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ESTABLISHING A PATTERN OF CHANGE IN THE QUALITY INDICATORS OF TOKAJ-TYPE WINE MATERIALS PREPARED BY DIFFERENT VARIANTS

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The object of this study is Tokaj-type wine materials made from white and red grape varieties grown in the foothills of the Goy-Gol region and the flat zone of the Samukh region in the Azerbaijan Republic. An important condition for the production of Tokaj wine is the high sugar content in the raw materials. Therefore, fully ripe and slightly withered grape varieties were used to prepare the wine materials. The quality indicators of wine materials prepared in three options were studied. Option 1 – preparation of Tokaj wine material by adding must with pulp from ripe grapes to alcohol; Option 2 – preparation of Tokaj wine material by adding must with pulp from grapes withered on the vine for 10–12 days to alcohol; Option 3 – preparation of Tokaj wine material by adding must with pulp from grapes withered on the vine for 4–5 days to alcohol. The most appropriate options were the first and second, according to which Tokaj wine material is produced by adding must with pulp from grapes ripened and dried on the vine for 4–5 days to alcohol. The content of sugar, volatile acids, titratable acidity, phenolic compounds, methyl alcohol, and the volume percentage of alcohol added to the must were studied in the prepared wine materials. For the preparation of wine material, it is advisable to use the white Rkatsiteli grape variety and the red Cabernet Sauvignon variety grown in the flat zone of the Samukh district. This is due to the fact that in the flat zone, grapes accumulate more sugar, and the volume percentage of alcohol added to the must is less, which is also economically advantageous. During the study, using mathematical and statistical methods, the most appropriate option was determined for the organoleptic indicators of Tokaj wines made from the Rkatsiteli grape variety, which was rated 9.8 points

Keywords: Tokaj wine, quality indicators, phenolic compounds, titratable acidity, contraction coefficient

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1. Introduction

Tokaj wines are categorized as sweet dessert wines. To produce quality Tokaj wine, it is important to examine the quality indicators of the grape varieties used. It is necessary to pay attention to the soil and climatic conditions of growing grapes used to make wine, their degree of maturity, richness of food components, and other factors. In addition, the raw materials should be more resistant to microbiological diseases [1].

The grape varieties used to produce Tokaj wine should have a high content of natural sugars. It is known that sugar contained in grapes is a representative of simple carbohydrates, consisting mainly of glucose and fructose. In the production of wine, grape varieties should be used that contain more fructose than glucose. This is mainly due to the fact that fructose is twice as sweet as glucose [2].

Tokaj wine is categorized as sweet dessert wines, it should naturally contain 16–20 % sugar. Sugars are the main indicator of the quality of grapes. Grapes are the only raw material that has no alternative for making natural wine. In order to make wine, the raw material must contain four main components. Otherwise, the wine will not be able to have its unique aroma, taste, specificity, fullness, consistency, and other useful nutritional properties. From the literature review, it became clear that at present there is no product of plant origin with a sufficient composition of the above four components that can replace grapes. Persimmon fruits, which are relatively close to grapes in chemical composition, are almost as rich in simple sugars, glucose, and fructose as grapes. Although their composition is rich in simple sugars and phenolic compounds, it has few acids and a lot of pectin substances [3].

To produce quality wine, it is important, first of all, to have quality raw materials, i. e., the presence in the grapes of the required amount of sugar, total acidity, phenolic compounds, and a small amount of pectin substances. Total sugar is used both for fermentation and for storing residual sugar in the wine material. Total acidity is involved in the formation of the unique taste and aroma of wine. Phenolic compounds create conditions for the fullness of wine and protect wine from oxidation and pathogens. Low content of pectin substances in wine, which are representatives of heteropolysaccharides, has a positive effect on its quality. Since pectin substances are colloidal particles that cause turbidity of wine.

In addition, the formation of highly toxic methyl alcohol in wine occurs due to the hydrolysis of pectin substances [4].

From the literature, it became clear that it is impossible to make quality wine from pectin-rich grape varieties. This principle is related to the fact that with a high amount of pectin substances in grapes, the content of methyl alcohol increases as a result of enzymatic hydrolysis [5].

According to Hungarian laws, Tokaj wines are environmentally friendly and are produced in a natural way. It is prohibited to add alcohol and other ingredients to wine materials during its production. In its homeland, this wine is also called royal wine. To make Tokaj dessert wine in a natural way, the sugar content in the grapes should be within 40–42 %. Since there are no technical grape varieties in the Republic of Hungary that can collect up to 40 % sugar, the sugar percentage is increased by twisting the grape bunch on the vine [6].

Therefore, the topic of the comparative analysis of Tokaj wine materials prepared in different ways, taking into account the varietal characteristics and zoning of grapes, is very relevant. It is important to take into account the change in the composition of nutrients in the process of wine making and the improvement of the organoleptic properties of the finished product.

