figure 2(b)), with higher-latitude regions like Târnave V. exhibiting lower alcohol for FA (11.7±0.95 % vol. alc.) due to cooler climates that limit sugar accumulation. In contrast, southern locations like Dealu Mare V. (Ceptura W.) with 13.1±0.07 %vol. (FA) and 13.5±0.64 %vol. (SB) and Vișinescu W. 12.9±0.71 %vol. (FA) and 13.5±0.52 % vol. (SB)) produce wines with higher alcohol levels, indicating warmer climates which favor greater sugar and alcohol potential [Jordão et al., 2015].

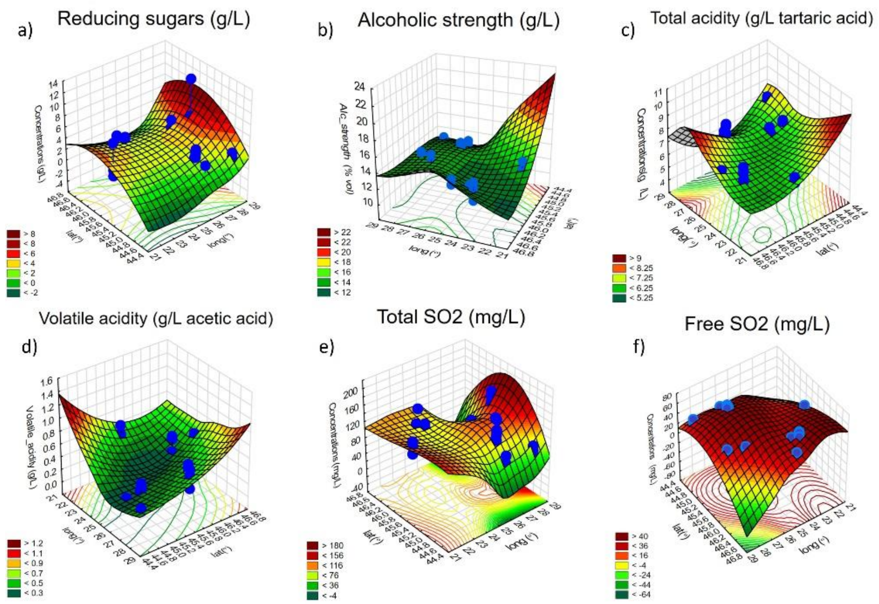

Fig. 2. Distribution of physico-chemical parameters according to longitudine (º) and latitude (º) corresponding to position in romanian teritory of the wineries

Latitude shows a weaker correlation with reducing sugars, though certain eastern regions, such as Dealu Bujorului V., display higher residual sugars in SB (8.70±4.67g/L), possibly due to specific regional practices or microclimate influences (figure 2b).

Optimal acidity gives wine freshness; lower values result in a flat taste without personality, while an excess produces a particular harshness to the wine [Koone et al., 2014] Acidity does not vary greatly, oscillating between 7.7±0.49 g/L tartaric acid for the sample from Panciu W. and 6.2±0.13 g/L tartaric acid in the Dealurile Silagiului V. (Aramic W.). The analysis of total acidity (TA) (figure 2(c)) and volatile acidity (VA) (figure 2(d)) for the samples from Romanian vineyards reveals distinct patterns based on latitude and varietal differences for FA and SB. In FA, TA ranges from 5.7±0.43 g/L tartaric acid in Dealu Mare V. (45.0° latitude) to 7.1±0.53 g/L tartaric acid in cooler, higher-latitude locations like Lechința V. (46.6°) and Panciu V. (45.9°). In this situation, cooler northern climates enhance acidity retention. Similarly, SB shows TA values ranging from 6.1±0.78 g/L tartaric acid in Dealu Bujorului V. (45.7°) to a high of 7.7±0.49 g/L tartaric acid in Panciu V. (45.9°), underlining possible acidity concentrations, particularly at higher latitudes.

For VA, FA varies between 0.11±0.16 g acetic acid/L and 0.56±0.50 g acetic acid/L, with the highest value in Lechința V. In SB, VA ranges from 0.28±0.10 g acetic acid/L in Dealu Mare V. (Ceptura W.) to 0.63±0.12 g acetic acid/L in Dealurile Silagiului V. (Aramic W.), reflecting varietal differences in VA production.

Examining Total_SO_2 (mg/L) (figure 2(e)) and Free_SO_2 (mg/L) (figure 2(f)) levels across Romanian vineyards, this shows distinct varietal responses for FA and SB, as well as geographic clustering based on SO_2 content. FA shows free SO_2 (mg/L) levels ranging from 23±2.7 mg/L in Sarica Niculițel V. to 57±4.3 mg/L in Dealu Mare V., while SB ranges from 26±6.3 mg/L to 57±2.5 mg/L, indicating significant regional influence on SO_2 management. Total SO_2 levels vary more dramatically, with FA from 51±0.5 mg/L in Târnave V. to 155±7.1 mg/L in Dealu Bujorului V., while SB ranges from 60±14.5 mg/L to 141±12.7 mg/L. Identified clusters reflect these variations. In these conditions Cluster 1 with high values of SO_2 includes Dealu Bujorului V. and Dealu Mare V.– Vișinescu W., where intensive preservation practices and warmer climates may necessitate higher SO_2 levels, as stated in other papers [Morgan et al., 2017]. Also, moderate values of SO_2 (Cluster 2) includes Lechința V., Aiud V. and Sarica Niculițel V., suggesting a higher role of winemaking procedures for antioxidant and microbiological preservation; and Cluster 3 represented by low SO_2 levels in Târnave V. may indicate a minimal intervention because of cooler natural conditions that allow for natural acidity retention.

