Application of ultrasounds to improve oak aging of white wines

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Abstract. Increasing the efficiency of the release for certain compounds during the maturation of some wines in the presence of oak chips is an important topic for oenology research. This study followed the influence of the use of ultrasound waves with a frequency of 35 kHz on the physicochemical and sensory characteristics of some white wines from Iasi, Romania. Oak chips (1 g/L and 2 g/L, fresh, light, and medium toasted) were added to the Fetească regală and Sauvignon blanc stabilized wines. The samples were kept at a constant temperature of 15ºC for 10 and 15 days, respectively. For comparison, 15 mins. ultrasound-treated samples were used. It has been observed that this technique in addition to reducing the aging time, significantly influences the organoleptic characteristics of the treated wines. New ways to continue research to clarify, optimize and streamline the methods of artificial aging of wines have also been identified.

1 Introduction

Wine maturation is the stage in which several processes take place, which together change the organoleptic characteristics and compositional characteristics of the wine. Over the years, several techniques have been developed in order to achieve accelerated maturation, as traditional maturation is expensive and has a significant negative impact on the final price of the wine [1, 2]. Thus, the use of oak chips in winemaking is a valid alternative for reducing production costs and accelerated extraction of wood compounds.

The oak species used in winemaking belong to the genus *Quercus*, namely the American white oak (*Quercus alba*) and two European varieties, *Quercus petraea* and *Quercus robur*, known as French oak [3, 4].

Oak species, geographical origin, morphological characteristics of oak wood (granularity, porosity, and permeability), processing and chemical composition, concentrations, type of toasting and contact time influence the physico-chemical and biochemical mechanisms occurring during the maturation process [5]. At present, increasing the efficiency of extraction from oak chips of certain compounds during wine maturation is an important issue for oenological research. To this end, ultrasound treatment is considered the most promising technique for accelerating the wine maturation process [6].

The cavitation produced by ultrasonic waves creates an increase in the liquid's temperature and pressure. Thus, ultrasound promotes certain chemical reactions and can produce chemical and structural changes in wine similar to those that occur after longer periods of maturation [7-9]. Thus, by applying this accelerated ageing method, ageing would be achieved in a shorter time, reduced costs and saved space [10–12].

The current study consisted of examining the changes in compositional and sensory parameters, which occur in Fetească regală wines, as a result of the addition of wood chips and the influence of ultrasound. At the same time, an important objective is compare the influence brought on by contact time, different types of wood or applied doses. The results of such a study are, for sure, of practical interest for winemakers, as it could improve the control of wood addition and the extraction process for better quality.

2 Materials and methods

2.1 Grapes and wine-making procedure

In order to achieve the proposed objectives, the raw material used was grapes of the local variety – Fetească regală, 2021 harvest from Iași vineyard, Romania. They were harvested by hand, under good sanitary conditions with a sugar concentration of 240 g/L.

The grapes were crushed, destemmed and the resulting must was subjected to a pre-fermentative maceration for 5 hours. After this process, the liquid part was separated and clarified, by gravity, after which selected were inoculated. The dose used was 20 g/hL.

Alcoholic fermentation was carried out at a controlled temperature of 14˚C. After stabilization, the obtained wine was divided into 38aliquots (named here V0-V37 variants), respectively: 1 control sample, 37 samples treated with 1 g/L and 2 g/L oak chips, 1 g/L and 2 g/L pellets, both with 3 different toasting degrees (light, fresh, and medium), kept in contact with wines for two time periods (10 days and 20 days). Moreover, 13 wine samples treated similarly were subjected to ultrasounds. The ultrasonic equipment used was a Bandelin Sanorex RK 1028 C model, which has a thermal power of 1450 W and an ultrasonic frequency of 35 kHz. Throughout the treatment the temperature was controlled, maintaining a temperature of 20˚C.

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2.2 Oenological oak products

The pellets are obtained from carefully selected oak wood from the middle area of the tree. They have a medium grain size, within 5 × 5 × 1 mm range and are able to enrich the wine in structure and roundness of taste.

