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THE INFLUENCE OF PRODUCTION TECHNOLOGY PARTICULARITIES ON THE RED WINES CHARACTERISTICS AND QUALITY

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Abstract

In this study, the technological development of two wines obtained from the Feteasca Neagra grape variety was investigated, by the comparison of production methods and the wine's specific characteristics. Although wines were made from the same grape variety, the differences between them are major. Wine production started from the same raw material, but harvested at different maturation periods, reaching different selection and processing methods, and aging methods. As for the production technologies, classical technology, and thermomaceration were used to obtain V-type wine and an artisanal technology for A-type wine (with fermentation in clay amphorae and then continued in oak barrels for 24 months, followed by bottling to aging for a minimum of 12 months). Finally, wine A-type had a lower density of 0.27% and residual sugar of 62.82%, a higher total acidity of 5.77 %, and an alcohol concentration of 13.15%. From the sensory point of view (taste, smell, color, clarity, aroma, general harmony), wine A-type received a higher score.

***Key words**: acidity, alcoholic concentration, Feteasca neagra, red dry wine, sensorial characteristics.*

INTRODUCTION

Wine is the drink of all times, appreciated for its qualities and for its positive effect on health when consumed in moderation. Among the advantages of moderate wine consumption is the reduction of the risk of cardiovascular diseases, due to the presence of antioxidants, especially in the case of red wines. Wine is obtained by total or partial fermentation of grapes or juice (Ofoedu et al., 2022; Xiang et al., 2014).

Feteasca Neagra is an old Romanian variety of grapes that has the most spectacular rise in the wine market in Romania, appreciated and requested both by local consumers, but also abroad, and which arouses a special interest on the part of grape producers in growing the areas cultivated with Feteasca Neagra (http://crama-apogeum.ro).

Feteasca Neagră wine has a discreet but very specific olfactory character, suggesting the smell of dried plums, and when the wine is older, shades of cinnamon appear. In perfecting the sensory properties, the substances involved in the formation of the taste, smell, color, and other characteristics (the degree of foaming and game of the wine, the clarity), being an exclusive effect of fermentation or a mechanical operation (https://tohaniromania.com).

The quality and the name (brand) of wine are its main assets, and influence consumer behavior and choice (Veríssimo et al., 2021; Oliveira et al., 2019a; Oliveira et al., 2019b).

The quality of a wine can be determined by many factors, including its chemical composition (concentration of sugars, acidity, pH, alcohol level, polyphenol content), as well as the technology of obtaining and aging process (Hopfer et al., 2015).

The chemical composition of wine is one of the main indicators of its quality and influences its acceptability and appreciation by consumers; studies have shown that high levels of polyphenols, especially tannins, are associated with higher wine quality (Cory et al., 2018).

Wine production technology can also influence its quality. The use of well-ripened grapes doubled by traditional methods of fermentation, and aging in oak barrels can improve its quality and sensorial characteristics (Ribéreau-Gayon, 2021).

Aging is an important production phase for high-quality wines, because of the synthesis of certain substances involved in aroma, taste, smell, general appearance, and particular mark (label) of wine. Aging wine in wooden barrels or bottles can improve the aroma and taste of the wine through complex chemical reactions that take place during this process (Boulton et al., 1996).

The evaluation of wine quality is based on organoleptic analysis, which involves the evaluation of the taste, smell, and appearance of the wine by the human senses. This evaluation method can be subjective and can vary depending on the tasters' individual tastes, but using highly trained specialists in wine tasting and evaluation can offer a good perspective on the value of a wine type (Barbe et al., 2021).

Therefore, in order to obtain a superior quality wine, it is important to pay attention to both its chemical composition and the production and aging process.

The chemical composition of dry red wine can influence wine quality through several factors. The level of sugars can influence the taste and aroma of the wine; a low concentration of sugars can result in a dry wine, while a higher concentration can result in a sweet wine. The alcohol level can also influence the taste and aroma of the wine, with too high an alcohol level leading to a burning sensation in the mouth and an unpleasant aftertaste (Miao, 2022).

