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ORIGINAL RESEARCH PAPER

THE IMPACT OF ULTRASOUND TREATMENT ON THE QUALITY OF DIFFERENT WINE VARIETIES

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Abstract: The aim of the present study was to characterize the quality of four varieties of wines obtained from grapes of Vrancea area: *Feteasca Alba* (FA), *Tamaioasa Romaneasca* (TR), *Cabernet Sauvignon* (CS) and *Muscat Hamburg* (MH) ultrasonicated (US) at different times (10 and 30 minutes), in terms of physico-chemical and sensory properties. The sensory characteristics (clarity, color, aroma, taste) and the physico-chemical properties (density, sugar and alcohol content, *p*H, acidity, electrical conductivity, turbidity) were determinated on must and wine samples. Sonicated wine (energy intake in liquid) gives a more uniform degree of dispersion to the components, which improves the taste and quality (intensification of the color, flavor, and taste of the wine by extracting valuable ingredients from grape seeds and skin, such as polyphenolic substances), but also accelerates its maturation.
The results revealed that the ultrasonic samples had a lower fermentation rate due to the inactivation of the yeasts.The wines have a more intense color than the untreated samples, results also related by physico-chemical parameters tested.

Keywords: *grape, physico-chemical and sensory characteristics, ultrasonication, uvological analysis, winemaking*

INTRODUCTION

Wine, beer, and rum are the most consumed drinks in the world, and consumer preferences vary from country to country. For example, beer is brewed in the USA and Canada, while in Europe wine is the most consumed alcoholic beverage. In Romania, the highest consumption is achieved for white wines (50 %), followed by red wines (30 %) and rosé wines (20 %). In terms of preferred taste, semidry and semisweet wines are the most commonly consumed locally. Regarding the production, Romania ranks 6th in Europe with an annual production of approximately 4.62 billion hL and sales of approximately 420 million euros [1].

Considering the increase in wine consumption not only locally but also worldwide, a problem for wine producers is their aging process. Especially for red wines, but also for white wines, the traditional method of aging involves storing the wine in large barrels until the aroma profile is reached the demanded level [2]. The disadvantage of this method is the long waiting period and the risk of developing undesirable microorganisms, which lead to diseases of the wine and implicitly additional treatments with chemical compounds or even loss of production.

The aroma of wines is influenced by intensity, acidity and the sensation of astringency [3], which are directly related to the content of polysaccharides, organic acids and phenolic compounds [4]. The astringency of wines decreases with the aging of the wine, but this is a disadvantage from the perspective of time. The specialized literature presents several non-conventional methods, such as the use of gamma radiation, high hydrostatic pressure (HHP) of ultrasonic waves and electric field [5 – 8], with the effect of reducing wine astringency.

Many studies demonstrate that ultrasonication could be utilized in the food industry due to its easy application, but also significant effects on the product [9].

Ultrasounds (US) are sound waves at frequencies over 20 kHz that recently have been used as non-thermal "green" technology for winemaking. The International Wine Organization (OIV) approved in 2019 the use of ultrasonic technology for the treatment of crushed grapes to increase the level of chemical compounds extraction [10].

US technology has a cavitation effect, causing bubbles to form and collapse rapidly as they travel through the medium. As ultrasound breaks the cell wall mechanically by the cavitation shear forces, it accelerates the transfer from the cell, the extraction of skin anthocyanins, phenols and aroma compounds into the must and wine [11 – 13]. Also, Munoz *et al*. [13] showed that ultrasound treatments had effects on the growth and development of wine microorganisms.

The applications of ultrasound attracts special attention, because can improve the quality of the wine from a sensory point of view, [14 – 16] intensification of the color, flavor and taste of the red wine by extracting valuable ingredients from grape seeds and skin, such as polyphenolic substances, accelerate maturation of wines, etc. [17, 18].

Ultrasonication has the effect of intensifying and modifying some chemical reactions, by fragmenting and recombining the polymers existing in rice alcoholic beverage [19] due to the high pressure and temperature. As these reactions occur, there is an increase in the concentration of polyphenols that have the effect of artificially aging of the alcoholic beverages.

