Analysis of Complex Technologies for Obtaining Wine Products with Increased Antioxidant Properties*

Yurij V. Grishin[1], Anatoliy N. Kazak[2] [0000-0001-7678-9210], Nikolay N. Oleinikov[2] [0000-0002-9348-9153], Nadezhda I. Gallini[2][0000-0001-8176-6419], Petr V. Chetyrbok[2][0000-0002-0115-9158]

[1]Magarach All-Russia National Research Institute for Viticulture and Wine-Making, Yalta, Russia
[2]V.I. Vernadsky Crimean Federal University, Simferopol, Russia
kazak_a@mail.ru

Abstract. This paper presents the results of studies of the phenolic composition and antioxidant activity of table wine materials from grapes of white technical European varieties grown in the soil and climatic conditions of the southern regions of Russia, depending on the method of its processing and using the solid components of the grape bunch. The study showed that the use of tegumental maceration provides an increase in the mass concentration of monomeric forms of phenolic compounds by 1.8 times, antioxidant activity by 1.3 times; partial (1/3 of grape sugars) fermentation of pulp with ridges allows increasing the mass concentration of monomeric forms of phenolic compounds by 2.8 times, and. and antioxidant activity 1.8 times; complete fermentation of sugars in pulp with ridges leads to an increase in the mass concentration of monomeric forms of phenolic compounds in products by 5.0 times and antioxidant activity by 2.1 times compared to the traditional "white" grape processing method, without contacting the must with the solid parts of the grapes. The developed complex technology of processing grapes of white technical European varieties with the use of winemaking wastes will make it possible to obtain high-quality products with increased antioxidant properties.

Keywords: Antioxidant Activity, Tegumental Maceration, Biologically Active Substances, High-Performance Liquid Chromatography (HPLC), Wine Material, Grape, Grape Crush, Componential Composition, Stems, Phenolic Compounds, Monomeric Forms of Phenolic Compounds, Procyanidins.

1 Introduction

The key to longevity and full life is the use of enriched foods in nutrition, as is customary, for example, in Japan, where the introduction of a healthy (functional) nutrition program has made it possible to increase life expectancy by 8 years throughout the country [1-4]. According to the US Department of Health, the minimum daily intake of antioxidants required by the human body is 3000-5000 units. ORAC (Oxygen Radical Absorption Capacity) is a unit for measuring the number of antioxidants, expressed in micromoles of Trolox per unit mass (μTE / 100g) [5-7]. It is known from the literature that when processing 1 thousand tons of grapes for must and wine, about 120 tons of pomace, 4 tons of seeds, 5 tons of ridges, and other secondary products of winemaking are formed. The characteristics of the ridges separated during crushing of grapes as a waste of winemaking have the following characteristics: mass concentration of sugars - 1.5-2.0 g / dm3, mass fraction of phenolic substances 3-6%, mineral substances up to 2.5%, tartaric acid up to 0, sixteen]. In the scientific literature, data on the study of antioxidant activity (AOA) of fruit crops, grape ridges, phenolic compounds, and AOA of white sparkling wines from various producing countries, quality and safety of wines obtained by secondary fermentation are also known.

According to J. Tauchen's research [7], still, white wines made from white technical grapes (Sauvignon Blanc, Chardonnay, and Rkatsiteli) according to the technology generally accepted in Europe, which involves the rapid separation of the must from the hard parts of the grapes, have a low mass concentration of phenolic substances. varying in the range from 0.2 to 0.29 g / dm3. At the same time, the wine made from Rkatsiteli grapes using the Kakhetian technology (fermentation of pulp with ridges) was distinguished by a higher mass concentration of phenolic substances, which amounted to 0.4 g / dm3. The key to longevity and full life is the use of enriched foods in nutrition, as is customary, for example, in Japan, where the introduction of a healthy (functional) nutrition program has made it possible to increase life expectancy by 8 years throughout the country [8-11].