2. Literature review and problem statement

Paper [7] reports the results of studies related to the change in the percentage of sugar during the withering process. It is shown that when the bunch is twisted on the vine, the berries wither, the percentage of sugar increases due to the evaporation of water. In such grape varieties, the yield of must is significantly less than in fully ripened ones. The reason for this is the activation of oxidative enzymes. Compared with fully ripened grape varieties, the activity of enzymes in withered grapes is significantly higher. An increase in enzyme activity creates conditions for the expenditure of nutrients in its composition on the respiration process. This means that compared to withered grapes, the amount of nutrients in ripe grapes remains significantly higher. In paper [8], the authors indicate that consumer awareness of the energy value of wines leads to a more conscious approach to the choice of wine products, taking into account the principles of rational nutrition. Excessive consumption of alcoholic beverages can pose a threat to human health. The study conducted by the authors was aimed at determining the energy value of various types of wine using the international methodology developed by the International Association of Official Analytical Chemists. The following physicochemical parameters were determined in the wines: volume fraction of ethyl alcohol, mass concentration of restored extract and sugars. As the results of the study showed, the state of the wine is the determining factor in energy value: for table wines, this parameter is 59–158 kcal and increases from dry to sweet, while the contribution of ethyl alcohol to the parameter value can reach 93.0 %; the energy value of liqueur wines fluctuates within the range of 79–208 kcal. Carbohydrates, represented by simple sugars, provide up to 45.0 % of the caloric value; the differences in the parameter for dry wines of the two groups are from 20.0 to 50.0 %. The researchers systematized fortified wines depending on the type in order to increase the energy value: Sherry→Marsala→Madeira→Port→Cahors→Tokaj→Muscat→Malaga. However, the work did not cover such important wine indicators as titratable acidity, volatile acidity and extractivity, which determine the quality of wines.

In paper [9], the authors reveal the history of the development of Tokaj wine; they point out that Tokaj wine is the noblest wine of Hungary, it is one of the unique Hungarian products. The role of wine quality is becoming increasingly important, and consumers, as well as the world market, demand quality wines. Increasing domestic consumption of Tokaj wine has always been an inspiring tool in the life cycle of the population. Considerable attention should be paid to the development and preservation of viticulture, the choice of raw material assortment and zoning. However, in the work, marketing research was carried out and less attention was paid to the quality of wine, which is formed not only by the varietal characteristics of the grapes but also by the method of its preparation. In work [10], the authors claim that the quality of wine is mainly determined by the qualitative and quantitative composition of the organic and inorganic components present, so their clarification is one of the most important tasks of wine analysis. On the other hand, from an economic point of view, it is extremely important to monitor and constantly check whether the wines are satisfactory enough. Therefore, it is important to produce quality products that meet the needs of the population and are competitive in the market in the long term. During the study, the authors resolved the issue of how the qualitative and quantitative ratios of components depend on agrotechnical conditions. Including the dependence of volatile organic components and metals on the year of harvest, place of cultivation, and grape variety. But issues related to the influence of lowland and foothill climatic conditions on the quality indicators of finished products remained unresolved. All this allows us to assert that it is advisable to conduct a study on the chemical composition of grape varieties depending on their zoning.

In work [11], the authors claim that it is important to use fully ripe technical grape varieties for the production of Tokaj-type wine material. Compared to unripe and overripe grape varieties, fully ripe grapes are rich in organic and inorganic substances. These substances have a positive effect on the taste and aroma of the wines being prepared, and also enrich it with extractive substances. It is impossible to make quality wine from unripe and overripe grape varieties. In unripe grapes, the sugar content necessary for making wine is low, and the acidity is above the norm. All this allows us to claim that it is advisable to conduct a study on determining the period of grape harvesting, during which the grapes accumulate the maximum amount of nutrients necessary for the preparation of high-quality wine material. The authors in work [12] indicate that the quantitative determination of the total acidity of grapes and wine is determined by tartaric acid. It is difficult to make quality wine from overripe grapes. This is due to the fact that grapes that have passed the ripening period soften, and the nutrients they contain are used for the respiration process. That is why the nutritional components of overripe grape varieties are significantly less compared to ripe grapes. But there are still unresolved issues related to the influence of volatile acidity on the wine making process. Volatile acidity is due to the presence of volatile acids in wine, for example, acetic acid, which is formed as a result of the oxidation of ethyl alcohol by acetic acid bacteria. Acetic acid subsequently reacts with ethanol to form an ester called ethyl acetate, which is the source of unpleasant odors in wine. The active acidity of must and wine plays an important role in the process of wine formation and maturation, determines the ratio of fermentation products, the tendency to oxidation, biological and colloidal opacities. This is the approach used in the work, but the effect of active and titratable acidity on the quality of wine material is not considered. Work [13] reports a study of red grape varieties, which are rich in phenolic compounds, and due to them, juices prepared from them have antioxidant and antimicrobial properties. However, their suitability for the production of different types of wines is not studied.

The author in his work [14] points out that the quality of wine consists of a set of properties that make it acceptable or desirable for the consumer who is impressed by the features of wine that cause pleasant sensations. Therefore, the problem of quality should be solved with the help of wine production technology, which is aimed primarily at preserving and developing these features. Quality is a set of pleasant taste sensations directly related to the chemical composition of wine. But it is well known how inaccurate and subjective the definition and evaluation of the taste properties of wine are, on the one hand, and the difficulty of linking them with the chemical composition of wine, on the other. In essence, it is impossible to completely solve this problem. However, it is well known that the quality of wine is a relative concept, that the consumer's taste changes dramatically over time and now varies depending on the region. The main difficulty is to determine and translate into precise and clear language the advantages and disadvantages of a particular wine. An option for overcoming the corresponding difficulties may be to study the effect of the method of preparation, processing, and material on the quality of wine. However, there are still unresolved issues related to the study of factors that ensure better quality, which is due to the reliable and convenient method for determining and expressing types, norms, limits, comparative values. This is the approach used in work [15], in which Tokaj varietal wines made from different grape varieties are compared. The identified volatile organic compounds were analyzed using one-way ANOVA. Wines made from white grape varieties were characterized by a high concentration of terpenoids. Enantioselective analysis of the dominant terpenoids (limonene, linalool, hotrienol and α-terpineol) was carried out using Heartcut-2D-GC: the R-form dominated for limonene and linalool, and the S-enantiomer for hotrienol and α-terpineol. Statistical analysis (ANOVA) confirmed that R-linalool is the most significant compound responsible for the main differences between the studied varietal wines. It is known that phenols also belong to volatile organic compounds, and their content dominates in wine materials prepared by the red method from white and red grape varieties. Identification of these compounds would determine the representative responsible for the differences between wines prepared from grapes grown under different climatic conditions. All this allows us to state that the conducted studies could become a useful tool for wineries seeking to increase the antioxidant content in prepared wines, thereby turning them into functional drinks and extending their shelf life. In this regard, the most suitable and economically advantageous technology is the production of wine material by fermenting the must on the pulp, during which the must is enriched with natural phenolic compounds.