Although most studies have been conducted on red wine, there are still few studies of the effect of noise on the artificial aging process of white wines [20] and aspects related to astringency.
The purpose of this study is to compare the effects of ultrasound on different varieties of red and white wines produced in Romania. The research looks at the changes brought about by the sonification treatment of young wines in two directions: the sensory characteristics (clarity, color, aroma, taste) and the physico-chemical properties (density, sugar and alcohol content, acidity, *p*H, electrical conductivity, turbidity).

MATERIALS AND METHODS

Grape samples

The grape *Vitis vinifera* L. were used, from vineyards in Vrancea county, Romania, including white varieties Feteasca Alba (FA) (Cotesti vineyard) and Tamaioasa Romaneasca (TR) (Marasesti vineyard), and red varieties Cabernet Sauvignon (CS) (Tifesti vineyard) and Muscat Hamburg (MH) (Jaristea vineyard). Grapes were harvested manually at full maturity during the 2019 vintage. The grape samples were subjected to a uvological analysis and than were processed according to winemaking under laboratory conditions.

Chemicals and reagents

All the chemicals (bentonite (Enartis, Italy), sodium hydroxide (Chempur, Poland), phenol red (SC Remed Prodimpex SRL, Romania), ethanol (Chemical Company, Romania) required in the experiments were of analytical purity and were used without further purification.

Uvological analysis

Uvological analysis consisted to determine the mechanical composition of the elements of the grapes (weight, number), as well as the calculating of uvologic index, according to the methods described in the literature [21 – 23].

Grape processing

The freshly harvested grapes were destemmed and crushed with specialized laboratory equipment. For the white varieties, the must was immediately separated from the marc, and for the red varieties, the fermentation-maceration on the marc was performed. Ultrasound was applied for two periods of time, for 10 and 30 minutes respectively, using a ultrasound bath model Biobase (BIOBASE BIOINDUSTRY CO, LTD, China) at 50 kHz frequency. One sample of each variety was processed without ultrasound, considering it to be a control sample. All samples were examined before fermentation (sugar content, density, acidity, *p*H, electrical conductivity, etc.). Alcoholic fermentation took place at temperatures between 20 - 22 °C for 15 - 28 days. After the fermentation of red wine with grape solids (skins, seeds and pulp) are transferred to the winepress for pressing. The wine samples were separated from the yeast and were treated with 5 % bentonite for clarification. The clarified and ripened white and red wines were subjected to physical-chemical and sensory analysis. The sample musts and wine were stored in bottles at 4 °C until the analyzes and they were brought to the ambient temperature before the analyzes.

Physico-chemical analyzes

All physico-chemical analyzes for must and wine samples were conducted according to standard methods presented in literature or Compendium of International Methods of Wine and Must Analyzes methods [24].
Sugar content was determined using refractometric method. Refractive index was measured at 20 °C with an Abbe refractometer (Kruss Optotronik D 22297, Germany) (OIV-MA-AS2-02:R2012) [24].
*p*H and conductivity were measured using Thermo Scientific™ Orion™ Versa Star Pro™ *p*H/Conductivity Multiparameter Benchtop Meter (Thermo Fisher Scientific, USA) [24].
The total acidity for must and wines (in g $H_2SO_4 \cdot L^{-1}$) were determinated by titration with 0.1N NaOH using phenol red as indicator [25].
The clarity of the wines was measured using a turbidimeter model MicroTPW HF Scientific, Watts Brand and expressed in NTU.
The density was determinated by pycnometer method (OIV-MA-AS2-01A) and it is expressed in $g \cdot mL^{-1}$ [24].
The alcoholic concentration was determined following the usual method by an ebulliometer model Alla-France, model 99004-va; the results are presented as volumetric percentage of ethanol in wine [26].
All the analyzes were done in triplicate.
Sensory analysis was performed testing the organoleptic characteristics by the scoring method with 20 points scale [27].

Data Processing

All the mathematical and statistical analyzes were performed using Microsoft 365 Excel 2021.

RESULTS AND DISCUSSION

Uvological analysis

The uvological analysis of the four grape varieties (FA, TR, CS, and MH) were conducted to determine the mechanical composition of the grapes by analyzing the structural elements of the grapes (berries, stem, skin, pulp and seeds). It was calculated the structure indices of the grape and the berry, as well. These data are presented in Table 1.