Another important factor is acidity, which can influence the taste and structure of the wine; a wine with high acidity can be perceived as sour, while a low-acidity wine can be perceived as lacking brightness and character (Scutarașu et al., 2021).

The content of polyphenols, especially tannins, can also play an important role in the quality of dry red wine. These are organic compounds that can contribute to wine aromas and tastes, as well as texture and structure. Studies have shown that high levels of polyphenols, especially tannins, are associated with higher wine quality (Hosu et al., 2016; Nemzer et al., 2022).

The chemical composition of wine can also influence organoleptic properties such as aroma and taste. For example, the concentration of volatile compounds in the wine can influence its aroma, and the level of sugars can influence the sweetness and body of the wine (Escudero et al., 2007).

The taste is a basic indication in the sensory assessment, the elements that are evaluated in the case of this characteristic are the intensity and quality of the taste, the harmony of the taste components and the softness of the taste, the alcoholic strength, the acidity, the sweetness, the astringency.

The substances involved in taste formation are ethyl alcohol (gives the wine viscosity, reduces the acidic taste, increases the degree of sweetness, and the taster's olfactory sensitivity), glycerol (reduces the sour-pungent taste, making the wines “softer”, also contributing the to the preservation of odorous substances); sugars (hexoses, pentoses); organic acids (gives wines their sour, harmonious taste, i.e. "vibrancy"), the tannin content. A study published in the journal Red Wine Technology analyzed aroma compounds in red wines and found that the level of tannins and phenolic compounds were the most important factor influencing the wine's sensory characteristics, including taste. Alcohol level and acidity were also associated with wine sensory characteristics such as fullness and freshness of taste (Escudero, 2007; Rauhut, 2019).

The substances involved in the formation of the odor are found in small quantities, from µg/l to a few mg/l. The most odoriferous compounds in wine are those that are not only found in large quantities but also have a higher vapor pressure as well as a higher odor intensity (terpene compounds: geraniol, neralol, α-terpinol, linalool, limonene, citronellol). The level of terpene compounds is 0.3-3.5 mg/l in aromatic varieties; 0.5 mg/l for mildly aromatic varieties; 0.2 mg/l for unflavored varieties (Meilgaard et al., 2015).

The smell of dry red wine can be described by various aromatic notes, such as black fruits (strawberries, raspberries, black currants), berries, spices (black pepper, vanilla, cinnamon), chocolate, coffee, or wood (depending on the type of barrels in which the wine was matured). These aromas are influenced by the chemical composition of the wine, but also by the fermentation and aging processes. Volatile aromatic compounds such as esters and aldehydes are produced during fermentation and can contribute to the wine's aromatic notes. In addition, the acidity level and pH of the wine can affect the aromatic notes, with a higher pH reducing the intensity of certain aromas (Ieri, 2021; Ribreau-Gayon, 2021).

MATERIALS AND METHODS

The study was carried out in a well-known winery in Romania and the influence of the use of different technologies for processing grapes from the Romanian variety Feteasca Neagra on the final quality of the obtained dry red wine was followed.

The research was carried out over two years (2020-2021), tracking three batches of V-type wine, obtained by classical technology and thermo-maceration, and one batch of A-type wine, obtained by artisanal technology.

Figure 1. Clay amphorae used for fermentation of grape juice to obtain A-type wine

Starting from the goal to enlighten the humble Feteasca Neagra grape variety, the winery brought back to life a 2000 years old unique Romanian fermentation process. The grapes come from an old vineyard, specially arranged and cared for, located in one of the best wine-growing areas in Romania. The plantation is 50 years old, on calcareous, has poor soil and benefits from small amounts of precipitation.

The production yield is small, 5-6 tons/ha, harvested by hand. The grapes are selected from the vineyard, picked in the optimal period, and transported with great care to the winemaking place, where fermentation takes place in clay amphorae (Figure 1), followed by a period of 24 months, during which the young Feteasca Neagra rests in the barrel; then, the wine is aged for at least 12 months in glass bottles, for its elegant maturity notes, expressed by an explosion of aromas (oak, vanilla, chocolate, coffee), soft, velvety tannins, elements which denote the value of a special, rare wine.

