Improving the criteria of assessing grapes and base wines in the production of sparkling wines

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Abstract. The production of high-quality sparkling wines consists in an integrated approach at all stages of production, taking into account the potential of grapes, soil and climatic conditions of its cultivation, etc. As a research result of 2016-2021, a comprehensive assessment in the system "grapes - base wine - sparkling wine" made it possible to establish additional indicators of grapes and base wines that allow obtaining high-quality sparkling wines. Based on the established criteria, significantly correlated with the quality of the finished product, promising grape varieties for the production of sparkling wines were identified. The results obtained will allow improving the quality of local sparkling wines, creating a great variety of products.

1 Introduction

In the conditions of market competition, the production of wines with requested characteristics remains an important direction. The development of high-quality sparkling wines requires special control of quality indicators not only in the finished product, but also in raw materials, as well as base wines before post fermentation. However, physicochemical and organoleptic indicators, provided by the current regulatory documentation, are not always sufficient for high quality wine production. In this regard, winemakers expand the existing list of quality indicators with additional criteria at different stages of production [1-3]. They also take into account various factors, among which a special attention is paid to soil and climatic conditions of grape growing [4-7], choice of used grape varieties [8-11] and yeast races for primary and post fermentation [12-14], as well as other technological operations [15-18]. At the same time, there is not enough information now on a comprehensive systemic assessment of grape and base wine indicators for the production of high-quality sparkling wines, which leads us to carry out this research. **The aim of the work** was to improve the criteria for assessing raw materials, necessary for production of high-quality sparkling wines.

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2 Materials and methods

The objects of research were: 250 batches of grapes; 325 samples of base wines; 557 samples of experimental sparkling wines. The experiments were carried out during 2016-2021. Various grape varieties were used in the process of research (selected, introduced, local). They are cultivated in different regions of Crimea: the South Coast of Crimea (Vasilyevka village, Otradnoye village, Gurzuf settlement (Yalta); the Western Piedmont Coastal region (Orlovka village (Sevastopol), Vilino, Plodovoye, Uglovoye villages (Bakhchisaray district). Base wines were obtained by traditional method of producing white, rosé and red wines. Various yeast races from the Magarach Collection of Microorganisms were used for primary and post fermentation. Base wines were used to compound tirages in accordance with current technological instructions for production of sparkling wines using method of bottle champagnization and GOST 33311-2015. Post-tirage aging during 9 months was followed by technological operations of remuage and degorgage.

The research scheme included three steps of quality control - at the stage of grapes, base wine and sparkling wine. We used generally accepted in enochemistry and modified methods of analyzing physicochemical and biochemical indicators of research objects in accordance with [19-21].

The grapes were assessed according to the method [20]. The following indicators were determined: mass concentrations of sugars and titratable acids (TA), pH value, technological stock of phenolic substances (TS PhS) in grapes, mass concentration of phenolic substances ($PhS_{init.}$) in fresh must, monophenolmonooxygenase (MPhMO) activity of the must, oxidative (PhS_{ox}) capacity of the must after settling for 1 hour, macerating (extracting) ($PhS_{mac.}$) capacity of the must with pulp settling for 4 hours; as well as estimated indicators: glucoacidometric indicator (GAI) and technical ripeness indicator (TRI) in accordance with [19].

Following quality indicators were assessed in base and sparkling wines: volume fraction of ethyl alcohol, mass concentration of total dry extract, titratable and volatile acids, the values of pH and redox potential (Eh), the content of sugars, titratable acids, phenolic substances (PhS), including their polymeric (PF PhS) and monomeric forms (MF PhS), coloring agents (anthocyanins) (CA), the content of amine nitrogen (AN), mass concentration of aldehydes (A); optical characteristics - yellowness (G), intensity (I) and color tone (T) ; potentiometric indicators - ΔEh/PhS - indicator of oxidizability of phenolic substances, I_2/PhS - specific reducing capacity of phenolic complex in relation to iodine; foaming properties - maximum foam volume, foam life cycle.

The mass concentration of total phenolic substances was determined colorimetrically using the Folin-Ciocalteu reagent. The solution under study in the amount of 1 ml, 15-20 ml of distilled water, 1 ml of reagent, 10 ml of Na_2CO_3 with mass concentration of 20 g/100 cm^3 was mixed in a 100 ml flask. The volume was adjusted to the mark level. The optical density of solutions was measured after 30 min at a wavelength of 670 nm in a cuvette with a distance between working faces of 10 mm against a reference solution, which was prepared identically, but replacing 1 ml of the solution under study with distilled water. The calibration curve was constructed using gallic acid as a standard in the concentration range of 60-600 mg/l.