Chips are by-products of the raw material used to make staves for oak barrels. They are characterized by a medium grain size but a fairly high variability, 10 × 7 × 2.5 mm, and can impart a complex, woody character to the wine. The oak fragments used in the experiment belong to *Quercus petraea* (French oak) [13-15].

The control variant was obtained without any addition of oak material.

2.3 Oak products addition

The experimental variants were matured in 5 L glass jars to which 1 g/L and 2 g/L oak fragments were added and placed in contact with the wine for a period of 10 and 20 days. The oak fragments used were of two types, granulated and chips, each with 3 degrees of toasting(light, fresh, and medium).The samples were kept at a constant temperature of 15°C for 10 and 20 days, respectively. For comparison, samples were treated with ultrasounds for 15 minutes at a frequency of 35 kHz.

2.4 Analysis methods

Physico-chemical parameters were determined for each experimental sample according to the OIV methods, Compendium of International Methods of Analysis of Wine and Musts, namely: pH, total and volatile acidity, alcoholic strength (% v/v), reductive sugars, total and free SO_2 [16].

Sensory analysis. Regarding the sensory perception of the effect of maturation on white wines, a professional panel of 15 tasters (represented by winemakers, laboratory staff and researchers) evaluated the obtained experimental results. The wines were previously kept cold and transferred to room temperature (20◦C) before sensory analysis.

Specific olfactory and gustatory descriptors were used. Olfactory phase descriptors are related to primary and secondary aromas, wood-wine interaction (spices, vanilla, sweet tobacco, coconut, almond, coffee). Scored taste descriptors were acidity, sweetness, texture, and persistence. Obtained results were centralized and mean values were represented and compared using so-called "spider web charts".

3 Results and Discussion

3.1 Physico-chemical characteristics

This article is a comparative study of samples of Feteasc ă regală wines, produced in 2021, subjected to maturation treatments by adding oak chips and ultrasound treatment. The physico-chemical parameters of the wine samples analysed are illustrated in Table 1.

Table 1. Quality parameters of the wines obtained.

Samples				1	2	3	4	5	6	7
Control samples V0				0.99163	7.65	0.32	13.9	49	128	3.2
10 days	1 g/ L	G	V1	0.99148	7.803	0.46	14	46	127	3.21
			V2	0.99148	7.803	0.46	14	44	127	3.21
			V3	0.99165	7.803	0.46	14	48	128	3.22
		C	V4	0.99152	7.803	0.46	14	48	128	3.2
			V5	0.9918	7.956	0.45	13.9	47	128	3.19
			V6	0.99148	7.803	0.46	14	47	127	3.19
20 days		G	V7	0.99162	7.803	0.43	14	47	127	3.16
			V8	0.99176	7.956	0.43	13.9	47	128	3.2
			V9	0.99125	8.109	0.43	14.1	44	127	3.17
		C	V10	0.99179	7.803	0.43	14	44	127	3.2
			V11	0.99187	7.803	0.42	13.8	45	127	3.15
			V12	0.99145	7.803	0.43	13.8	45	127	3.17
10 days	2 g/ L	G	V13	0.9915	7.956	0.4	14.1	45	127	3.24
			V14	0.99157	7.803	0.45	13.9	46	127	3.21
			V15	0.99163	7.803	0.43	14	46	127	3.22
		C	V16	0.99169	7.803	0.44	13.9	46	126	3.23
			V17	0.99164	7.803	0.44	13.9	42	126	3.22
			V18	0.9915	7.803	0.46	13.9	42	126	3.21
20 days		G	V19	0.99176	7.956	0.41	14.1	41	125	3.15
			V20	0.99154	7.803	0.43	14	42	127	3.18
			V21	0.99148	7.956	0.4	13.9	44	126	3.22
		C	V22	0.99181	7.956	0.41	13.9	44	126	3.18
			V23	0.99208	7.956	0.43	13.8	45	126	3.15
			V24	0.99173	7.956	0.41	14	44	126	3.17
Control samples US			V25	0.99173	7.803	0.4	14	49	128	3.17
15 minutes	1 g/ L	G	V26	0.99153	7.803	0.42	14.1	49	124	3.17
			V27	0.99193	7.803	0.38	14.1	48	123	3.19
			V28	0.99137	7.956	0.44	14.1	48	124	3.16
		C	V29	0.99217	7.803	0.39	13.7	42	122	3.17
			V30	0.99112	8.262	0.32	13.7	47	125	3.37
			V31	0.99128	7.803	0.4	13.8	46	122	3.23
	2 g/ L	G	V32	0.99162	7.956	0.42	14.1	43	124	3.18
			V33	0.99151	7.956	0.41	14.1	46	124	3.25
			V34	0.99158	7.956	0.43	14.1	45	124	3.17
		C	V35	0.99155	7.956	0.42	14.1	44	124	3.19
			V36	0.99183	7.956	0.42	13.9	44	124	3.16
			V37	0.99142	7.956	0.44	14.1	42	124	3.16