The physicochemical parameters analyzed during the fermentation process were: density, residual sugars, alcohol content, free and total SO_2 content, total and volatile acidity.

The two wines were also analyzed from the sensorial point of view.

The results were processed statistically by classical methods.

RESULTS AND DISCUSSIONS

The physicochemical parameters analyzed during the fermentation period for the two wines are shown in Tables 1 and 2, respectively in Figure 2.

The initial density was 1.107-1.113 g/cm^3 for V-type wine and 1.117 g/cm^3 for A-type wine.

During fermentation, the density decreases, so at the end of the fermentation period, V-type wine has a density between 1.009-1.013 g/cm^3, and A-type wine, 0.994 g/cm^3.

References from the literature indicate values of the density of dry red wine at the end of fermentation of 0.992-0.998 g/cm^3 (Cabernet Sauvignon: 0.992-0.996 g/cm^3, Merlot: 0.990-0.996 g/cm^3, Pinot Noir: 0.993-0.996 g/cm^3). This can vary depending on many factors, such as grape variety, fermentation process, and other processing conditions (Boulton et al., 1999).

Jackson (2020) shows that the density is 0.990-1.020 g/cm^3, which can also vary depending on the temperature at which it is measured and the atmospheric pressure.

The content of sugars in V-type wine decreases by 93.2-95.2 % compared to the initial values; for A-type wines, the decrease is 88.89-90.25 %

The literature states that the amount of residual sugar in dry red wine at the end of the fermentation process can vary depending on the type of wine, fermentation conditions, and other factors. In general, the residual sugars in dry red wine at the end of fermentation can be 2 g/l or less, indicating that most of the sugars have been converted to alcohol. However, some dry red wines can have higher residual sugar, up to 5-6 g/l or even more, to achieve a certain sweetness or balance in taste (Blazquez Rojas, 2012)

Table 1. The evolution of must parameters followed by days of fermentation in 2021, V-type wine

Fermentation day	Batch 1			Batch 2			Batch 3		
	Density (g/cm³)	Temperature (°C)	Residual sugars (g/l)	Density (g/cm³)	Temperature (°C)	Residual sugars (g/l)	Density (g/cm³)	Temperature (°C)	Residual sugars (g/l)
1	1.113	19	270	1.111	20	264	1.107	16	252
2	1.113	20	270	1.109	20	260	1.082	15	190
3	1.110	18	262	1.094	20	223	1.075	16	172
4	1.097	17	228	1.071	23	167	1.065	20	150
5	1.076	20	177	1.048	20	106	1.056	18	126
6	1.068	20	156	1.025	23	72	1.046	20	100
7	1.038	23	83	1.015	24	45	1.032	20	78
8	1.030	22	75	1.009	20	34	1.013	23	44
9	1.019	23	50	1.005	20	22	1.008	18	32
10	1.011	20	39	1.001	19	16	1.004	19	20
11	1.006	20	28	0.997	20	8	1.002	20	16
12	1.003	19	18	0.994	20	3,20	0.999	20	12

Table 2. The evolution of must parameters followed by days of fermentation, A-type wine

Fermentation day	2020			2021		
	Density (g/cm³)	Temperature (°C)	Residual sugars (g/l)	Density (g/cm³)	Temperature (°C)	Residual sugars (g/l)
1	1.117	16	277	1.117	20	279
2	1.103	19	245	1.112	19	267
3	1.060	18	136	1.099	18	235
4	1.048	19	106	1.086	19	203
5	1.037	20	94	1.075	19	174
6	1.030	17	80	1.069	18	159
7	1.022	17	52	1.057	19	129
8	1.010	17	35	1.050	18	111
9	1.007	20	30	1.043	19	93
10	1.000	19	14	1.021	18	52
11	0.998	20	10	1.011	19	38
12	0.997	20	8	1.006	20	28
13	0.996	20	6	0.999	19	13
14	0.995	20	5.1	0.994	18	3.1
15	0.994	20	2.7			