Work [16] presents the data on the antioxidant and antiradical action of red table wines. It has been studied that the antioxidant and antiradical properties of red table wines are due to the varietal characteristics of grapes and the technology of their processing. A correlation has been established between the antioxidant property and the concentration of phenolic complex components, as well as the antioxidant and antiradical properties of red wines. Variants with the highest concentration of phenolic compounds – catechins and tannins – had high antioxidant and antiradical value. It has been proven that in red grape varieties and with the technology of wine preparation using must fermentation on the pulp, the antioxidant and antiradical properties of wines also increase. Depending on the grape variety and the technology of preparation, the antioxidant activity changed by more than 30 %. The data obtained indicate that the technology of wine preparation allows increasing the intravarietal antioxidant activity from 10 to 20 %. It has been proven that in red grape varieties and in winemaking technology using must fermentation on pulp, the antioxidant and antiradical properties of wines also increase. However, issues related to determining the influence of varietal characteristics and grape zoning on the activity of enzymes that break down phenolic compounds and the quantitative change in these compounds remain unresolved. The authors in [17] studied red, white, and Tokaj wines using electron paramagnetic resonance (EPR) spectroscopy. The ability to remove radicals was studied in 30 samples of wines from the Slovak region. 10 samples of red and 10 samples of white wines prepared from different grape varieties grown in different regions were compared. The studies showed that Tokaj wines demonstrate very good cleaning ability, occupying a position between white and red table wines. The cleaning capacity was expressed in the equivalent antioxidant capacity of trolox (TEAC): 14.8±1.5 for red, 8.1±3.4 for Tokaj, and 3.3±1.6 for white wines. However, questions related to the study of the quality indicators of wine materials prepared from grapes of lowland and foothill regions remained unresolved.

The authors of [18] studied the mineral composition of wines depending on many environmental and technological factors. They claim that the studied variables affect human health. The paper presents data on possible changes in the mineral composition and pH of wines due to 4-hour skin maceration and fermentation under a layer of sulfur. The experiments were carried out on acidic sandy soil in the Middle East of Hungary. The mineral composition of wines was determined using a ThermoFischer Scientific iCAP 6300 ICP-OES, pH was measured using a pH10pen (VWR International) in the field and a SevenEasyTM pH meter (Mettler Toledo) in the laboratory. The results of the first version of the study demonstrated the effect of skin maceration, which is widely used to enhance aroma. In the second version, red grape varieties were used, which were used for double maceration in rose and red wine technology. The data of the first study showed that skin maceration increases the content of K, Cu, Mn, and P, and significantly reduces Fe. The data from the second study show that with longer skin contact and higher fermentation temperatures, the contents of K, Mg, Mn, P, Sr, and B increase, while Fe and Ba decrease. As for pH, the data show that skin maceration and fermentation increase the K content by approximately 30–70 % and pH by 0.4–0.5. The development of innovative methods for producing environmentally friendly products could be an option to overcome these difficulties; this is a pressing issue, the solution of which requires special approaches to improving existing technologies. For the production of environmentally friendly products, it is not allowed to use additional ingredients; the authors used the method of skin maceration and fermentation under a layer of sulfur. The authors in [19] note that the use of selected yeasts has not become widespread because the quality improvement that could be expected from it was not always obvious enough. It is now known that the use of pure cultures and yeasts generally has only an indirect effect on wine quality. For example, the use of alcohol-resistant yeasts helps complete the fermentation and, accordingly, the risk of its stoppages disappears. Another example is the use of acid-reducing yeasts (*Schizosaccharomyces*), which makes it possible to obtain wines with reduced acidity. It is important to note that the strain *Candida stellata*, which is usually isolated from grape must, is competitive and stable in the fermentation of both white and red wine in various wine regions of the world and can withstand an ethanol concentration of at least 9 % (by volume). An option to overcome these difficulties may be studies related to the characterization of *C. stellata* for their ability to produce desirable metabolites for wine flavor, such as acetate esters, or for the presence of enzymatic activity that enhances wine aroma.

In work [20], the authors used the method of solid-phase microextraction followed by gas chromatography in combination with mass spectrometric analysis to study volatile organic compounds in healthy and botrytized grape berries, as well as in botrytized wines (of the Tokaj selection). The studies showed that more than 95 compounds were detected in uninfected grape berries. And botrytizing significantly increased the number of volatile compounds. Such compounds as higher alcohols, carbonyls, furans, terpenoids and esters of carboxylic acids, as well as alcohol in botrytized wines, were identified in grapes. The authors selected seven chiral compounds (α-terpineol, hot-trienol, limonene, diethyl malate, 2,3-butanediol, and whiskey lactones) for further chiral separation. The results of the study showed that botrytizing affected the enantiomeric ratio of the studied terpenes of all grape varieties. The distribution of α-terpineol enantiomers was affected by the wine processing technology used. However, there are still unresolved issues related to the study of volatile organic compounds of dried grapes since it is Tokaj wine material prepared using the technology of infusing the must on the pulp of grapes dried on the vine for 4–5 days that produces high organoleptic indicators. The authors of work [21] indicate that the grape variety and various aging methods used in winemaking are key factors that can affect the chemical and organoleptic profile of wines and allow them to be distinguished from other wines. They studied the chemical and organoleptic characteristics of white wines made from different varieties and using different winemaking technologies. The results of their research showed that wines with a high content of alcohol and polysaccharides, volatile terpene groups, and 2-phenylethanol have floral notes. All this allows us to state that it is advisable to conduct a study on the role of phenolic compounds in the formation of the aroma and taste of wine. In wines in which the highest content of total tannins, total polysaccharides and ethyl esters have fruity tones, the content of lactones and aldehydes is undesirable since they negatively affect the taste and aroma of wine. Wines containing wine esters and flavanols, as well as volatile groups of alcohol acetates, phenolic compounds and aldehydes, have a fruity and herbaceous aroma.

