Changes in the phenolic complex of red aboriginal grape varieties in the system “grapes – base wine - sparkling wine”

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Abstract. Due to the increased consumer interest in domestic wine products, winemaking enterprises are paying special attention to the use of aboriginal grape varieties now, in order to give products with distinctive characteristics, enabling to take the rightful place in wine market. However, there is no sufficient information about changes in the phenolic complex of grapes in the process of producing sparkling wines from red aboriginal varieties. The phenolic complex of grapes, base wines and sparkling wines produced from them was assessed, followed by the correlation established between the content of total phenolic, including coloring, substances in base wines and sparkling wines with their initial content and macerating (extracting) ability of these grape components, with corresponding correlation coefficients, which can be used for targeted regulation of accumulating these components.

1 Introduction

The high-quality competitive wine production is a priority task for viticulture and winemaking. Due to the active development of enotourism and an increased consumer interest in domestic wine products, winemakers are paying special attention to the use of aboriginal grape varieties in order to release products with unique characteristics, and take the rightful place in wine market. Russian and foreign scientists are working now in the directions of using aboriginal grape varieties in winemaking. They establish the genetic characteristics of varieties, on the basis of which their DNA passports are created [1-5], assess uvological, agrobiological and economic properties [6-10], replenish databases and create models of physicochemical and technological parameters of individual varieties [11-13], develop promising production directions for each individual aboriginal variety [14-18], etc. It should be noted that one of distinctive features of aboriginal varieties is an increased resistance to unfavorable environmental factors. It is believed that the phenolic complex occupies a special place in the formation of protective properties of grape plants [19]. At the same time, phenolic substances are the substrates for oxidative enzymes, and their increased content leads to the appearance of bitter flavor. It determines the control of

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accumulation of these components in the production of high-quality sparkling wines. At the moment, there is no sufficient data about the changes in phenolic complex during the production of sparkling wines from aboriginal grape varieties, which determines the requirement for our research. The purpose of the work is to study the transformation of phenolic complex of aboriginal grape varieties at different stages of sparkling wine production.

2 Materials and methods

Samples of grapes, base wines and sparkling wines were used as the objects of research. Red aboriginal grape varieties 'Kefesiya', 'Ekim Kara', 'Solnechnaya Dolina 58' were used for the experiment. Grapes were cultivated in the Western Piedmont-Coastal region of Crimea (Vilino village, Bakhchisaray district), and on the Southern Coast of Crimea (Solnechnaya Dolina village, Sudak district). The experiments were carried out in 2019-2022.

Grapes were hand-harvested at the stage of technological ripeness. Base wines were producing under the similar micro-winemaking conditions, according to the traditional scheme for red wines, and not including the influence of production technology. Technological scheme included the following stages: crushing and de-stemming of grapes; sulfitation (at a rate of SO_2 50-75 mg/dm^3); fermentation using the yeast strain *Sacch. cerevisiae* I-25 (Cabernet 5) from the Magarach Collection of Winemaking Microorganisms (CWM) at a temperature of 25-28 ºC to 2/3 of residual sugars, followed by pressing the fermented pulp; post-fermentation of base wines; decanting the yeast sediment. For sparkling wine production in accordance with the current regulatory documentation (GOST 33311), tirage mixture was prepared, which included the obtained red base wines, pure yeast culture (strain *Sacch. cerevisiae* I-525 (Sevastopolskaya 23) from the Magarach CWM), tirage liqueur and bentonite (0.2 g/dm^3). Tirage mixture was bottled, capped and stacked. The secondary fermentation temperature was 10-12ºC. After the end of secondary fermentation followed by aging for 9 months, the remuage (sliding down the sediment into the bottleneck) and degorgeage (the removal of this sediment) were carried out.

The methods of analyzing the physicochemical parameters of research objects, both standard for enochemistry and modified ones, were used in accordance with [20, 21].

Monitoring of phenolic complex indicators was carried out at the stages of grape harvesting, base wines and sparkling wines.

The following was evaluated:

- in grapes: technological stock of phenolic (TS PS) and coloring (TS CS) substances, their initial content ($PS_{init.}$ and $CS_{init.}$) and macerating (extracting) ability ($PS_{mac.}$ and $CS_{mac.}$);
- in base wines (bw) and sparkling wines (sw): the content of total phenolic substances (PS_{bw} and PS_{sw}, respectively), including coloring substances (CS_{bw} and CS_{sw}, respectively).

The mass concentration of total phenolic substances (PS) was determined by the colorimetric method using the Folin-Ciocalteu reagent. The following was sequentially mixed in a 100 ml flask: 1 cm^3 of the sample under study, 15-20 cm^3 of distilled H_2O, 1 m^3 of Folin-Ciocalteu reagent, 10 cm^3 of 20% wt. Na_2CO_3. A similar solution was used as a control, but instead of the sample under study, distilled H_2O was used in the same volume. After 30 minutes, the optical density of solutions was estimated (wavelength 670 nm, cuvette with a distance between working faces - 10 mm), in comparison with a control reference solution. Analytical curve was constructed using gallic acid as a standard in the concentration range of 60-600 mg/dm^3.

The mass concentration of coloring substances (anthocyanins) (CS) was determined colorimetrically after stabilizing the color of sample with ethyl alcohol acidified to pH 1.2

according to the readings of optical density. Analytical curve was constructed using malvidin-3-glycoside as a standard in the concentration range of 5-250 mg/dm^3.