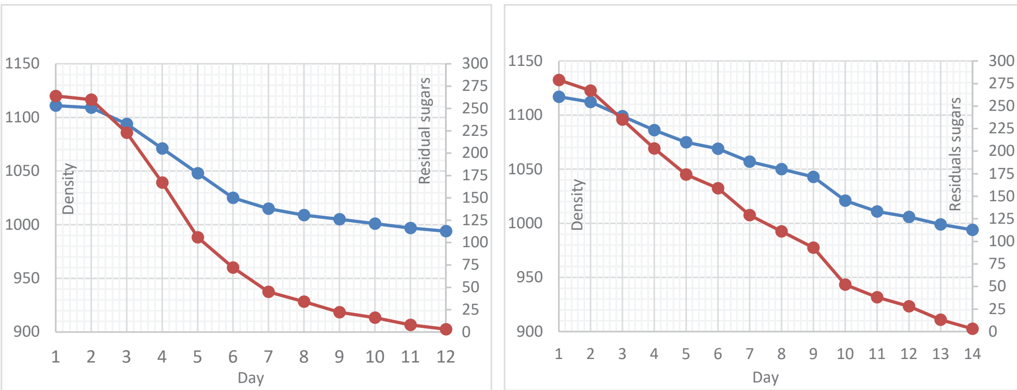

Figure 2. Evolution of density and residual sugars: V-type wine, batch 2/2021; A-type wine, 2021

V-type wine, obtained by classical technology, respectively by thermomaceration, was analyzed sensory (Table 3) and from the point of view of physicochemical parameters (Table 4).

Table 3. Sensory characteristics of wine V

Feteasca Neagra V-type	Sensory characteristics			
	The clarity	Color	Flavor	The taste
Classical	Clear, without sediment and foreign inclusions	Intense red	Characteristic of the variety with nuances of black currant and dried fruit	The characteristic taste of the blackberry variety is generally balanced, consistent and vigorous. The right acidity, relatively persistent
Thermomace-rated	Clear, without sediment and foreign inclusions	Red, very intense	Characteristic of the variety with nuances of black currants and dried fruits, especially prunes	The taste characteristic of the variety. The right acidity, relatively persistent and "baked" taste

The analysis of the sensory properties of V-type wine obtained by the two processes shows that they correspond to the characteristics of young wines. Both processes were conducted on wines with good clarity, without sediment and mechanical inclusions. The color is different in intensity, being weaker in the case of the classic process than in the thermomaceration one. The aroma of wines obtained from Feteasca Neagra is pleasant, complex, and original. The taste is generally consistent and vigorous, with a suitable acidity, characteristic of the variety, which intervenes beneficially, leaving behind a pleasant and persistent memory.
These values of the physicochemical parameters (Table 4) characterize the young wine and express their future behavior, respectively the potential that will be reached. It is noted that the wines have a high alcohol content, a welcome factor that can ensure physicochemical stability. The titratable acidity is within the permissible limits for red wines, and the volatile acidity shows relatively high values for young wines, but which do not exceed the norms. The mass concentration of sulfur dioxide is relatively low.

Table 4. Physicochemical characteristics of V-type wine

Indices	V-type wine (classical)	V-type wine (thermomaceration)
Alcohol concentration (% vol.)		14
Mass concentration of sugars (g/dm^3)	2.6	2.8
Mass concentration of titratable acids (g/dm^3)	7.7	7.1
Mass concentration of volatile acids (g/dm^3)	0.90	0.93
Mass concentration of free sulfur dioxide (mg/dm^3)	26	13
Mass concentration of total sulfur dioxide (mg/dm^3)	80	65.5
Mass concentration of iron (mg/dm^3)	6	6
Ph	3.72	3.76
Total polyphenolic index, TPI (units)	62.6	68.3
Color intensity, I_c (unit.)	16.73	21.04
Color purity (dA)	53.5	47.4
Anthocyanins (mg/dm^3)	163.8	193.8

