Young sparkling wines from the Sevastopol grape-growing area of Crimea

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Abstract. Wine is a product of the area, so the study of its properties should be carried out in relation to the terroir. The aim of the work was to evaluate the quality of young sparkling wines made from 'Glera', 'Rhenish Riesling', 'Pinot Blanc', 'Pinot Noir', and 'Kokur belyi' grapes varieties grown in the valley of the Belbek River in the Sevastopol wine-growing zone of Crimea. Bottle fermentation was carried out at a temperature of 12-14 °C for 2 months using existing live yeast cells of primary fermentation. Young sparkling wines were characterized by typical properties (foamy and sparkling properties) for this type of product: maximum foam volume > 400 ml, high foam stability – more than 60 s, mass fraction of bound CO_2 > 8%, equilibrium CO_2 pressure – more than 300 kPa. The samples of sparkling wines from 'Riesling Rhenish' and 'Kokur belyi' varieties, which were characterized by a harmonious organoleptic profile, received the maximum tasting ratings (above 85 points). The wine samples obtained from 'Pinot Blanc', 'Glera', and 'Kokur belyi' grapes were distinguished by a high coefficient of sparkling properties (K > 100 min.). This indicator had a high correlation with the mass fraction of bound forms of carbon dioxide (r=0.93).

1 Introduction

In conditions of high competition in the alcohol market and widespread use by wineries of common European grape varieties, the success of enterprises producing sparkling wines from their own raw materials largely depends on the terroir, which includes varietal characteristics of the grapes being cultivated, agro-climatic conditions and agrotechnological techniques used in grape cultivation, winemaking technology, type of equipment and strains the yeast used. The very concept of "terroir" began to be identified with high-quality products and well-known brands. The leadership in the promotion of "terroir" wines belongs to France, although in other countries this trend is becoming a fashion trend [1]. At the same time, there are two opposite trends: the first is when popular brands seek to expand their production, increase production volumes by expanding vineyard areas and yields [2]. In this regard, studies are even being conducted to determine whether some wine companies occupy a dominant position in the sparkling wine market [3]. The second is the tendency towards the

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formation of "microterroirs", when small differences in soil composition, water availability and microclimate lead to noticeable differences in the chemical composition of wine [4]. This approach is typical mainly for small farms interested in promoting their products on the wine market. If winemakers use similar grape varieties, then the task of creating exclusive products is to look for differences in terroirs that affect the physico-chemical parameters of the wine [5]. In addition to soil and climatic differences [6], there are differences in the vineyard microbiome, which also has a significant impact on the properties of sparkling wines [7]. Since the classical sparkling wine technology implies a fairly long production cycle (from 15 months to 20 years or more) for small farms, it may be preferable to produce young sparkling wines obtained by single fermentation, which contributes to better foamy and sparkling properties [8].

The main grape varieties used for producing champagne in the Champagne region are Pinot Noir, Pinot Meunier, and Chardonnay, which occupy approximately 99% of all vineyard plantings in the area [9]. In Italy, Glera is a traditional grape variety used for making Prosecco sparkling wines [10]. Kokur Belyi is a white wine grape variety indigenous to the Crimean Peninsula, and it is used to produce still, sparkling, and liqueur wines. All the grape varieties studied, including Glera, Rhenish Riesling, Pinot Blanc, Pinot Noir, and Kokur Belyi, that are cultivated on farms in the Belbek Valley, are included in the list of authorized sparkling wines with the traditional name "Russian Champagne."

The aim of the work was to evaluate the quality of young sparkling wines made from ‘Glera’, ‘Rhenish Riesling’, Pinot Blanc’, Pinot Noir’, and ‘Kokur belyi’ grapes varieties grown in the valley of the Belbek River in the Sevastopol wine-growing zone of Crimea.