All experiments were carried out in triplicate. When processing the obtained data, methods of mathematical statistics were used (confidence level $p<0.05$) using the Microsoft Excel and Satistica software.

3 Results and discussion

As a result of assessing the phenolic complex of red aboriginal varieties at the first stage of research, it was established that variation ranges in the values of TS PS and TS CS indicators were within the limits of 2160-3865 mg/dm^3 and 460-890 mg/dm^3, respectively, depending on the grape variety and crop year. Earlier studies [22] showed the role of phenolic complex in the formation of typical properties of base wines. And therefore, in order to control extraction, the initial content of the sum of phenolic and coloring substances in the must was assessed after pressing whole berries, as well as when extracting these components for 4 hours (Fig. 1). It was revealed that with minimal contact of must with pulp, the following is extracted into the must: 19-33% of the total phenolic substances ($PS_{init.}$) from its TS PS, which is 400-855 mg/dm^3; and 4-15% of coloring substances ($CS_{init.}$) from TS CS, which is 25-65 mg/dm^3. When macerating the pulp, an increase in the content of phenolic substances and coloring substances was observed up to 22-35% (460-960 mg/dm^3), and up to 9-27% (40-130 mg/dm^3), respectively, from TS PS and TS CS, due to the extraction process behavior.

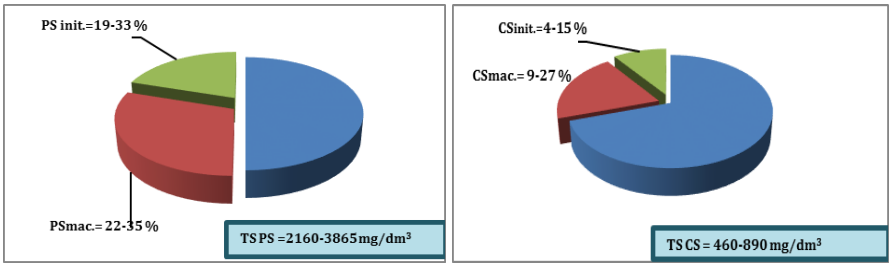

Fig. 1 Technological assessment of grapes

At the next stage, the phenolic complex of base wines, as well as of sparkling wines obtained from them, was assessed. It was established that the total content of phenolic substances in base wines (PS_{bw}) and in sparkling wines (PS_{sw}) was in the range of 1820-3120 mg/dm^3 and 1730-2530 mg/dm^3, respectively; and the mass concentration of coloring substances in base wines (CS_{bw}) and in sparkling wines (CS_{sw}) varied in the range of 165-371 mg/dm^3 and 155-242 mg/dm^3, respectively (Fig. 2). In sparkling wines, a decrease in the content of phenolic complex substances was noted (possibly due to partial polymerization of these components, as well as due to the precipitation on yeast cell walls):

up to 18% of the total phenolic substances and up to 44% of coloring substances (Fig. 2).

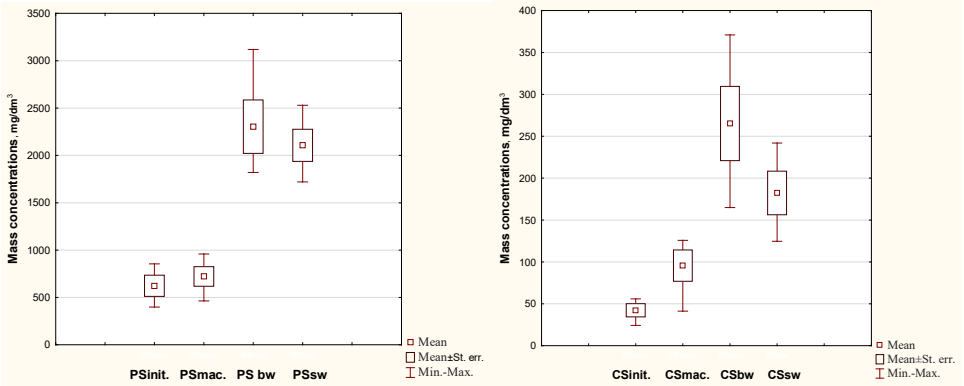

Fig. 2 Changes in the mass concentration of coloring substances during the production of sparkling wines

As a result of mathematical data processing, a correlation between the content of phenolic substances, including coloring substances, in base wines and sparkling wines with their initial content and macerating (extracting) ability of these components in grapes, with corresponding correlation coefficients, was established (Table 1).

Table 1. The values of correlation relationships between the phenolic complex indicators

Indicator		Grapes			
		$PS_{init.}$	$PS_{mac.}$	$CS_{init.}$	$CS_{mac.}$
Base wine	PS_{bw}	0.58	0.65	-	-
	CS_{bw}	-	-	0.63	0.81
Sparkling wine	PS_{sw}	0.54	0.57	-	-
	CS_{sw}	-	-	0.52	0.55

4 Conclusions

Therefore, the phenolic complex transformation at basic stages of sparkling wine production was studied. Positive correlation relationships between grape indicators ($PS_{init.}$, $CS_{init.}$, $PS_{mac.}$, $CS_{mac.}$) and the indicators of phenolic complex of base wines and finished products (PS_{bw}, CS_{bw}, PS_{sw}, CS_{sw}) are shown. The obtained data can be used if it is necessary to regulate the accumulation of phenolic complex components in the production of sparkling wines of a specific brand with target indicators.

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