The mass concentration of coloring agents (anthocyanins) was determined colorimetrically after stabilization of sample color with ethyl alcohol acidified to pH 1.2 according to the readings of optical density. The calibration curve was constructed using malvidin-3-glycoside as a standard in a range of mass concentrations 5-250 mg/l.

The volume fraction of ethyl alcohol was determined by hydrometric method in a distillate obtained by distillation of wine sample. The content of titratable acids was

assessed by the method of direct titration, equivalent to tartaric acid. The mass concentration of total dry extract was determined by hydrometric method.

Foaming capacity (maximum foam volume (V_{max})) and time of foam break (t_{br}) were determined using the developed method (STO 01580301.015–2017) of degassed wine sample air barbotage in a graduated cylinder (with 1 dm^3 capacity) using portable compressor and sprayer placed to the cylinder bottom. The volume of foam developed was determined visually using cylinder grading scale. The time of foam break was determined using a stopwatch.The total content of carbon dioxide in sparkling wines was defined according to the developed method STO 01580301.016–2017, according to which CO_2, released from wine under the action of ultrasound, was displacing the sealing liquid from graduated cylinder. The volume of displaced sealing liquid corresponded to the volume of carbon dioxide contained in a bottle of sparkling wine. The content of carbon dioxide bound forms was calculated by difference of determined CO_2 content and CO_2 solubility at a certain pressure and volume fraction of ethyl alcohol [21].

The organoleptic assessment was determined according to GOST 32051-2013 “Wine products. Methods of organoleptic analysis”, using a 10-point system (the minimum allowed score for base wines is 7.5 points; for sparkling wines - 8.8 points).

All studies were carried out in triplicate. The obtained data were processed using methods of mathematical statistics (at a significance level of $p<0.05$) and Microsoft Excel and Satistica software.

3 Results and discussion

A comprehensive analysis was carried out in the system "grapes - base wine - sparkling wine".

One of key factors in grape processing for base wine is the analysis of its carbohydrate-acid complex. The role of harvest time influence on quality indicators of base wines was determined as a study result of this grape complex. It was noted that with an increase in the content of sugars in grapes, the following results were observed:

- at the stage of grape assessment - an increase in the TS PhS (up to 42%) and TS CA (up to 40%), a decrease in the concentration of TA (by 13-36%), an increase in pH value (by 15-26%);

- at the stage of base wine assessment - lower values of TA (decrease up to 25%), with a corresponding increase in the active acidity indicator (by 16-25%), a higher concentration of CA (by 32-48%), as well as an increase in the content of aldehydes (by 50-100%). At the same time, the analysis of foaming properties showed that in white and rosé base wines a decrease (by 5-10%) in the maximum foam volume (V_{max}) and time of foam break ($t_{br.}$) was revealed, while in red base wines an increase in these indicators was observed (by 2.2 times).

The next step was the assessment of phenolic complex of grapes. We have determined the importance of using additional indicators of grapes ($PhS_{init.}$, $PhS_{mac.}$, TS PhS, TS CA, $CA_{init.}$, $CA_{mac.}$), with the help of which it is possible to control the duration of extraction activity when processing grapes. The relationship between components of phenolic complex in grapes and base wines, as well as the effect of these components on foaming properties were identified (Table 1). A positive correlation dependence of PhS and CA in base wines on grape indicators - technological stock, initial content, and after the extraction of corresponding components, was established. However, the negative correlation of PhS and CA in base wines with their foaming properties (there was a decrease in these properties at concentration of PhS more than 2000 mg/dm^3, and CA - more than 300 mg/dm^3) indicates the necessity to control the accumulation of these substances.

Table 1. Values of correlation indices

Indicator name		Base wine	Indicator name	Base wine
		PhS		CA
Grapes	$PhS_{init.}$	0.81	$CA_{init.}$	0.72
	$PhS_{mac.}$	0.73	$CA_{mac.}$	0.82
	TS PhS	0.76	TS CA	0.78
Base wine	V_{max}	-0.72	V_{max}	-0.61
	$t_{br.}$	-0.74	$t_{br.}$	-0.68

The resulting consistent pattern is reflected in typical properties of sparkling wines. The relationship between foaming properties of base wines and sparkling wines was revealed not only in the amount of PhS, but also in individual forms of phenolic complex, in particular, with PF PhS. Thus, the correlation coefficient for red sparkling wines was 0.83, and for rosé wines - 0.78.