According to the US Department of Health, the minimum daily intake of antioxidants required by the human body is 3000-5000 units. ORAC (Oxygen Radical Absorption Capacity) is a unit for measuring the number of antioxidants, expressed in micromoles of Trolox per unit mass (μTE / 100g) [11-13]. It is known from the literature that when processing 1 thousand tons of grapes for must and wine, about 120 tons of pomace, 4 tons of seeds, 5 tons of ridges, and other secondary products of winemaking are formed.

The characteristics of the ridges separated during crushing of grapes as a waste of winemaking have the following characteristics: mass concentration of sugars - 1.5-2.0 g / dm3, mass fraction of phenolic substances 3-6%, mineral substances up to 2.5%, tartaric acid up to 0, sixteen]. In the scientific literature, data on the study of antioxidant activity (AOA) of fruit crops, grape ridges, phenolic compounds, and AOA of white sparkling wines from various producing countries, quality and safety of wines obtained by secondary fermentation are also known.

According to J. Tauchen's research [7], still, white wines made from white technical grapes (Sauvignon Blanc, Chardonnay, and Rkatsiteli) according to the technology generally accepted in Europe, which involves the rapid separation of the must from the hard parts of the grapes, have a low mass concentration of phenolic substances. varying in the range from 0.2 to 0.29 g / dm3. At the same time, the wine made from Rkatsiteli grapes using the Kakhetian technology (fermentation of pulp with ridges) was distinguished by a higher mass concentration of phenolic substances, which amounted to 0.4 g / dm3 [14-18].

The purpose of the article is to analyze the phenolic composition and antioxidant activity of table wine materials from grapes of white technical European varieties grown in the soil and climatic conditions of the southern regions of Russia using machine analysis technologies.

2 Materials and Methods

The objects of research were samples of wine materials from grapes of white technical varieties: Rkatsiteli, Rhine Riesling, and Chardonnay, grown in the soil and climatic conditions of the southern regions of Russia. The samples under study were obtained by micro-winemaking using the traditional technological method "in white" (control) and using complex technologies for processing grapes with hard parts of the grape bunch (ridges, skin, and seeds). A sampling of the test samples was carried out following GOST 31730-2012 [17], sample preparation - by GOST 26671-2014. The main physical and chemical indicators of samples of table white wine materials were determined by standardized and accepted in winemaking methods of analysis [18-21]. Antioxidant activity was determined by the chemiluminescence method using a Photochem photochemiluminometer (Analytik Jena AG, USA).

The mass concentration of phenolic substances was determined by the photocolorimetric method. The qualitative and quantitative composition of phenolic substances in the objects of the study was determined by HPLC using an Agilent Technologies chromatographic system (model 1100, United States) with a diode array detector. To separate substances of polyphenolic nature, we used a Zorbax SB-C18 chromatographic column with a size of 2.1 × 150 mm, filled with silica gel with a grafted octadecylsilyl phase with a sorbent particle size of 3.5 μm. Chromatography was performed in a gradient mode.

A 0.6% aqueous solution of trifluoroacetic acid and methanol was added to the eluent. The flow rate of the eluent was 0.25 ml/min, the volume of the injected sample was 1 μl. Components were identified by their retention time. Calculation of the quantitative content of individual components was carried out using calibration plots of the dependence of the peak area on the concentration of a substance, built from solutions of individual substances. Gallic acid, caffeic acid, (+) - D-catechin, quercetin dihydrate (Fluka Chemie AG, Switzerland) and (-) - epicatechin, lilac acid (Sigma-Aldrich, Switzerland) were used as standards. All determinations were carried out in triplicate. The research results were processed by standard methods of mathematical statistics. The standard deviation of the measurement results is no more than 5%.

3 Results and Discussion

The main chemical and technological indicators of the samples of table white wine materials prepared by various technological schemes corresponded to GOST 32030-

2013. The article introduces the concept of tegumental maceration. Tegumental (lat. Tegumentum "protective layer, shell") maceration is a technological method, which consists in the fact that immediately after crushing grapes and obtaining pulp (must, skin, seeds), an estimated amount of 75 mg/dm^3 of sulfurous anhydride (antiseptic and reducing agent) and it is cooled to 10-12 ° C, followed by 24-hour extraction at a given temperature.