Our review of the literature revealed that in the field of Tokaj wine production, the method of withering grapes on the vine for 4–5 days is used for the first time, they are pre-cleaned of foreign impurities, washed, and then the production technology continues. According to the traditional technology for the production of Tokaj wine, grapes withered by twisting on the vine for 10–12 days are used and fed to the production without washing. And this is not safe from an ecological point of view. At the same time, the percentage of sugar in grapes is artificially increased due to the evaporation of moisture. The percentage of sugar in pre-dried grapes should be within 40–45 %. During this time, the bunches of grapes dry out and fall to the ground, which leads to a decrease in raw materials. In addition, when withering for 10–12 days, the content of such important components as sugars, extractive substances, phenolic compounds, etc. decreases. This is due to the fact that when grapes wither, they are spent on metabolic processes. It is known that when producing sweet dessert wines, the percentage of sugar in the grape varieties used should be higher along with the increased content of extractive substances. This is mainly due to the fact that dessert wines, including Tokaj wines, should contain from 16 to 20 % sugar. However, when grapes wither, despite the increase in the percentage of sugar, especially glucose and fructose, the volume of extractive substances decreases, so the developed technology provides for the use of grape varieties withered only for 4–5 days as raw materials. Raw materials grown in lowland areas are rich in exactly the components required to obtain high-quality wine material. The novelty of the proposed technology is that with the traditional method, alcohol is added to the must to stop the fermentation process, in this case, the taste and smell of ethyl alcohol is preserved for a long time. According to the proposed technology, the must together with the pulp is added to alcohol, in this case, vigorous fermentation occurs, and the assimilation of alcohol is accelerated. The finished wine material and the wine made from it have high organoleptic indicators.

Thus, dessert wines, in particular Tokaj type wines, should be included in the human diet. Analysis of literary data confirms that the methods for characterizing wines, identifying volatile organic compounds, differences in wines depending on the country of origin, the effect of technological methods on the content of phenols and their antioxidant activity have been sufficiently studied. However, there is no data on the effect of grape zoning on the quality of wine materials and changes in the quality indicators of finished products. In addition, no studies have been conducted in the field of preparing Tokaj wine material using withered grapes; there is data on healthy and botrytized grapes.

Therefore, it is important to justify the production of Tokaj wine material using innovative technology applying local raw materials. When developing the technology, it is important to take into account the varietal characteristics and the area of cultivation of raw materials. All this will enable the expansion of the range of dessert sweet wines of the Tokaj type and will satisfy various consumer preferences. And to achieve this goal, a comprehensive analysis of the finished product and the choice of a more appropriate preparation option are necessary.

3. The aim and objectives of the study

The aim of our study is to establish the pattern of change in the quality indicators of the prepared Tokaj-type wine materials depending on the zoning of grape varieties and the choice of the most appropriate preparation option. This will make it possible to prepare an environmentally friendly product with high organoleptic and quality indicators based on local raw materials.

To achieve this goal, the following tasks must be solved:

– to study the chemical components of the Tokaj wine material prepared from white grape varieties Bayan-shirei and Rkatsiteli;

– to study the chemical components of the Tokaj wine material prepared from red grape varieties;

– to choose the appropriate option for preparing the Tokaj wine material.

4. The study materials and methods

4. 1. The object and hypothesis of the study

The object of our study was wine material prepared from white grape varieties widely spread in the territory of the Republic of Azerbaijan – Bayan-shirei, Rkatsiteli, as well as red grape varieties – Cabernet Sauvignon and Madrasa, grown in the Samukh and Goygol regions. In the proposed technology for preparing Tokaj wine material, the amount of alcohol added to the must during fermentation is less. This is due to the fact that must with a high sugar content requires less alcohol. When preparing wine material from the Rkatsiteli grape variety, the alcohol consumption was lower, which is due to the high sugar content. It is important to note here that in the lowland zone, grapes accumulate more sugar and other nutrients. In the wine material prepared according to the third option, the relatively low content of volatile acidity is explained by the large amount of added alcohol, weak and long fermentation process. The amount of methyl alcohol in wine materials prepared according to the third option is also small, which is due to the lower hydrolysis of pectin substances in grapes withered for 4–5 days. It was assumed that in the production of wine material it is advisable to use ripe or slightly withered on the vine for 4–5 days grapes, since it is impossible to obtain high-quality finished products from unripe and withered for 12 days grapes. According to the traditional technology of Tokaj wine production, withered grapes are used, but in this case the amount of such important components as sugars, extractive substances, phenolic compounds, etc. decreases. This is due to the fact that when grapes wither, they are spent on metabolic processes. Raw materials grown in lowland areas are rich in exactly those components that are required to obtain high-quality wine material. With the traditional method, alcohol is added to the must to stop the fermentation process, in this case the taste and smell of ethyl alcohol is preserved for a long time. According to the proposed technology, the must together with the pulp is added to the alcohol, in this case, vigorous fermentation occurs, and the assimilation of alcohol is accelerated. The finished wine material and the wine made from it have high organoleptic indicators.