1− density; **2**− total acidity (g tartaric acid/L); **3**− volatile acidity (g acetic acid/L); **4**− alcohol strength (%); **5**− free SO_2 (mg/L); **6**− total SO_2 (mg/L); 7− pH ; G- French oak granular; C- French oak chips; US-ultrasound treatment.

The parameters of the obtained wines vary to a small extent in terms of alcohol content, variation in total acidity and pH value, but also free and total SO_2. There

are no remarkable differences in the physico-chemical characteristics.

The acids in wine are one of the essential components that have a direct influence on the color, balance, and on the taste [17]. In addition, the acids present in wines assure the growth and the vitality of yeast during fermentation and also have a protective role against harmful bacteria [18-20]. On the other hand, excessive concentrations give the wine a tart or a sour taste. All samples register a correct level of acidity, imprinting a specific freshness, registering between 7.6 and 7.9 g/L tartaric acid. In comparison, ultrasound treatment was unable to significantly influence the pH, but a slight decrease appeared between the two control variants, V0 and V25.

As for the alcohol level in the wine, the effect of ultrasound on it is still unclear, but it can be observed that the lowest concentration (V29- 13.5% vol.) and the highest concentration were found in the variants subjected to ultrasound. These results indicate that ultrasound treatment can lead to slight changes in wine parameters.

3.2 Organoleptic evaluation of the experimental samples

Sensory analysis is an indispensable tool for a comprehensive assessment of a wine's quality. The results of the organoleptic evaluation of the Fetească regală wines obtained following the various maturation processes are represented in Figures 1-9.

All experimental wines are considered fresh, with a good texture and persistence, typical for wines obtained from the Fetească regală grape variety.

In Figures 1-4, the "spider web" diagrams are charted using the mean intensity scores of the olfactory attributes of the wines treated with 1g/L French oak fragments for a period of 10 and 20 days compared to the wines treated ultrasonically with the same oak fragments, but in a much shorter time, 15 minutes.

In wines treated with 1g/L French oak granular for a period of 10 days (Fig. 1) compared to the ultrasound treatment, the V3 variant jumps forth with notes of spices and V28 and V 27 with notes of vanilla. In wines treated with 1g/L French oak chips for a period of 10 days (Fig. 2) compared to the ultrasound treatment, the V6 variant springs forward and brings notes of vanilla, coconut and sweet tobacco. Figures 3 and 4 represent wines where slight spicy notes start to be defined. One can focus on the perception level the ultrasound treatment impaired, managing to enrich wines with specific woody notes in a shorter time.

Also, in the same experiment, an extraction was carried out using a quantity of 2 g/L French oak fragments for a period of 10 and 20 days and in comparison, the same samples were subjected to ultrasound treatment for 15 minutes. These are shown in Figures 5-8. Among wines matured with 2 g/L over a period of 10 days, the V16 variant stands out with pronounced notes of exotic fruits, vanilla and sweet tobacco. For the ultrasound-treated variants, V37 and V34 stand out with notes of vanilla and spice.