As a result of the use of tegumental maceration, more complete extraction of aromatic and biologically active compounds occurs, and the introduction of sulfurous anhydride into the resulting pulp (in a stream) provides fast, within the first 5 minutes, the binding of sulfurous acid with phenolic compounds, aldehydes, sugars, and some other substances, which ensures their reliable protection against oxidation and the premature start of fermentation.

Analysis of the data obtained by the HPLC method (Tables 1 and 2) showed that the identified component composition of the phenolic compounds of table wine materials from grapes of white technical European varieties obtained using various complex processing technologies consists of monomeric forms - flavones, flavan-3-ols, hydroxybenzoic and hydroxycinnamic acids, as well as from polymeric forms - oligomeric and polymeric procyanidins.

Table 1. Phenolic component composition of samples of table wine materials from white technical European grape varieties obtained by various processing technologies

№	Name of wine material	Mass concentration, mg / dm3			
		Fla-vones	Flavan-3-ols	Oxyben-zoic acids	Oxyric acids
1	Chardonnay "in white" way (control)	0,29	8,01	1,80	18,90
2	Chardonnay tegumental maceration	12,35	10,70	6,15	23,60
3	Chardonnay, 1/3 sugar fermentation with combs	4,15	56,95	13,00	28,70
4	Chardonnay, complete fermentation of sugars with combs	37,40	119,56	15,69	42,26
5	Rkatsiteli "in a white" way (control)	0,20	14,70	1,30	25,00
6	Rkatsiteli, 1/3 sugar fermentation with combs	3,60	62,40	8,20	29,60
7	Rkatsiteli full of sugars fermentation with ridges	4,70	111,60	17,80	34,40
8	Rhine Riesling, "white" way (control)	-	12,65	3,01	31,13
9	Rhine Riesling, 1/3 sugar fermentation with combs	7,34	65,24	12,49	36,96
10	Rhine Riesling, complete fermentation of sugars with ridges	16,20	115,01	19,92	48,00

Table 2. Phenolic component composition and AOA of samples of table wine materials from white technical European grape varieties obtained by various processing methods

№	Name of wine material	Mass concentration, mg / dm3		AOA, g / dm3
		Oligomeric procya-nidins	Polymeric procya-nidins	
1	Chardonnay "in white" way (control)	90,00	104,00	0,79
2	Chardonnay tegumental maceration	408,00	496,00	1,00
3	Chardonnay, 1/3 sugar fermentation with combs	163,00	433,00	1,32
4	Chardonnay, complete fermentation of sugars with combs	291,00	770,00	1.65
5	Rkatsiteli "in a white" way (control)	259,00	375,00	0,87
6	Rkatsiteli, 1/3 sugar fermentation with combs	626,00	1328,00	1,42
7	Rkatsiteli full of sugars fermentation with ridges	786,00	2122,00	1,74
8	Rhine Riesling, "white" way (control)	106,00	146,00	0,81
9	Rhine Riesling, 1/3 sugar fermentation with combs	209,00	662,00	1,50
10	Rhine Riesling, complete fermentation of sugars with ridges	276,00	840,00	1,68

The use of tegumental maceration (Fig. 1) makes it possible to obtain in the wine material 1.8 times higher content of monomeric forms of phenolic compounds and 1.3 times higher value of antioxidant activity than the traditional method of processing grapes "in white", without contacting the must with the hard parts of the grapes (control).

In the course of the research, it was found that the values of the mass fraction of individual components of the monomeric phenolic composition of wine materials obtained according to the generally accepted technology for obtaining table white wines (control) are arranged in the following sequence: hydroxycinnamic acids (64.3%)> flavan-3-ols (29, 9%)> hydroxybenzoic acids (5.2%)> flavones (0.6%).