At the next step of research, the conditions of cultivating grapes were studied. The effect of soil and climatic conditions of grape growing on specific features of forming physicochemical indicators in the system "grapes - base wine - sparkling wine" was noted. After statistical data processing, important indicators that divide studied samples into groups depending on growth conditions at each stage of production were identified. Thus, distinctive indicators of research objects from the South Coast of Crimea and the Western Piedmont Coastal region were established: at the stage of grapes (TS PhS, TS CA, TA, $PhS_{init.}$, $PhS_{mac.}$, $CA_{mac.}$, MPhMO); base wines (Eh, pH, % MF PhS, % PF PhS, % CA PhS, I, T, ΔEh/PhS, I_2/PhS); sparkling wines (Eh, pH, A, AN, % MF PhS, % PF PhS, I, T).

The systematization of the data obtained, based on the above established patterns, made it possible to determine the significant indicators of grapes and base wines, which make it possible to obtain high-quality sparkling wines (Table 2). Based on the system of organoleptic, physicochemical and biochemical indicators of grapes (in addition to GOST 31782) and base wines (in addition to GOST 33336), the possibility of their use in sparkling wine production is determined by comparing the values of observed indicators with the ranges indicated in Table 2. If indicator values of grapes and base wines obtained from one grape variety within three harvest years are within the allowable ranges, then this grape variety is suitable for production of sparkling wines.

Table 2. Physicochemical indicators recommended for control.

Indicator name	Value / variation range of indicator	Optimal value
Grapes		
Mass concentration of sugars, g/dm^3:		
for white	170-200	180
for rosé	180-210	190
for red	190-220	200
TA, g/dm^3, not less	5.0	6.0-8.0
pH value, not above	3.5	2.9-3.2
$PhS_{init.}$, g/dm^3:		
for white	180-800	300
for rosé	180-1000	600
for red	180-2000	1000
TS PhS, mg/dm^3:		
for white	300-1700	1000
for rosé	320-3000	2000

for red	800-3000	3000
TS CA, mg/dm^3: for rosé for red	100-2000 300-3000	150-250 500
$PhS_{init.}$/ TS PhS*100, %: for white for rosé for red	10-60 10-40 10-70	10-50 10-60 10-70
$PhS_{mac.}$/TS PhS*100, %: for white for rosé for red	5-50 13-60 13-80	5-30 10-50 13-70
MPhMO activity, c.u./cm^3 , not above	0.2	0.1
TRI: for white for rosé for red	143-205 150-215 160-225	150-184 160-195 170-205
GAI: for white for rosé for red	2.1-3.3 2.3-3.5 2.4-3.7	2.3-3.0 2.4-3.2 2.5-3.3
Base wine		
TA, g/dm^3	5.0-10.0	6.0-8.0
pH value, not above	3.5	2.9-3.2
PhS, mg/dm^3: for white for rosé for red	110-400 120-540 610-2620	200 200 1200-1400
CA, mg/dm^3: for rosé for red	3-44 64-443	20 300
PF PhS/PhS*100, %: for white for rosé for red	5-20 10-30 30-60	10 20 40
AN, mg/dm^3	100-250	200
Maximum foam volume, cm^3,not less	400	400-1200
Time of foam break, sec, not less	20	20-60
Tasting assessment, points, not less	7.7	7.75-8.0

Owing to a comprehensive assessment, grape varieties promising for the production of sparkling wines were identified: white – 'Aligote Muscatnoye', 'Kokur Belyi', 'Riesling Muscatnyi', 'Solnechnodolinskiy'; rosé – 'Ai-Petri', 'Antei Magarachskiy', 'Malbec', 'Kokur Krasnyi'; red – 'Ai-Petri', 'Antei Magarachskiy', 'Rubinovyi Magaracha', 'Prazdnichnyi Magaracha', 'Bastardo Magarachskiy', 'Syrah', 'Morastel', 'Kefesiya', 'Malbec', etc.

4 Conclusion

As a research results, we can conclude that the selected criteria for quality formation of sparkling wines in the system "grapes - base wine - sparkling wine", including the determining of additional physicochemical indicators of grapes and base wines, make it possible to obtain sparkling wines of high-quality. The use of the data obtained will allow improving the quality of local sparkling wines, creating a great variety of products.

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