2 Research method

The object of the research was young sparkling wines made from grapes of the ‘Glera’, ‘Rhenish Riesling’, ‘Pinot Blanc’, ‘Pinot Noir’, and ‘Kokur belyi’ varieties cultivated in the Belbek River valley (Povorotnoe village, Nakhimovsky district) Sevastopol wine-growing zone. The grapes of the studied varieties were selected in an amount of at least 50 kg at the stage of technical maturity during the industrial harvest. The average sample of grapes was taken from four different areas of 5 hectare (10-15 kilograms each) that were planted with the same grape variety and managed using the same bush system. The areas were divided diagonally into 5-10 rows, and the bunches were cut from different sides and at different heights of the bush.

Grapes were evaluated according to the following physico-chemical parameters: mass concentration of sugars and titrated acids [11]. The experimental batches of grapes met the requirements of regulatory documentation: the mass concentration of sugars was at least 160.0 g/L, the content of titrated acids was in the range of 6.0 to 11.0 g/L.

The grapes were processed using the white method according to the following scheme: crushing on a roller crusher after separating the ridges → extraction of gravity must in an amount not exceeding 50-55 liters/100 kg after pressing the pulp on a basket press and sulfitization (75 mg/L) → clarification of the must by settling at a temperature of 14-16 °C for 16-18 hours → decanting → fermentation of clarified grape must at a temperature of 16-18 °C using a pure culture of *Saccharomyces cerevisiae* yeast strain I-527 (47-K) from the Collection of microorganisms of the Magarach for wine industry → removal of fermenting must from the sediment when the sugar concentration reaches 22-24 g/L → addition of bentonite (0.2 g/L) → bottling for champanization using existing live yeast cells of primary fermentation (at a concentration of at least 1 million cells/ml). Bottle fermentation took place at a temperature of 12-14 °C for 2 months. Then the remuage was carried out, the wine was cooled to a temperature of minus 3-4 °C, the sediment was frozen in the neck of the bottle, disgorging (degourgage), topping up with the same wine and capping.

The obtained sparkling wines were analyzed for physico-chemical parameters according to the methods accepted in oenology [11]. Optical density spectra were measured using a Specord 40 spectrophotometer (Analytik Jena, Germany) in a cuvette with an optical layer thickness of 10 mm. The indicators of foamy properties (the maximum volume of foam and the time of its destruction) were determined by bubbling air in a measuring cylinder (with a capacity of 1 l) of a degassed wine sample using a portable compressor and a sprayer, which was lowered to the bottom of the measuring cylinder. The volume of foam formed was determined visually by calibrating the cylinder, and the time of foam destruction was determined using a stopwatch [12]. The total carbon dioxide content in sparkling wines was determined by the amount of CO_2 released from the wine under the influence of ultrasound and displacement of the shut-off fluid from a graduated container. The volume of the displaced liquid corresponded to the volume of carbon dioxide contained in a bottle of sparkling wine. The content of bound forms of carbon dioxide was calculated from the difference between the measured CO_2 content and its solubility at a certain pressure and ethanol concentration. Sparkling properties were determined by measuring the rate of CO_2 desorption from a wine sample when pressure was released to atmospheric pressure [13]. The organoleptic evaluation of sparkling wines was carried out in accordance with 100-point scale [14]. The data obtained was processed using mathematical statistics methods using the Microsoft Excel software package. All the studies were conducted in three dimensions. The paired correlations between the indicators were calculated at a significance level of 0.05.

3 Results and discussion

The first stage of the study included the determination of the physico-chemical parameters of young sparkling wines (Table 1).

Table 1. Physico-chemical parameters of young sparkling wines

Grape variety	Volume fraction of ethyl alcohol, %	pH	Eh, mV	G	Mass concentration			
					g/l	mg/l		
					titrable acids	Σ phenolic substances	polymer forms of phenolic substances	Amine nitrogen
Pinot Blanc	11.5±0.13	2.7±0.05	239±8	11.0±0.3	7.9±0.26	244±15	26±2	130±6
Glera	13.0±0.15	2.8±0.02	235±5	10.9±0.2	7.7±0.17	252±13	38±5	123±4
Pinot Noir	12.1±0.10	2.9±0.01	228±3	-	6.4±0.11	274±11	87±7	161±6
Rhenish Riesling	12.0±0.12	2.99±0.02	225±3	08.6±0.1	5.8±0.07	216±8	20±1	105±3
Kokur belyi	13.5±0.18	2.93±0.01	227±5	23.5±0.4	7.7±0.06	490±23	227±14	147±2