The vinification of Feteasca Neagra grapes through the two technological processes led to different values, both of the chromatic and phenolic characteristics. The wine obtained by thermomaceration showed a higher level of color intensity (+9.1%) and a higher polyphenolic index (+25%).
The average final density of the two analyzed wines was significantly equal (only 0.2% higher in V-type wine), and the remaining sugars were 2.68 times higher in V-type wine.
Total sulfur dioxide had an average of 54.1 mg/l in A-type wine and with 18.5% lower in V-type wine.
The literature states that the level of total sulfur dioxide (total SO_2) concentration in dry red wine can vary depending on many factors, such as the grape variety, the location of the crop, the winemaking technique, and the level of preservation. In general, the concentration of total sulfur dioxide in dry red wine can be from 10 to 40 mg/l for regular wines, and up to 160 mg/l for premium wines.
It is important to note that total SO_2 levels in wine are regulated by law and the maximum allowed for dry red wine in the European Union is 160 mg/l. In the USA, the maximum level allowed for dry red wine is 350 mg/l (https://www.oiv.int/; https://www.fao.org/).

Table 5. The final values of the wort parameters (when it is drawn)

Specification			Density (ρ)	Residual sugars (g/l)	Alcohol (%)	Free SO_2 (mg/l)	Total SO_2 (mg/l)	Total acidity (g/l)	Volatile acidity (g/l)
Wine V	2020	Charge 1	995	5.20	14.1	12.6	40.8	5.74	0.29
		Charge 2	998	10	12.5	19.4	36	5.50	0.30
		Charge 3	994	2.4	15.7	16.8	33.6	4.72	0.34
	2021	Charge 1	994	3.2	15.3	12.4	48	4.64	0.34
		Charge 2	1000	14	15	17.8	56	4.59	0.37
		Charge 3	999	12	14.1	15	50.21	4.98	0.40
Wine A	2020	Charge 1	994	2.7	16.2	19.4	47.80	5.39	0.31
	2021	Charge 1	994	3.1	16.5	24.30	60.4	5.24	0.37

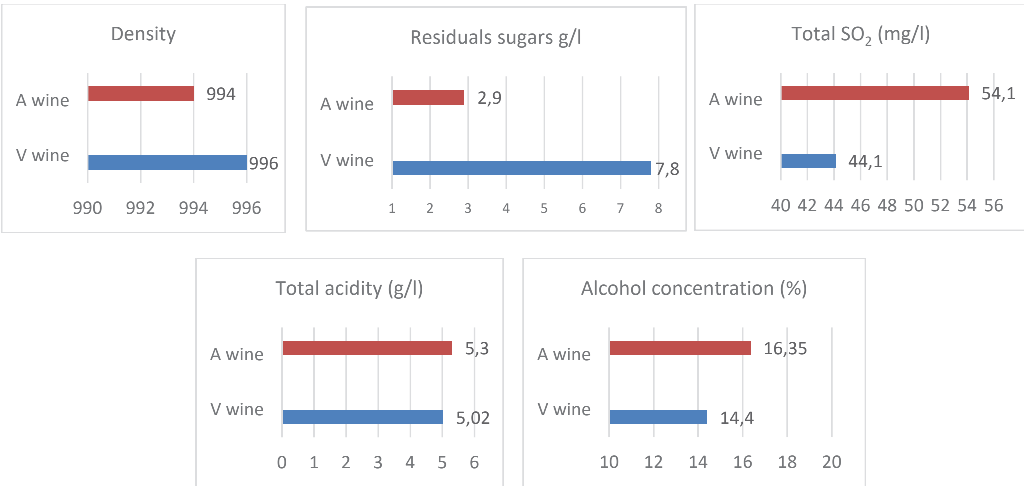

Figure 2. Average final physicochemical parameters of the studied wines

It should be noted that there are differences between free sulfur dioxide (free SO_2), which can be toxic in high concentrations, and total sulfur dioxide (total SO_2), which includes both free SO_2 and bounded SO_2, which is not toxic. Most of the SO_2 content in dry red wine is in bound form and therefore poses no health risk to consumers.