4. 2. Studied materials

The grape varieties were collected from the vineyards of the winery located in the Goygol district and from the Amin farm located in the Gara-Yeri village of the Samukh district in the Republic of Azerbaijan. A technology has been developed for the production of environmentally friendly sweet dessert wines of the Tokaj type using technical grape varieties grown in the foothills of the Goy-Gol district and the flat zone of the Samukh district. The studies were carried out in 2018–2023 at the Department of Food Engineering and Expertise of the Azerbaijan Technological University, as well as in the laboratory at the Georgian State Agrarian University (Georgia).

4. 3. Methods for studying the quality indicators of Tokaj wine material

The technology for preparing Tokaj wine materials was studied, prepared according to the following options:

Option 1 – preparing Tokaj wine material by adding must with pulp from ripened grapes to alcohol.

Option 2 – preparing Tokaj wine material by adding must with pulp from grapes withered on the vine for 10–12 days to alcohol.

Option 3 – preparing Tokaj wine material by adding must with pulp from grapes withered on the vine for 4–5 days to alcohol.

The following were studied in the prepared wine materials:

– total sugar by the areometric method [22];

– titratable acidity by the direct titration method [22];

– volatile acidity by the potentiometric method [22];

– active acidity by electrometric method [22];

– extractivity by pycnometer based on relative density of wine [22];

– methyl alcohol by photocolorimetric method [23];

– phenolic compounds by chromatograph mass spectrometry [23];

– tasting of finished wine material [24].

During the study, a mathematical-statistical method was used to ensure the accuracy and reliability of the assessment of each determined parameter.

5. Results of scientific and experimental study of the chemical composition of Tokaj-type wine materials prepared according to different options

5. 1. Studying the chemical components of Tokaj wine material prepared from white grape varieties Bayan-shirei and Rkatsiteli

Table 1 illustrates a comparative analysis of the chemical components of Tokaj wine material prepared from white grape varieties Bayan-shirei and Rkatsiteli, grown under the conditions of the Samukh region.

Table 1

Comparative analysis of quality indicators of Tokaj wine materials prepared from white technical grape varieties grown in the Samukh region according to different options

No.	Indicator	Bayan-shirei			Rkatsiteli		
		Option I	Option II	Option III	Option I	Option II	Option III
1	Total grape sugar, g/100 cm^3	21.6	28.4	27.6	28.5	35.2	33.8
2	Alcohol pre-added to must, vol %	12.5	7.9	8.5	7.8	3.3	4.3
3	Consideration of the contraction ratio (k=0,08), vol %	11.5	7.3	7.8	7.2	3.0	3.9
4	Alcohol losses during contraction, in vol %	1.0	0.6	0.7	0.6	0.3	0.4
5	Alcohol yield in wine material, in vol %	3.5	7.7	7.2	7.8	12.0	11.1
6	Alcohol in Tokaj wine material, in vol % (total)	15.0	15.0	15.0	15.0	15.0	15.0
7	Sugar in Tokaj wine material, g/cm^3	16.0	16.0	16.0	16.0	16.0	16.0
8	Titratable acidity, g/dm^3	6.4	4.2	5.7	5.8	3.9	5.6
9	Volatile acidity, g/dm^3	0.58	0.86	0.42	0.60	0.88	0.44
10	Active acidity, g/dm^3	3.1	3.3	3.2	3.2	3.4	3.1
11	Extractivity, g/dm^3	36.2	31.8	35.4	36.1	32.4	37.3
12	Phenolic compounds, g/dm^3	0.61	0.32	0.56	0.64	0.36	0.58
13	Methyl alcohol, g/dm^3	0.21	0.76	0.31	0.24	0.81	0.36
14	Evaluation, points	8.7	8	9.1	9.5	8.3	9.8

From the data in Table 1 it is evident that the total sugar content in the wine material from the Bayan-shirei grape variety grown in the Samukh district is 21.6 %. The sugar content in the wine material prepared from the Rkatsiteli grape variety was 28.5 %. In the wine material prepared from the Bayan-shirei grape variety withered on the vine for 10–12 days, the total sugar content was 28.4 %, and from the Rkatsiteli variety – 35.2 %. In the 3rd variant, the sugar content in the wine material prepared from slightly withered Bayan-shirei grape variety was 27.6 %, from Rkatsiteli it was significantly higher – 33.8 %. As can be seen from Table 1, in wine materials prepared from grape varieties withered for 10–12 days and withered for 4–5 days, there is no significant difference in the percentage of sugar. One of the important tasks of the research work is to reduce the amount of alcohol added to the must during fermentation. Alcohol consumption depending on the percentage of sugar in Tokaj wine material prepared from white grape varieties grown in the Samukh region is shown in Fig. 1.