An analysis of the data obtained indicates that, according to the main criteria, the prepared wine samples met the requirements of regulatory documentation: the volume fraction of ethyl alcohol was in the range of 11.5-13.5%, the mass concentration of titrated acids ranged from 5.8 to 7.9 g/l, due to the grape variety. The value of the hydrogen index, regardless of the experimental variant, did not exceed 3.0. The value of the redox potential of young sparkling wines was in the range of 225-239, which indicates a low degree of non-enzymatic redox processes and, as a result, a high reduction of the samples. The evaluation of the phenolic complex of wines showed that the mass concentration of polymer forms of phenolic substances varied in a wide range: from 20 to 227 mg/l. The maximum value of this indicator was characterized by a sample of white sparkling wine from the Crimean autochthonous grape variety 'Kokur belyi', the proportion of polymer forms in which reached 46%. This was reflected in the yellowness index, which was the highest in this sample (23.53). The dependence of the yellowness index and the mass concentration of polyphenols is described by a high correlation coefficient r = 0.99. The content of amine nitrogen varied in the range of 105-147 mg/l.

The color of white wines can be estimated based on the contribution of two components – red (D_{520}) and yellow (D_{420}) pigments. An analysis of the optical density spectra of sparkling wines showed that the maximum values of these indicators were characterized by samples obtained from 'Pinot Noir grapes': 0.357 and 0.463 for D_{420} and D_{520}, respectively. The results obtained are a consequence of the higher content of phenolic substances in wine, which causes their more intense coloring. For other experimental variants, the optical density values did not differ significantly and varied in the range of 0.077-0.108 for D_{420} and 0.027-0.042 for D_{520} (Fig. 1).

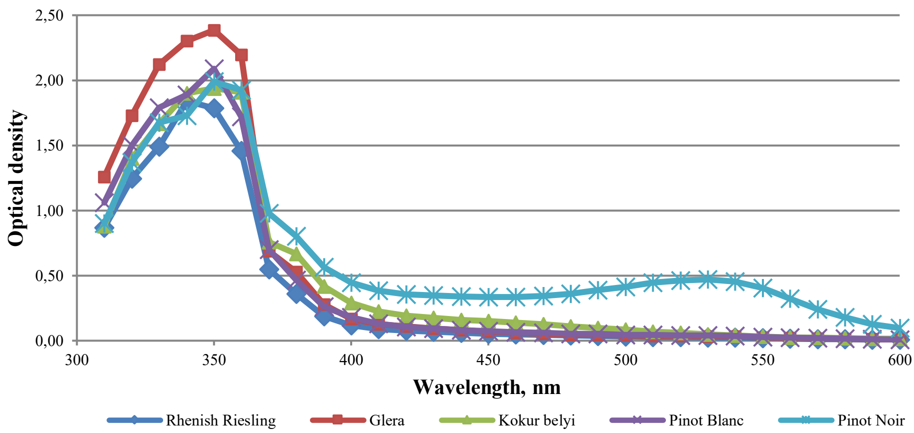

Fig. 1. Optical density spectra of young sparkling wines

According to the method of assessing the typical properties of sparkling wine by Merzhanian A.A., carbon dioxide in sparkling wine is contained in 3 types: dissolved, gaseous and bound. High-quality sparkling wines must contain at least 8% bound forms of CO_2. According to the data obtained (Table 2), the samples prepared of young sparkling wines were characterized by a high value of this indicator, the value of which varied in the range of 12.5-15.6%, which in quantitative terms ranged from 0.814 to 1.460 g. The total carbon dioxide content of the experimental samples of young wines differed slightly. The value of the indicator ranged from 8.2 to 9.88 g. The exception was a sample of wine made from Pinot Blanc grapes – the total CO_2 content in the bottle was 1.38-1.66 times lower than in other experimental variants.