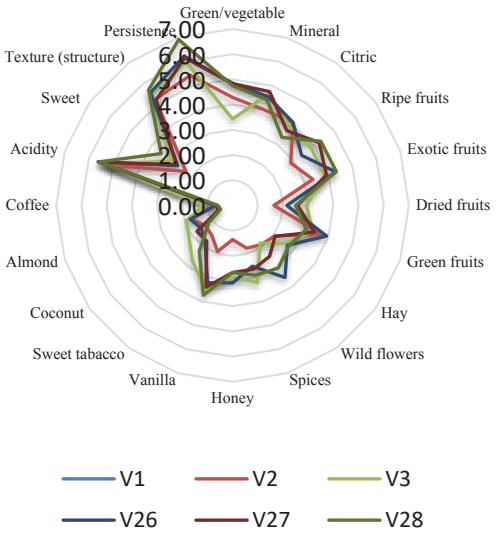

Figure 1. Chart of organoleptic features of the analyzed samples with 1 g/L French oak granular for a period of 10 days compared to the wines US.

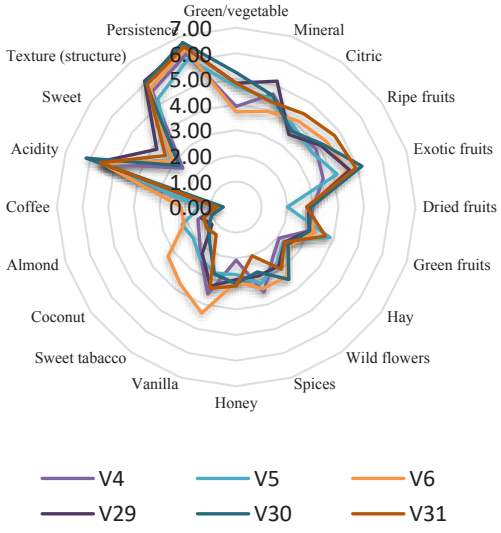

Figure 2. Chart of organoleptic features of the analyzed samples with 1 g/L French oak chips for a period of 10 days compared to the wines US.

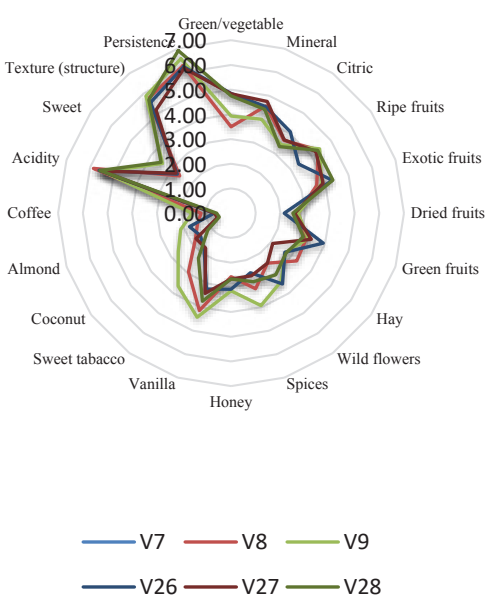

Figure 3. Chart of organoleptic features of the analyzed samples with 1 g/L French oak granular for a period of 20 days compared to the wines US.

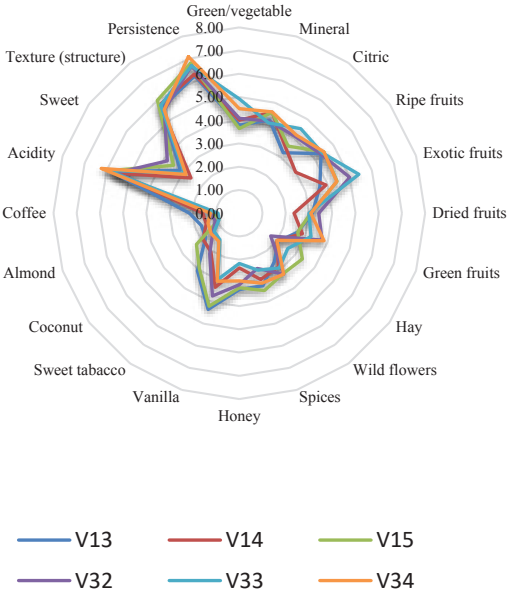

Figure 5. Chart of organoleptic features of the analyzed samples with 2 g/L French oak granular for a period of 10 days compared to the wines US.