Table 1. *Uvological analysis*

Grape variety / Parameter	FA	TR	CS	MH
Grape composition				
Bunch grape weight [g]	160	190.1	137.5	120.25
Number of grape berries by bunch	79	74	103	52
Berries weight [g]	117.82	173.35	129.44	117.78
Stem weight [g]	2.33	2.17	6.89	2.47
Index of grape composition	50.56	79.89	18.78	63.64
Index of berries	31	41	75	43
Berry grape composition				
Skin weight* [g]	19.47	13.4	39.75	13.19
Pulp weight* [g]	283.71	202.55	71.35	202.53
Seed weight* [g]	2.33	16.3	15	4.21
Number of seeds from berry	1	2	2	2
Weight of 100 berries grape [g]	306.51	234.25	126.1	221.93
Index of berries composition	14.57	15.11	1.79	15.35
Structure of the grape by uvologic units [%]				
Stem	1.45	1.14	5.01	2.05
Pulp	91.44	86.19	56.58	90.12
Skin	6.35	5.72	31.52	5.94
Seed	0.76	6.95	11.89	1.89
Yield must index	67.33	78.60	53.26	88.26

** to 100 berries grape*

The index of grape composition, the index of berries, the index of berries composition and yield must index have been calculated according to methods described in the literature [21 – 23].
From the uvological analysis it was observed that the CS variety had the smallest berry size, but all the varieties are suitable for winemaking.
Although the yield must index had the highest values for TR (78.6 %) for white varieties and MH (88.26 %) for red varieties, having large berries, it is not mandatory that it is proportional to the winemaking yield, due to the greater consistency of the pulp.

Physico-chemical analyzes

For the untreated must (mFA, mTR, mCS and mMH) and wine (FA, TR, CS and MH) samples and ultrasonicated at 10 minutes (mFA10, mTR10, mCS10, mMH10, FA10, TR10, CS10 and MH10) and at 30 minutes (mFA30, mTR30, mCS30, mMH30, FA30, TR30, CS30 and MH30), a series of parameters were determined, shown in Tables 2 and 3.

Table 2. *Physico-chemical analyzes of must*

Parameters / Samples	Sugar content [g·L^{-1}]	Density [g·cm^{-3}]	Acidity [g H_2SO_4·L^{-1}]	*p*H	EC at 25 °C [µS·cm^{-1}]
mFA	231	1.05187	3.73	3.301	2217
mFA10	233	1.05244	3.63	3.480	2299
mFA30	233	1.05222	3.83	3.280	2318
mTR	193	1.07832	3.89	3.051	3059
mTR10	195	1.04561	4.81	3.086	3045
mTR30	197.5	1.04319	3.54	3.161	2859
mCS	235	1.05723	4.91	3.022	2668
mCS10	237.5	1.05619	5.01	3.149	1476
mCS30	236	1.05677	4.91	3.065	2642
mMH	248	1.05680	2.95	3.485	1990
mMH10	246	1.05692	2.65	3.768	2049
mMH30	244	1.05703	3.04	3.478	2030

From the data presented in Table 2, it could be seen that in the FA, TR and CS varieties, the sugar content of the must increased significantly for the ultrasonic samples with increasing time of sonication, while in the MH variety the tendency was to decrease. After the 10 minute US treatment, the acidity increased significantly for the mCS and mTR varieties, while for mMH, at a higher sugar content, the acidity value decreased greatly. The *p*H had a tendency to vary according to the acidity, but not entirely because the organic acids present in the must (tartric, malic, citric) are weak, polycarboxylic acids, with low and very low acidity constants. However, the US treatment at 10 minutes increased the *p*H value compared to the untreated samples and the value remained comparable at 30 minutes respectively, for all must varieties. Electrical conductivity is given by the presence of ionic compounds and is proportional to their contents [28]. It was observed that, after the US treatments, each variety of must behaves differently, the electrical conductivity values being still higher than in the untreated samples for mFA, mCS and mMH, but they decreased once the sonication time increases for mTR.