Table 2. The content of the main forms of carbon dioxide in young sparkling wines

Grape variety	**The CO_2 content in the bottle (mCO_2), g**				**Mass fraction of bound CO_2, %**
	Σ CO_2	**dissolved**	**gaseous**	**bound**	
Pinot Blanc	5.946±0.028	4.848±0.013	0.284±0.006	0.814±0.005	13.7±0.09
Glera	9.331±0.036	7.492±0.016	0.378±0.011	1.460±0.010	15.6±0.06
Pinot Noir	9.879±0.023	8.205±0.008	0.321±0.009	1.353±0.009	13.7±0.04
Rhenish Riesling	9.514±0.017	7.958±0.011	0.365±0.014	1.190±0.018	12.5±0.08
Kokur belyi	8.233±0.009	6.655±0.009	0.331±0.005	1.247±0.013	15.1±0.09

During the analysis of the typical properties of sparkling wines (Table 3) it was found that all experimental samples of sparkling wines are characterized by good foaming properties (Vmax > 400 ml). The highest index of the maximum foam volume was determined in samples from 'Pinot Noir' (950 ml), Kokur belyi' (950 ml) and 'Pinot Blanc' (900 ml) grape varieties.

Table 3. Typical properties of young sparkling wines

Grape variety	Maximum foam volume V_{max}, ml	Foam destruction time t, s	Equilibrium pressure CO_2 (P_{CO2}), кPa	The rate of CO_2 desorption from the wine sample (υ), mg/min	Coefficient of sparkling properties (К), min.
Pinot Blanc	900±15	>60	400±10	4.550±0.15	100.0±1.2
Glera	730±10	>60	700±20	4.767±0.13	109.5±3.3
Pinot Noir	950±20	>60	750±15	5.117±0.08	89.1±1.7
Rhenish Riesling	740±10	>60	740±10	6.000±0.09	78.0±1.4
Kokur belyi	950±10	>60	600±10	4.583±0.11	103.0±1.9
Recommended values	>400	>60	>300		>100.0

The foam destruction time in all experimental variants was more than 60 s, which indicates the high stability of the foam [20]. The equilibrium CO_2 pressure in the wines varied in the range of 400-750 kPa, which is 1.3-2.5 times higher than the minimum value for this type of wine (300 kPa).

Estimating the rate of carbon dioxide desorption in experimental wine samples, it can be concluded that the most intensive process took place in a sample of sparkling wine from 'Rhenish Riesling grapes (υ=6 mg/min). The intensity of the desorption process of wine from 'Pinot Blanc, 'Glera and 'Kokur white grapes did not differ significantly.

The coefficient of sparkling properties measures the time (in minutes) it takes for the entire volume of carbon dioxide to be released from a 50-centiliter sample of sparkling wine contained in a standard tulip glass. Based on the data obtained previously, a coefficient of more than 100 indicates excellent sparkling qualities of the wine [13]. The samples of young sparkling wines obtained from grapes of the 'Glera' (109.5), 'Pinot Blanc' (100.0) and 'Kokur belyi' (103.0) varieties were distinguished by a high coefficient of sparkling properties. A close correlation was established between the coefficient of sparkling properties of wines and the mass fraction of bound forms of carbon dioxide (r = 0.93).