The final total acidity was 5.3 g/l in A-type wine and slightly lower in V-type wine (5.02). The values found in scientific studies are between 4.5-7.5 g/l (Ofoedu et al., 2022; Veríssimo et al., 2022, Hopfer et al., 2015).

The final alcoholic concentration recorded average values of 16.35% for wine A and 14.4% for wine V.

Literature cites an alcohol content of dry red wines between 11.5% and 13.5% vol in Italy, between 12 % and 14 % vol in France, and between 13.5% and 15.5% vol (Oliveira, 2019a şi 2019b; Xiang, 2014).

Studies have shown that the alcohol level can influence the taste and aroma of dry red wine. In general, higher alcohol content can give the wine a warmer feel and a more pronounced sweetness, but it can reduce the complexity and subtlety of the aromas and tastes. Conversely, lower alcohol content can make the wine more subtle and delicate in taste and aroma, but can also lead to a cooler mouthfeel (https://www.oiv.int/).

For a complete analysis, we continued with the evaluation of the sensory properties, since the wine cannot be qualitatively judged only according to the chemical composition or the microbiological state, but also according to the sensory quality.

During the tasting process, the samples were taken out of the barrel into clean bottles with labels, 1-2 hours before the actual tasting, avoiding aeration of the wine. The tasting temperature was around 15-17°C. The longer maceration period can lead to a deeper and more intense color of the wine.

Related to the color of the young dry red wine, the anthocyanin pigments in the grapes are the main determining factor. The pigments are present in the skin of the grapes and are released during the fermentation process. Younger red wines are usually more intense in color and have purple or ruby tones. As the wine ages, the color may change to darker shades such as brown or orange. This is due to the oxidation of anthocyanins and the formation of more stable pigments (Barbe et al., 2021; Oliveira et al., 2019a).

The color of dry red wine can influence taste perception. One study showed that participants described red wine with deeper shades of red as sweeter and more aromatic, while wines with lighter shades were perceived as drier and sourer. (Oliveira et al., 2019a).

Regarding the taste of dry red wine, the specialized literature describes it as being characterized by intense aromas of red and black fruits, such as cherries, currants, raspberries, plums, or blackberries, together with notes of spices, vanilla, or chocolate. The taste can be described as dry or slightly sweet, with moderate acidity and well-balanced alcohol strength (Meilgaard, 2015).

Following the sensory analysis, it was found that V-type wine has an intense ruby color. The wine is extremely generous, with aromas of jam and ripe cherry, plus notes of black truffle, cloves, and dry tobacco leaves.

On the palate, there is a remarkable voluptuousness, which meets an aroma of red berries, black cherries and sour cherries. The supple tannins integrate perfectly into the complexity of this wine. The total average score obtained by this wine was 90 points.

In the case of A-type wine, the color was ruby red, dense, and bright. Primary aromas of plum, blueberry, and blackcurrant are complemented by hints of licorice and coffee. The spices that define the wine's character, pepper, cloves, and vanilla, are integrated and complete the aromatic picture.

The taste is soft, with soft and juicy tannins. The average score obtained by this wine was 94 points.

CONCLUSIONS

The results of the experimental study which analyzed the evolution of the same raw material processed by two different technological processes highlighted the impact on the finished product and notable differences in terms of the physicochemical parameters and the seasonal properties of the two wines.

These differences are directly influenced by the technological process.

V-type wine, processed in a classic, industrial system (the must be obtained by pressing, and the fermentation is done in stainless steel vessels, without a subsequent aging period) finally had a lower SO_2 content, a higher residual sugar, and a smaller amount of alcohol. As the level of carbohydrates decreases, the level of alcohol concentration increases.

A-type wine was obtained in an artisanal way, benefiting from a cold maceration of the grapes, a longer fermentation period in clay amphorae, which led to a lower residual sugar, a higher amount of alcohol and SO_2, but also a slightly higher acidity. They ensure the wine an increased shelf life, without the need for interventions on the values.

Following the performance of the sensory analysis test, the fullness of the wines, the perceived intensity, and strength, the outline of the complexity, and also the specific aromatic notes from which the uniqueness of wine A was deduced.

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