Table 3. *Physico-chemical analyzes of wine*

Parameters / Samples	Sugar content [g·L^{-1}]	Density [g·cm^{-3}]	Acidity [g H_2SO_4·L^{-1}]	*p*H	EC at 25 °C [µS·cm^{-1}]	Turbidity [NTU]	Alcohol content [% vol. al.]
FA	62	1.00649	3.92	3.247	1537	0.60	10.2
FA10	54	0.99163	4.12	3.341	1707	0.27	10.8
FA30	51	0.99463	3.73	3.377	1763	0.17	11.1
TR	50	0.99497	3.34	3.632	2012	3.84	8.8
TR10	51	0.99394	4.32	3.617	2414	7.89	8.5
TR30	55	0.99417	3.14	3.617	2345	1.13	8.7
CS	56	0.99486	4.32	3.513	1933	5.38	10.9
CS10	58	0.99382	4.22	3.566	2157	7.24	10.8
CS30	56	0.99348	4.62	3.536	2094	1.48	10.9
MH	56	1.00419	3.34	3.624	1783	17.94	11.6
MH10	57	0.99256	4.02	3.625	1938	20.65	11.4
MH30	57	0.99359	3.93	3.607	1400	28.58	11.3

First of all, in the fermentation process, it was observed that in all the ultrasonicated samples, the alcoholic fermentation started much more difficult and proceeded more slowly compared to the non-ultrasonicated samples. This was also reflected in the residual sugar content of the resulting wines. The explication can be attributed to the effect of ultrasound on the microorganisms in the must (yeasts, bacteria) [13]. The residual sugar content of all wine varieties is between 50 - 62 $g \cdot L^{-1}$, as seen in Table 3, so it is considered semi-sweet wines. In red wines (CS and MH) there were no significant difference in residual sugar content between treated and untreated samples, while in white wines (FA and TR) the increase of sonication time led to a significant increase for TR variety and a decrease for FA variety. For the FA, TR and MH varieties, 10 minutes sonication time conducted to obtaining a maximum value of acidity (4.12, 4.32, 4.02 g $H_2SO_4 \cdot L^{-1}$), and for CS, the maximum acidity was observed at 30 minutes sonication time (4.62 g $H_2SO_4 \cdot L^{-1}$). We could say that sonication led to an increase in acidity for all treated varieties.

Although the treated must samples compared to the untreated ones had different *p*H values, it was found that after fermentation and maturation, the *p*H values of the sonicated or non-sonicated wine samples were uniform, for all white or red varieties, as can be seen in Table 3. Also, the electrical conductivity values decrease compared to the must samples. The turbidity shows the degree of wine clarification. It had a tendency of reducing values with increasing sonication time for FA, TR, CS varieties. On the other hand, it was found that sonication did not have the same effect for MH variety. A trend of increasing alcohol content was observed for white wines, but not for MH with increasing sonication times.

Compared to the varieties FA, TR and CS, where a positive influence of US on the physico-chemical parameters of the wines was observed, it was found that the MH variety has an atypical behavior. This can be explained on the basis of the chemical composition specific to the variety, because the MH variety produces wines that are on the border between mass production and quality wines, being influenced by the climatic conditions of the wine-growing year.

Sensory analysis

The sensory profile for the four varieties of wine are presented in Figures 1 – 4.

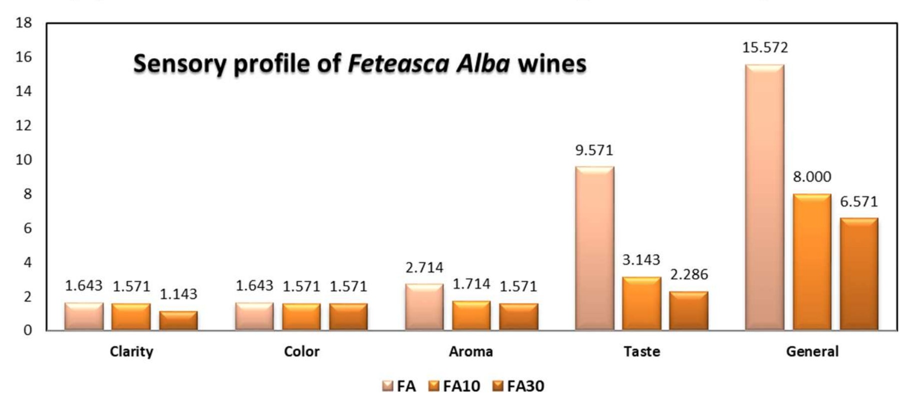

Figure 1. *Sensory profile of Feteasca Alba wines*

As it appears from the physico-chemical analyzes, the US treatment did not bring significant changes to the FA variety, an aspect that correlates with the sensory analysis in which the highest scores were recorded for the non-ultrasonic wine.