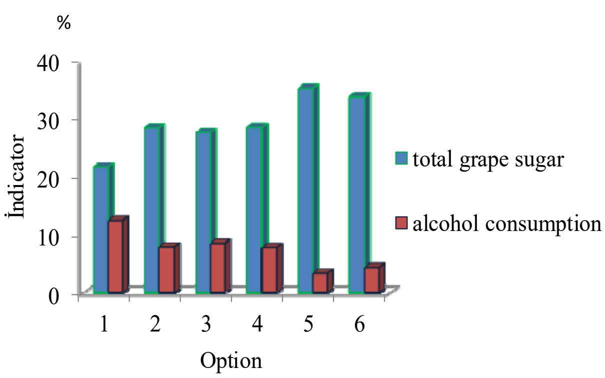

Fig. 1. Alcohol consumption depending on the percentage of sugar in Tokaj wine material prepared from white grape varieties grown in the Samukh region: 1, 2, 3 — Bayan-shirei; 4, 5, 6 — Rkatsiteli; 1, 4 — 1st option; 2, 5 — 2nd option; 3, 6 — 3rd option

Table 1 and Fig. 1 show that must with a lower sugar content requires more alcohol. The calculations showed that 12.5 % alcohol by volume is added in variant 1, 7.9 % by volume in variant 2, and 8.5 % alcohol by volume in variant 3. When making wine from the Rkatsiteli grape variety, 7.8 % alcohol by volume is added in variant 1, and 3.3 % alcohol by volume in variant 2. Comparison of the varieties showed that in all variants, less alcohol is added to the wine material made from the Rkatsiteli grape variety compared to Bayan-shirei. These indicators are described in more detail in Fig. 1. As can be seen from Fig. 1, the lowest alcohol consumption was recorded in the Tokaj type wine material made from the Rkatsiteli grape variety according to variants II and III. If in the 3rd variant 8.5 % alcohol is added to the must obtained from the Bayan-shirei grape variety, then 4.3 % alcohol is added to the must from Rkatsiteli. This indicator is identical to other variants. As a result of must fortification, the alcohol consumption (contraction coefficient) in both variants was much lower compared to the 1st. The specified indicators are given in Table 1. From the data in Table 1 it is clear that for wine materials prepared according to the 1st and 2nd variants from the Rkatsiteli grape variety, less alcohol was used – 3.3÷4.3 vol. % compared to other variants.

From the comparison of the variants, it was found that the acidity of wines made from ripe and slightly withered grape varieties complies with the norm, except for the 2nd variant. According to the instructions, titratable acidity in the production of sweet dessert and Tokaj wines should not be lower than 5 g/dm^3. If in the wine material made from ripe grape varieties, the titratable acidity was 6.4 g/dm^3, then in the 2nd variant this figure was 4.2 g/dm^3, and in the 3rd – 5.7 g/dm^3. From the data in Table 1 it is clear that the titratable acidity was lower in wine materials made according to the 2nd variant from the Rkatsiteli grape variety. If the titratable acidity in the wine material prepared according to the 1st option was 5.8 g/dm^3, then in the wine material prepared according to the second option it was recorded at 3.9 g/dm^3, and according to the 3rd option – 5.6 g/dm^3.

One of the main factors negatively affecting the quality of wine is its high volatile acidity. Volatile acids, especially acetic acid, have a negative effect on the quality of wine and human health. Wine materials prepared from ripened and slightly withered grape varieties have significantly lower volatile acidity than wine materials prepared from grapes withered for 10–12 days.

The relatively high content of volatile acidity in the wine material prepared according to the third option is explained by the large amount of added alcohol, weak and long fermentation process. It is known that volatile acids are mainly oxidation products of ethyl alcohol. Thus, in the wine material prepared according to the third option, the volatile acidity varies within the range of 0.42÷0.44 g/dm^3, and in the wine material prepared according to the second option, it varies within the range of 0.86÷0.88 g/dm^3. A comparison of volatile acids by options is illustrated in Fig. 2.

No significant changes in active acidity were observed in the composition of the prepared wine materials. It is known that the main quality indicator of wine is its extractivity. Extractivity was high in wines prepared from both grape varieties according to the 1st and 3rd options, and significantly less in wines prepared according to the 2nd option. The change in the volume of phenolic compounds was identical to extractivity. The change in phenolic compounds is shown in detail in Fig. 3.

As can be seen from Fig. 3, in wines prepared from the Bayan-shirei grape variety according to the 1st and 3rd variants, the content of phenolic compounds was 0.56 and 0.61 g/cm^3. However, in the second variant, this indicator was much lower and was 0.32 g/cm^3. This indicator was identical to the indicators of wine materials prepared from the Rkatsiteli grape variety.

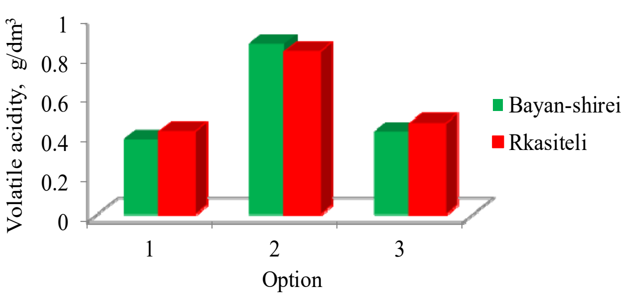

Fig. 2. Quantitative change of volatile acidity in Tokaj wine material prepared from white grape varieties grown in the Samukh region

As was indicated above, during the production of wine materials, such conditions must be created under which the content of methyl alcohol, which has a highly toxic effect, was significantly less than the norm. The presence of methyl alcohol in wine, close to the norm or even exceeding the norm, negatively affects the quality of wine and is very dangerous for human health.

For this purpose, the content of methyl alcohol in the prepared wine materials was studied. The results of the studies showed that wines prepared from both grape varieties according to the 1st and 3rd options contain less methyl alcohol – 0.21÷0.31 g/dm^3, and in wines prepared from both grape varieties according to the 2nd option – 0.76÷0.81 g dm^3 (Fig. 4). The comparatively large amount of methyl alcohol in wine materials prepared according to the second option is due to excessive hydrolysis of pectin substances as a result of long-term withering of grape varieties.