Regarding the variance of data as function of period of monitorization (Figure 3), acidity and pH levels have remained stable, with slight acidity reductions in some areas by 2021, helping preserve freshness and aging potential. Box plots highlight year-to-year differences, particularly in volatile acidity and free SO_2, with grape type and vintage (notably for FA and SB) impacting composition. Terroir distinctions are evident in SO_2 levels (Figure 3a), volatile acidity (Figure 3b) and alcoholic strength (Figure 3c).

Previous relations were confirmed for SB, alcohol levels have generally risen from 2019 to 2021, likely influenced by climate change, as regions like Lechința V. (Jelna W.) and Aiud V. (Domeniile Boieru W.) shows consistently higher alcohol.

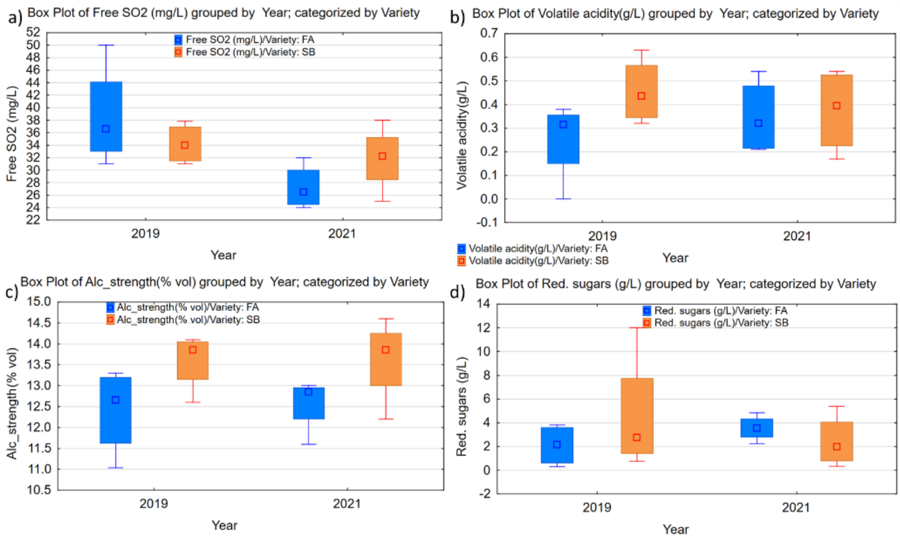

Fig. 3. Comparison of Free SO_2 (a), Volatile Acidity (b), Alcohol Strength (c), and Reducing Sugars (d) in Fetească albă and Sauvignon blanc Wines by Year

FA displays higher reducing sugars than SB, with a slight increase in reducing sugars correlating with rising alcohol [Goold et al., 2017]. Volatile acidity remains stable due to controlled vinification, showing minor reductions from 2019 to 2021. Other shifts include a slight increase in total acidity, a decrease in free SO_2 (potentially reducing oxidation protection), and an increase in total SO_2, possibly due to more sulfur additions. Reducing sugars at 20 °C have decreased, indicating more complete fermentation (Figure 3d). Overall, Romanian Sauvignon blanc wines show quality improvements, with higher alcohol and lower volatile acidity, although further study is needed to understand the impact on flavor and stability [Scutarașu et al., 2022].

CONCLUSIONS

This study reveals distinct correlations between physico-chemical properties and terroir in Romanian white wines, specifically Fetească albă (FA) and Sauvignon blanc (SB) from diverse vineyards. Higher reducing sugar content generally increases wine density, while elevated alcohol content correlates with lower sugar levels, particularly in warmer, lower-latitude regions like Dealu Mare, which fosters greater sugar accumulation.

Latitude influences alcohol content, with cooler, northern areas like Târnave yielding lower alcohol due to limited sugar development. Total acidity (TA) and volatile acidity (VA) display regional variability, with cooler climates supporting acidity retention, crucial for freshness.

The clustering of SO_2 levels by vineyard suggests that both regional climate conditions and winemaking practices significantly impact SO_2 concentrations in

Romanian wines. Vineyards in warmer regions, such as Dealu Bujorului and Dealu Mare (Vișinescu W.), exhibit higher SO_2 levels, likely due to the need for greater preservation measures. In contrast, cooler areas like Târnave show lower SO_2 concentrations, indicative of minimal intervention practices.

Stability in acidity and pH by 2021 indicates aging potential, while annual variations in VA and free SO_2 underscore the impact of grape type and vintage. Terroir distinctions are pronounced in alcohol, SO2, and VA levels, highlighting unique profiles shaped by both natural conditions and winemaking practices across regions.

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