Also, as a result of research, it was found that the values of the mass fraction of individual components of the monomeric phenolic composition of wine materials obtained using complex technologies for processing grapes are located in the following sequence: tegumental maceration method - oxycinnamic acids (44.7%)> flavones (23.4%) > flavan-3-ols (20.3%)> hydroxybenzoic acids (11.6%); fermentation of 1/3 of the sugars of the pulp with ridges - flavan-3-ols (56.2%)> hydroxycinnamic acids (29.0%)> hydroxybenzoic acids (10.2%)> flavones (4.6%); complete fermentation of sugars with ridges - flavan-3-ols (59.6%)> hydroxycinnamic acids (21.4%)> flavones (10.0%)> hydroxybenzoic acids (9.0%).

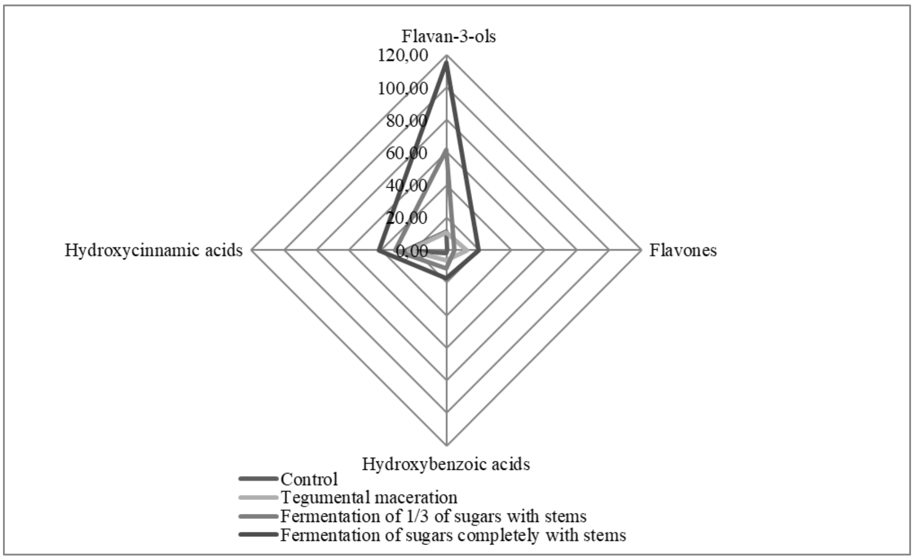

Fig. 1. Influence of complex grape processing technologies on the monomeric phenolic composition of white table wine materials.

4 Conclusions

The identified component composition of phenolic compounds of table wine materials from Riesling Rhine, Rkatsiteli, Chardonnay grapes obtained using various processing methods (the traditional "white" method and using solid parts of grapes) consists of monomeric forms - flavones, flavan-3-ols, hydroxybenzoic and hydroxycinnamic acids, and polymeric - oligomeric and polymeric procyanidins. The quantitative composition of phenolic compounds of wine materials and antioxidant activity were also established.

Integrated grape processing technologies allow obtaining high-quality wine products showing 1.3 times higher antioxidant activity during tegumental maceration, 1.8 times - fermentation of 1/3 of the sugars of the pulp with ridges, and 2.1 times - with complete fermentation of sugars pulp with ridges, compared to the traditional "white" grape processing method.

To obtain high-quality wine-making products, enriched with biologically active compounds and exhibiting increased antioxidant properties.