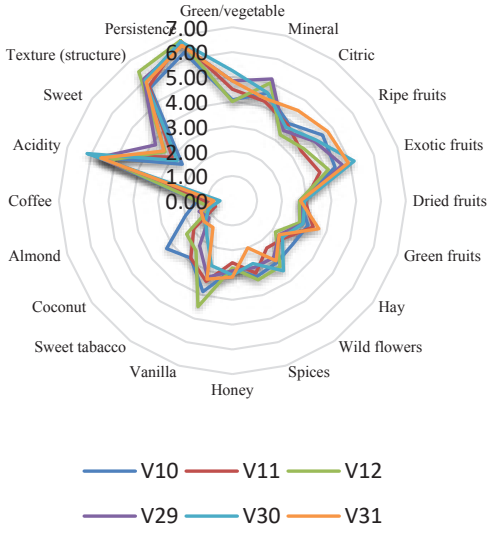

Figure 4. Chart of organoleptic features of the analyzed samples with 1 g/L French oak chips for a period of 20 days compared to the wines US.

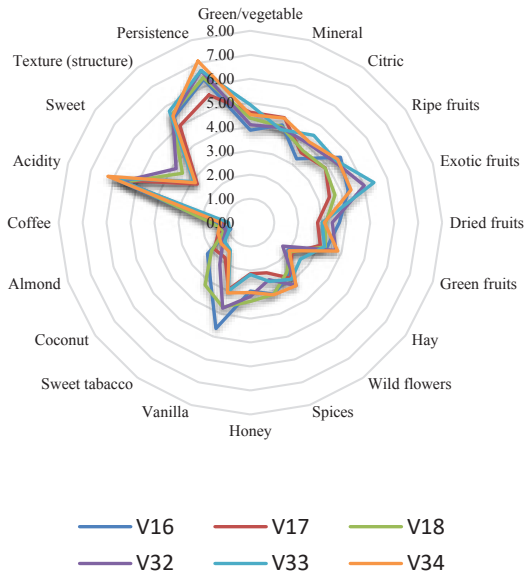

Figure 6. Chart of organoleptic features of the analyzed samples with 2 g/L French oak chips for a period of 10 days compared to the wines US.

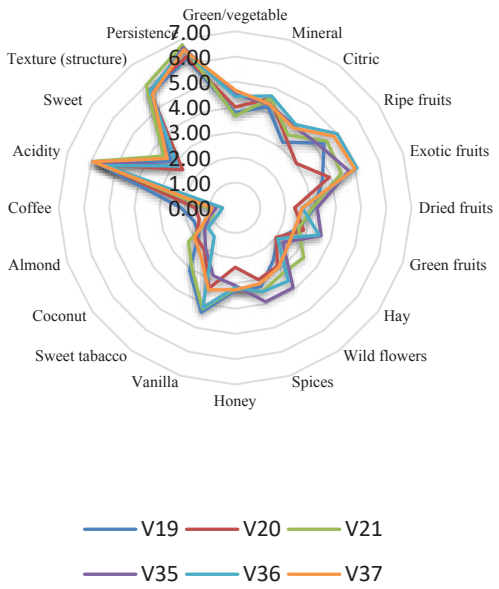

Figure 7. Chart of organoleptic features of the analyzed samples with 2 g/L French oak granular for a period of 20 days compared to the wines US.