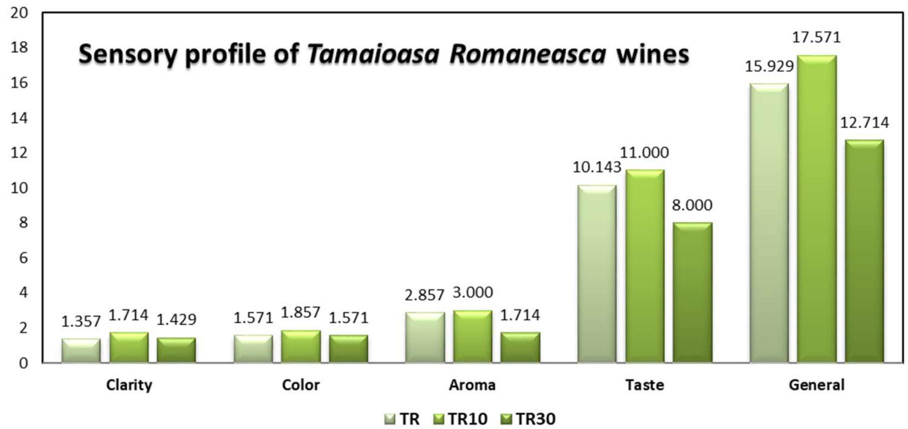

Figure 2. *Sensory profile of Tamaioasa Romaneasca wines*

For the TR variety, the sensory analysis scores were better for the ultrasonic samples. TR registers superior scores on all characteristics for the 10 minutes US treatment.

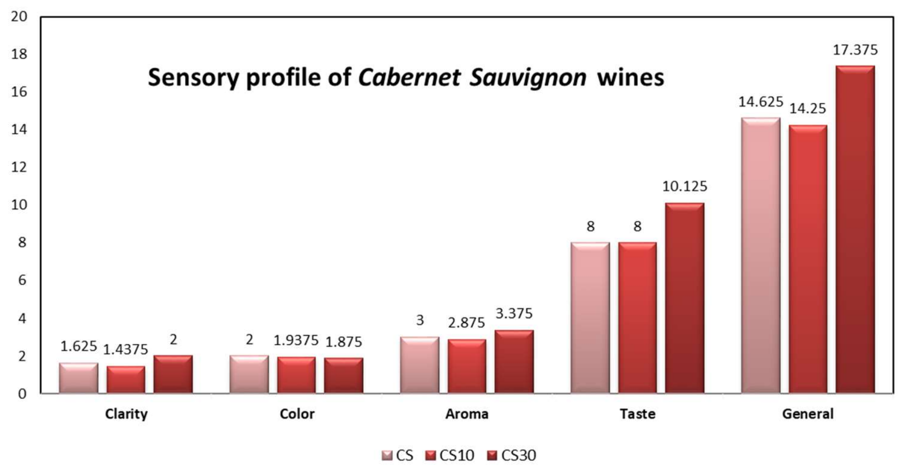

Figure 3. *Sensory profile of Cabernet Sauvignon wines*

Also, for the CS variety, the sensory analyzes scores were better for the ultrasonic samples. CS registers better scores for the 30 minutes US treatment.

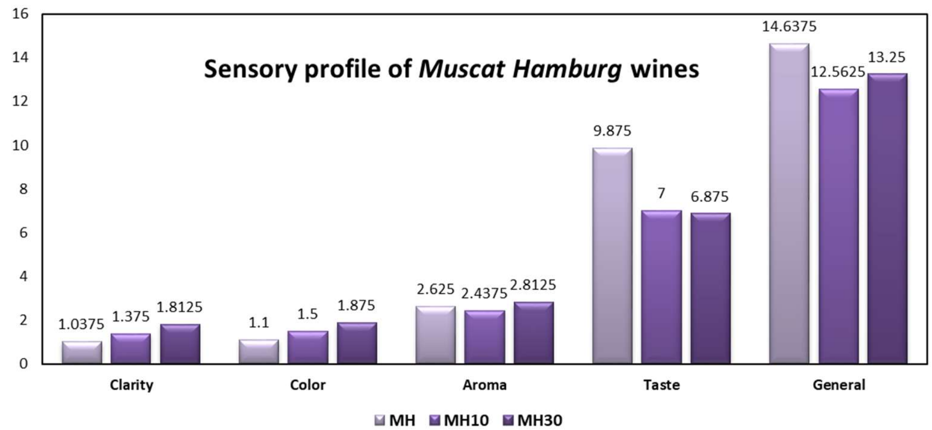

Figure 4. *Sensory profile of Muscat Hamburg wines*

As well as FA variety, from a sensory point of view, the non-ultrasound sample of MH had better scores.