References

1. Duka, G., Gaina, B., Kovaleva O.: Environmentally Friendly Wine Production. Acad. Sciences of Moldova. Mold. state un-t. Nat. Institute of Viticulture and Winemaking of Moldova. Ch .: I.E.P. Stinta, 2004. 432 p. (2004)
2. Valuyko, G.G.: About Hygienic and Nutritional Value of Grape Wines. Yalta: NIIViV "Magarach", 24 p. (1990).
3. Valuyko G.G.: Wine and Health. Simferopol Di I Pi, 170 p. (2007).
4. Osipova, L.A., Kaprelyants, L.V., Burdeau, O. G.: Functional drinks. Odessa: Druk, 288 p. (2007).
5. Oxidative stress and antioxidants: body, skin, cosmetics, Moscow: Firma KLAVEL LLC, 288 p. (2006)
6. Scholz, E.P.: Grape processing technology: textbook. manual for universities M.: Agropromizdat. 447 p. (1990).
7. Scholz, E.P.: Grape processing technology: textbook. manual for universities, M .: Agropromizdat, 447 p. (1990).
8. Tauchen J., Marsik P., Kvasnikova M., Maghradze D., Kokoska L., Vanek T., Landa P.: In vitro antioxidant activity and phenolic composition of Georgian, Central and West European wines, J. of Food Composition and Analysis, 41, 113 (2015), DOI: https://doi.org/10.1016/j.jfca.2014.12.029
9. Geok, V.N.: Technological characteristics of a new technical grape variety Viognier for Crimea, Scientific works of KubGTU (8), pp. 77-81 (2015).
10. Karpenko, E.N.: Prospects for the use of secondary resources of wine-making enterprises of the Anapo-Taman, Fruit and viticulture of the South of Russia (6), pp. 183-191 (2018**)**, DOI: 10.30679/2219-5335-2018-6-54-183-191.
11. Teissedre, P.L.: Inhibition of in vitro human LDL oxidation by phenolic antioxidants from grapes and wines, J. Sci. Food Agricult, vol 70(1), pp. 55-61 (1996).
12. Darias-Martin, J.J., Rodriquez, O., Diaz, E., Lamuela-Raventos, R.M.: Effect of skin contact on the antioxidant phenolics in white wine, J. Food Chem (71, pp. 483-487 (2000), DOI: https://doi.org/10.1002/(SICI)1097-0010(199601)70:1%3C55::AID-JSFA471%3E3.0.CO;2-X
13. Serrelli, G., Jerkovic, I., Marianovic, Z., Gil, K.A., Tuberoso, C.I.G.: Evolution of naturally occurring bioactive compounds and antioxidant activity in Nugarus white wines, J. Food Research International, Vol. 99(1), pp. 571-576 (2017), DOI: 10.1016/j.foodres.2017.06.038.
14. Tourtoglou, C., Nedalis, N., Paraskevopoulou, A.: Phenolic composition and radical scavenging activity of commercial Greek white wines from Vitis vinifera L. cv. Malagousia, J. of Food Composition and Analysis, vol. 33(2), pp. 166-174 (2014), DOI: http://dx.doi.org/10.1016/j.jfca.2013.12.009
15. Olejar, K.J., Fedrizzi, B., Kilmartin, P.A.: Enhancement of Chardonnay antioxidant activity and sensory perception through maceration technique, Food Science and Technology, vol. 65, pp. 152-157 (2016), DOI: https://doi.org/10.1016/j.lwt.2015.08.001.
16. Ragusa, A., Centonze, C., Grasso, M.E., Manstrangelo, M.F., Sparascio, F., Fanizzi, F.P., Mafia, M.: Comparative study of phenols in Apulia Italian wines. Foods, Vol.6 (24), pp.1-10 (2017), DOI: https://doi.org/10.3390/foods6040024.
17. Aleixandre-Tudo, J.L., Weightman, C., Panzeri, V., Nieuwoudt, H.H., du Toit, W.J.: Effect of skin contact before and during alcoholic fermentation on the chemical and sensory profile of South African Chenin Blanc white wines, South African Journal of Enology and Viticulture, Vol. 36 (3), pp. 366-377 (2015), DOI: https://doi.org/10.21548/36-3-969.

18. GOST 32030-2013. Table wines and table wine materials. General technical conditions, M.: Standartinform, 7 p (2013).
19. GOST 26671-2014. Fruit and vegetable processing products, canned meat, and meat and vegetable products. Sample Preparation for Laboratory Analysis (Reprint), M.: Standartinform, 7 p. (2014).
20. Gerzhikova, V.G.: New methods of identification and assessment of the quality of grape wines, Bulletin “Crimean quality”: scientific and technical collection, Simferopol, vol 2 (8), pp. 103-107 (2006).
21. Solovyova, L.M., Grishin, Y.V., Kazak, A.N., Oleinikov, N.N., Chetyrbok, P.V.: The possibility of using the potentiometric titration method to determine the antioxidant properties of wines, Journal of Physics: Conference Series, 2020, 1703(1), 012048 (2020)