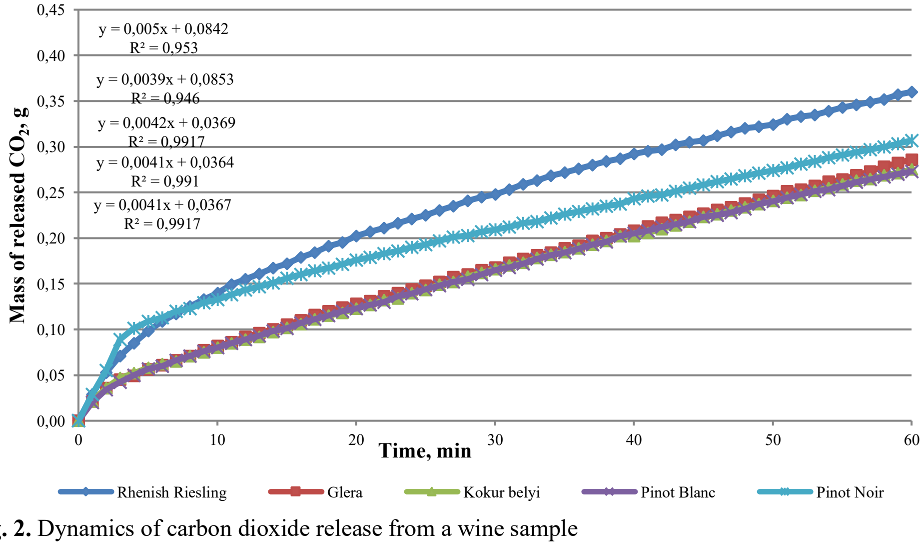

Fig. 2. Dynamics of carbon dioxide release from a wine sample

A graphical representation of the dynamics of carbon dioxide release from a wine sample is shown on Fig. 2. The intense release of CO_2 in wine leads to a rapid end of effervescence in a glass. It can be seen from the presented data that the process was most intensive in samples of young sparkling wines from ‘Riesling Rhenish’ and ‘Pinot Noir’ grapes. The carbon dioxide desorption rate in these sparkling wine samples is lower compared to other experimental variants, suggesting that they have weaker sparkling properties.

The second stage of assessing the quality of young sparkling wines was the organoleptic characteristics of the samples (Table 4). Analysis of the organoleptic profile of the wines showed that all the samples were pure, without extraneous shades in aroma and taste.

Table 4. Organoleptic characteristics of young sparkling wines

Grape variety	Characteristic	Tasting assessment, points
Pinot Blanc	The color is light straw. The fragrance is fruity, with a "green" note. The taste is too fresh and light.	81
Glera	The color is light straw. The fragrance is floral, with a candy note. The taste is fresh, quite harmonious, with good CO_2 saturation	84
Pinot Noir	The color is golden straw. The aroma is bright berry (strawberries with cream) and caramel shades. The taste is full, harmonious, with good CO_2 saturation.	83
Rhenish Riesling	The color is light straw. The fragrance is pronounced, floral, with a slight mineral tint. The taste is full, harmonious, with good CO_2 saturation.	87
Kokur belyi	The color is golden. The aroma is pronounced bright, fruity, with hints of exotic fruits. The taste is full, harmonious, with a slight tannic bitterness, with good CO_2 saturation.	88

Samples of sparkling wines from ‘Riesling Rhenish’ and ‘Kokur belyi’ grapes, which were characterized by a pronounced aroma, harmonious taste and good CO_2 saturation, received high tasting ratings (87 and 88 points respectively). This allows to consider these samples as of very good quality [14]. The aroma of sparkling wines from the ‘Glera’ and ‘Pinot Noir’ grape varieties are pure, with individual varietal characteristics, the taste is quite harmonious, with good CO_2 saturation, which was reflected in the tasting ratings – 84 and 83 points. A sample of ‘Pinot Blanc’ sparkling wine received a tasting score of 81 points for its "green" note in the aroma and light taste.

4 Conclusion and recommendation

Young sparkling wines made from ‘Glera’, ‘Rhenish Riesling’, ‘Pinot Blanc’, ‘Pinot Noir’, and ‘Kokur belyi’ grapes grown in the Belbek River valley of the Sevastopol wine-growing zone complied with regulatory documentation and were characterized by typical properties (foamy and sparkling properties) for this type of product: maximum foam volume > 400 ml, high stability foams – more than 60 s, the mass fraction of bound CO_2 is > 8%, the equilibrium pressure of CO_2 is more than 300 kPa. The results indicate that the production of this type of product in this region is promising. The samples of sparkling wines from ‘Riesling Rhenish’ and ‘Kokur belyi’ varieties, which were characterized by a harmonious organoleptic profile, received the maximum tasting ratings (above 85 points). The wine samples obtained from ‘Pinot Blanc’, ‘Glera’, and ‘Kokur belyi’ grapes were distinguished by a high coefficient of sparkling properties (K > 100 min.). This indicator had a high correlation with the mass fraction of bound forms of carbon dioxide (r=0.93).

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