The results demonstrated that the clarity, color, and aroma obtained a higher score than the sonicated samples on both varieties of red wine (CS and MH) at 30 minutes US treatment. Regarding the taste, the CS sonication samples were preferred by 26.5 % compared to the untreated sample, the taste being preferred by 31 % to the untreated MH sample. The US treatment improved the clarity, color, taste and global quality of CS wines, but in the case of the MH variety, a higher score for taste was obtained for the wine not treated with US.

Also, the white wine TR recorded the highest scores for all sensory characteristics (clarity, color, aroma, taste and global quality) at 10 minutes US treatment.

The highest values for all sensory characteristics were obtained for the unsonicated sample in the case of white wine FA variety.

CONCLUSIONS

The results showed that the ultrasonic samples had a lower fermentation rate due to the species and the strains present in the must are differit affected by ultrasound treatments, some being more sensitive to ultrasound. The sonicated red wines have a more intense color than the control samples, results also correlated with physico-chemical parameters tested.

The results of the sensory analysis were correlated with the physico-chemical parameters for all the wines, but the sensory attributes of the wines obtained by ultrasound treatment were superior in red wines.

The ultrasonic technique is suitable for red wine production because a weak ultrasonic irradiation can promote an increase in the amount of phenolic compounds in red wine.

REFERENCES

1. https://www.oiv.int/what-we-do/country-report?oiv accessed on May 19, **2024**;
2. Carpena, M., Pereira, A.G., Prieto, M.A., Simal-Gandara, J.: Wine aging technology: Fundamental role of wood barrels, *Foods*, **2020**, **9** (9), https://doi.org/10.3390/foods9091160;
3. He, Y., Wang, X.Y., Li, P.H., Lv, Y.C., Nan, H.L., Wen, L.K., Wang, Z.T.: Research progress of wine aroma components: A critical review, *Food Chemistry*, **2023**, **402**, https://doi.org/10.1016/j.foodchem.2022.134491;
4. Gawel, R., Smith, P.A., Waters, E.J.: Influence of polysaccharides on the taste and mouthfeel of white wine, *Australian Journal of Grape and Wine Research*, **2016**, **22**, 350-357;
5. Sosa,V., Contreras, V., Blanc, L., Dellacassa, E., Carrau, F., Bracesco, N., Radioprotective effect of tannic acid and wines of the *Vitis vinifera L*. cv Tannat on *Saccharomyces cerevisiae*, *Anales de la Facultad de Medicina-Universidad de la Republica Uruguay*, **2022**, **8** (1), https://doi.org/10.25184/anfamed2021v8n1a10;
6. Kumar, Y., Marangon, M., Marangon, C.M.: The application of non-thermal technologies for wine, processing, preservation, and quality enhancement, *Beverages*, **2023**, **9** (2), https://doi.org/10.3390/beverages9020030;
7. Blanco-Huerta, C., Rodríguez-Nogales, J. M., Vila-Crespo, J., Ruipérez, V., Fernández-Fernández, E.: Impact of high hydrostatic pressure and ultrasounds technologies in the autolytic process of Saccharomyces cerevisiae in a model wine system, *Food Bioscience*, **2024**, **57**, https://doi.org/10.1016/j.fbio.2024.103614;
8. Martínez-Lapuente, L., Guadalupe, Z., Higueras, M., Ayestarán, B., Pérez-Porras, P., Bautista-Ortín, A.B., Gómez-Plaza, E.: Effect of pre-fermentative treatments on polysaccharide composition of white and rose musts and wines, *Journal of Agricultural and Food Chemistry*, **2023**, **72** (4), 1928-1937, https://doi.org/10.1021/acs.jafc.2c08976;
9. Ojha, K.S., Mason, T.J., O'Donnell, C.P., Kerry, J.P., Tiwari, B.K.: Ultrasound technology for food fermentation applications, *Ultrasonics Sonochemistry*, **2017**, **34**, 410-417;
10. https://agrovin.com/en/ultrasound-applied-in-wine-production/ accessed on May 19, **2024**;
11. https://www.hielscher.com/food_01.htm accessed on March 17, **2023**;
12. Bo-Yu Chen, Qing-An Zhang, Bao-Shan Zhang, Ya-Feng Zhang, Er-Chun Li, Effects of ultrasound on the formation of oxidative pigments in a model red wine solution containing glutathione, *Journal of Food Composition and Analyzes*, **2021**, **103**, 104092, https://doi.org/10.1016/j.jfca.2021.104092;
13. Munoz, R., Viveros, N., Bevilacqua, A., Perez, M.S., Arevalo-Villena, M.: Effects of ultrasound treatments on wine microorganisms, *Ultrasonics Sonochemistry*, **2021**, **79**, 105775, https://doi.org/10.1016/j.ultsonch.2021.105775;
14. Wu, Z.Q., Li, X.S., Zeng, Y.Y., Cai, D.B., Teng, Z.J., Wu, Q.X., Sun, J.X., Bai, W.B.: Color stability enhancement and antioxidation improvement of sanhua plum wine under circulating ultrasound, *Foods*, **2022**, **11** (16), https://doi.org/10.3390/foods11162435;
15. Li, X.S., Zhang, L., Peng, Z.Y., Zhao, Y.Q., Wu, K.Y., Zhou, N., Yan, Y., Ramaswamy, H.S., Sun, J.X., Bai, W.B.: The impact of ultrasonic treatment on blueberry wine anthocyanin color and its In-vitro anti-oxidant capacity, *Food Chemistry*, **2020**, **333**, https://doi.org/10.1016/j.foodchem.2020.127455;
16. Ahmad, I., Sadiq, M.B., Liu, A., Benjamin, T-A., Gump, B.H.: Effect of low-frequency ultrasonication on red wine astringency, *Journal of Culinary Science & Technology*, **2023**, **21** (5), https://doi.org/10.1080/15428052.2021.2002228;
17. Hernanz Vila, D., Heredia Mira, F.J., Beltran Lucena, R., Recamales, F.M.: Optimization of an extraction method of aroma compounds in white wine using ultrasound, *Talanta*, **1999**, **50**, 413-421, https://doi.org/10.1016/s0039-9140(99)00128-9;
18. Chang, A.C., Chen, F.C.: The application of 20 kHz ultrasonic waves to accelerate the aging of different wines, *Food Chemistry*, **2002**, **79**, 501-506, https://doi.org/10.1016/S0308-8146(02)00226-1;
19. Chang, A.: Study of ultrasonic wave treatments for accelerating the aging process in a rice alcoholic beverage, *Food Chemistry*, **2005**, **92** (2), 337-342; https://doi.org/10.1016/j.foodchem.2004.07.027;