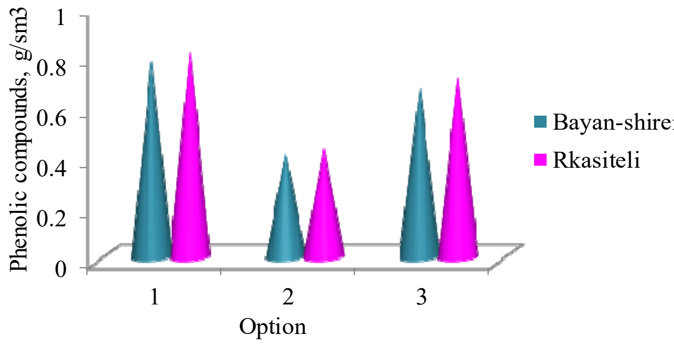

Fig. 3. Quantitative change of phenolic compounds in Tokaj wine material prepared from white grape varieties grown in the Samukh region

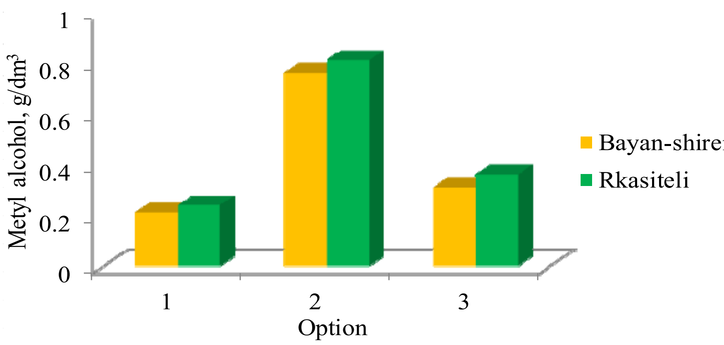

Fig. 4. Quantitative change of methyl alcohol in Tokaj wine material prepared from white grape varieties grown in the Samukh region

Thus, in order to determine the organoleptic indicators, a tasting of Tokaj-type wine materials was also conducted, prepared according to different options from the Bayan-shirei and Rkatsiteli grape varieties grown in the Samukh region.

The prepared wines were tasted according to a 10-point system to determine the most appropriate option [24].

The developed 10-point scale was divided into 5 main indicators, which were assigned the following points: transparency – 0.5; color – 0.5; aroma (smell) – 3; taste – 5, and typicality – 1 (Table 2). The table gives the tasting assessments of the white technical grape variety Rkatsiteli. This variety was selected as a result of a study of the quality indicators of raw materials for the preparation of Tokaj wine material [7].

Table 2

Tasting scores for Tokaj wine made from Rkatsiteli grape variety grown in the Samukh region according to the third option on a 10-point scale, in points

Tasters, people	Indicator					Total
	Transparency	Color	Bouquet	Taste	Typicality	
Maximum value	0.5	0.5	3	5	1	10.0
Taster 1	0.5	0.5	3	4.7	0.9	9.6
Taster 2	0.4	0.5	3	4.8	1	9.7
Taster 3	0.5	0.5	2.9	5	1	9.9
Taster 4	0.5	0.5	3	5	1	10.0
Taster 5	0.5	0.4	2.9	5	1	9.8
Taster 6	0.4	0.5	3	5	0.8	9.7
Taster 7	0.4	0.5	3	5	1	9.9
Average number	0.45	0.49	2.99	4.92	0.95	9.8

The wine material from the Bayan-shirei grape variety prepared according to the 1st option was rated 8.7 points, according to the 2nd option – 8.0 points, and according to the 3rd option – 9.1 points. The wine material prepared from the Rkatsiteli grape variety was rated 9.5 points according to the 1st option, 8.3 points according to the 2nd option, and significantly higher according to the 3rd option – 9.8 points.

From the tasting assessment it turned out that the quality of the wine prepared from the Rkatsiteli grape variety is significantly higher compared to the wine prepared from the Bayan-shirei grape variety. The main reason for the low score of the wine materials prepared according to the 2nd option is associated with the low content of extractive substances and phenolic compounds in them. In the wine materials prepared according to the second option, these indicators were significantly below the norm, and the volume of volatile acids and methyl alcohol was much higher. During the preparation of the wine material, the volume percentage of alcohol added to the must from the Bayan-shirei grape variety was significantly higher than from Rkatsiteli. This is explained by the high content of total sugar in the Rkatsiteli grape variety compared to the Bayan-shirei variety.

During the study, wine material was also prepared from the Bayan-shirei and Rkatsiteli grape varieties grown in the Goygol region according to the above options.

From the data in Tables 3, 4 it became clear that the percentage of sugar in white grape varieties grown in the Samukh region is significantly higher than in the Goygol region. For this reason, more alcohol was used in wine materials prepared from white grape varieties grown in the Goygol region. Wine materials produced in the Goygol region had a low alcohol yield, and the total acidity was significantly higher. Compared with the 2nd option, the volume of volatile acids in the 1st and 3rd options exceeded, and the volume of extractive substances and phenolic compounds was less. Thus, the amount of volatile acidity in wine materials prepared from both grape varieties according to the 2nd option was 0.76÷0.80 g/dm^3, and in the 1st and 3rd options this indicator varied within 0.58÷0.60 g/dm^3. This indicator was identical to the extractivity indicator.