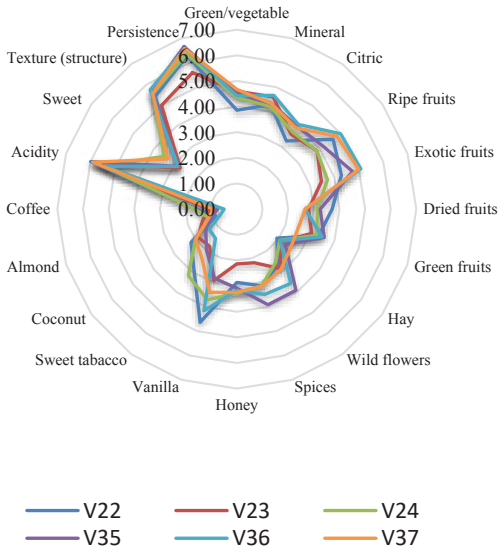

Figure 8. Chart of organoleptic features of the analyzed samples with 2 g/L French oak chips for a period of 20 days compared to the wines US.

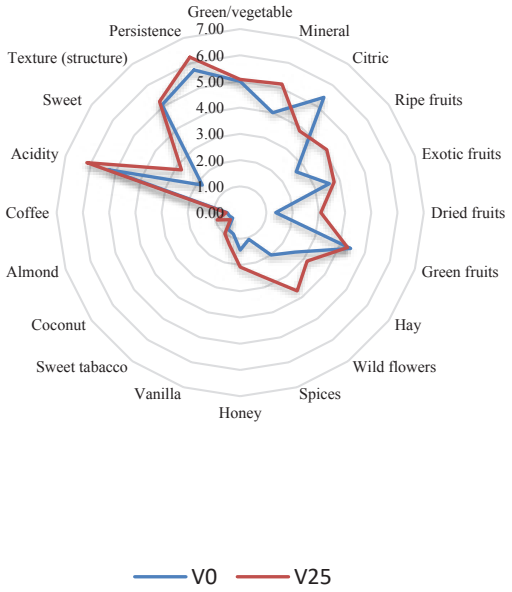

Figure 9. Chart of organoleptic features of the analyzed samples control compared to the control samples US.

In wines where maturation was done for 20 days, two variants that have undergone ultrasound treatment stand out, namely V35 with notes of spices and V36 with notes of vanilla at almost the same intensity as V21 which has been in contact with wood for a much longer period of time. It was observed that this technique, in addition to reducing the maturation time, significantly influences the organoleptic characteristics of the treated wines.

The two control variants can be seen in Figure 9, V0 is the control variant obtained without any addition of oak material and V25 is represented by the ultrasound-treated wine sample. V25 has more intense notes of exotic fruits, wild flowers, and spices. The application of ultrasounds during maturation resulted in enriching the wine in spicy notes, aromatic intensity, and woody feelings.

Using these processes, wines with better integrated wooden notes were obtained. Furthermore, important sensory characteristics are subsequently enhanced during maturation steps. Over that process, wines are organoleptically enriched as typical wood compounds are extracted into the wine and its aroma evolves.

4 Conclusions

Following the results of the physico-chemical characteristics, the considered samples could be included in the category of dry wines.

The chemical composition and sensory properties of the wines varied according to the type of oak chips, the dosage and the treatments used for maturation. Considering all the results obtained, it can be concluded that maturation with French oak chips is an effective alternative method that could enhance the sensory complexity of the wines. At the sensory level it can be observed that depending on the fragments of oak used, granular and chips, the samples that were subjected to maturation with chips showed a better perception of oak notes, obtaining higher scores in tasting.

The ultrasound treated wine samples V35 with notes of spices and V36 with notes of vanilla, graded at the same level with V21, sample that was kept in contact with oak products for 20 days. It was observed that this technique, in addition to reducing the ageing time, significantly influences the organoleptic characteristics of the treated wines.

Using these processes, wines with better integrated wooden notes were obtained. Over that process, wines are organoleptically enriched as typical wood compounds are extracted into the wine and its aroma evolves.

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