20. Lukić, K., Brnčić, M., Ćurko, N., Tomašević, M., Tušek, A.J., Ganić, K.K.: Quality characteristics of white wine: The short- and long-term impact of high power ultrasound processing, *Ultrasonics – Sonochemistry*, **2020**, **68**, https://doi.org/j.ultsonch.2020.105194;
21. Pomohaci, N.: *Oenologie*, Vol. II, [in Romanian], Ed. Ceres, Bucureşti, **2001**;
22. Cotea, V.D., Sauciuc, J.H.: *Tratat de oenologie*, Vol. II, [in Romanian], Ed. Tipo Moldova, Bucureşti, **2010**;
23. Pomohaci, N., Stoian, V., Gheorghiţă, M., Sîrghi, C., Cotea, V.V., Nămoloşanu, I.: *Oenologie. Prelucrarea strugurilor şi producerea vinurilor*, Vol. I, [in Romanian], Ed. Ceres, Bucureşti, **2000**;
24. https://www.oiv.int/standards/compendium-of-international-methods-of-wine-and-must-analyzes accessed on Octomber 2, **2019**;
25. SR 6182-1:2008 Vin. Partea 1: Determinarea acidităţii totale;
26. Bowyer, P.K: The measurement of alcohol levels in wine, *The Australian Grapegrower and Winemaker, Annual Technical Issue*, **2006**, 90-96;
27. SR 13461:2001 Vin. Analiza senzorială;
28. Lee, J.H., Choi, K.H., Kim, S.H., Park, K.S., Park, S.H., Kim, J.S., Jang, K.H.: Physicochemical characteristics and electric conductivity of various fruit wines, *International Food Research Journal*, **2013**, **20** (6), 2987-2993.