Table 3 shows that the titratable acidity of wine materials prepared according to the 2nd variant from the Bayan-shirei and Rkatsiteli grape varieties grown under the conditions of the Goygol district was below the norm, within 4.4÷4.6 g/dm^3. The reduced content of titratable acidity has a negative effect on the taste, aroma, stability, and fullness of wine. In addition, the volume of extractive substances, which are the main indicator of wine quality, was significantly less in wine materials prepared according to the second variant. The extractivity of wine materials from white grape varieties grown under the conditions of the Goygol district fluctuated within 30.8÷37.1 g/dm^3 for the Bayan-shirei variety and 31.7÷39.2 g/dm^3 for the Rkatsiteli variety. The volume of phenolic compounds with high antioxidant properties was also low in the 2nd variant (0.25÷0.30 g/dm^3) and almost 2 times more in the composition of wines prepared according to the 1st (0.54÷0.62 g/dm^3) and 3rd variants (0.54÷0.58 g/dm^3). A smaller volume of phenolic compounds in the wine material makes it more susceptible to microbiological diseases.

The volume of methyl alcohol in wine materials prepared according to the 2nd variant from grape varieties grown under the conditions of the Goy-Gol region was almost 3 times higher (0.80÷0.84 g/dm^3) than in wine materials prepared according to the 1st (0.21÷0.23 g/dm^3) and 3rd variants (0.36÷0.37 g/dm^3). Thus, the results of the tasting evaluation of wine materials showed that wine materials prepared from Bayan-shirei grape varieties were rated 8.2; 7.8; and 8.7 points, and wine materials from Rkatsiteli grape variety – from 9.0 to 9.2 points. Comparison of indicators by districts confirmed that the quality of wine materials prepared from grape varieties grown in the Samukh district is much better than in the Goy-Gol district.

The results of the research showed that it is more appropriate to prepare Tokaj-type wine material of higher quality, rich in extractive substances, from the Rkatsiteli grape variety grown in the Samukh district.

Table 3

Comparative study of quality indicators of Tokaj wine materials prepared according to different variants from white technical grape varieties grown under the conditions of the Goygol region

No.	Indicator	Bayan-shirei			Rkatsiteli		
		Option I	Option II	Option III	Option I	Option II	Option III
1	Total sugar in grapes, g/100 cm^3	18.5	26.4	25.1	23.4	30.1	28.7
2	Alcohol pre-added to must, vol %	14.6	9.3	10.1	11.3	6.9	7.7
3	Contracting coefficient (k=0.08), in vol %	13.4	8.6	9.3	10.4	6.3	7.1
4	Alcohol losses during contraction, in vol %	1.0	0.7	0.8	0.6	0.6	0.6
5	Alcohol yield in wine material, in vol %	1.6	6.4	5.7	4.6	8.7	7.9
6	Alcohol in Tokaj wine material, in vol % (total)	15.0	15.0	15.0	15.0	15.0	15.0
7	Sugar in Tokaj wine material, g/cm^3	16.0	16.0	16.0	16.0	16.0	16.0
8	Titratable acidity, g/dm^3	7.1	4.6	6.1	6.4	4.4	5.8
9	Volatile acidity, g/dm^3	0.58	0.80	0.60	0.60	0.76	0.53
10	Active acidity, g/dm^3	3.2	3.4	3.3	3.3	3.5	3.2
11	Extractivity, g/dm^3	37.1	30.8	34.2	39.2	31.7	35.6
12	Phenolic compounds, g/dm^3	0.62	0.30	0.54	0.65	0.25	0.58
13	Methyl alcohol, g/dm^3	0.21	0.80	0.37	0.23	0.84	0.36
14	Evaluation, in points	8.2	7.8	8.7	9.0	8.1	9.2

5. 2. Studying the chemical components of Tokaj wine material prepared from red grape varieties

The chemical composition of Tokaj wine material from red grape varieties grown in the Samukh and Goygol districts was also prepared and studied (Tables 4, 5).

Table 4

Comparative study of quality indicators of Tokaj wine materials prepared according to different variants from red technical grape varieties grown under the conditions of Samukh district

No.	Indicator	Cabernet Sauvignon			Madrasa		
		1	2	3	1	2	3
1	Total sugar in grapes, g/100 cm^3	27.8	34.7	33.2	24.3	29.7	28.1
2	Alcohol pre-added to must, vol %	8.3	3.7	4.7	10.6	7.1	8.0
3	Contracting coefficient (k=0.08), in vol %	7.6	3.4	4.3	9.8	6.5	7.4
4	Alcohol losses during contraction, in vol %	0.7	0.3	0.4	0.8	0.6	0.6
5	Alcohol yield in wine material, in vol %	7.4	11.6	10.7	5.2	8.5	7.6
6	Alcohol in Tokaj wine material, in vol % (total)	15.0	15.0	15.0	15.0	15.0	15.0
7	Sugar in Tokaj wine material, g/cm^3	16.0	16.0	16.0	16.0	16.0	16.0
8	Titratable acidity, g/dm^3	6.0	4.1	5.7	6.2	4.0	5.5
9	Volatile acidity, g/dm^3	0.4	0.88	0.51	0.44	0.84	0.54
10	Active acidity, g/dm^3	3.2	3.4	3.3	3.3	3.5	3.2
11	Extractivity, g/dm^3	39.4	32.1	36.5	41.2	33.2	37.4
12	Phenolic compounds, g/dm^3	0.78	0.41	0.68	0.82	0.44	0.72
13	Methyl alcohol, g/dm^3	0.32	0.72	0.41	0.26	0.78	0.42
14	Evaluation, in points	9.3	8.7	9.6	9.2	8.5	9.4

It is clear from the data in Table 4 that the percentage of sugar in ripened grape varieties, those withered on the vine for 10–12 days and those slightly withered for 4–5 days fluctuates within the range of 24.3÷34.7 %. From the comparison of varieties, it became known that the percentage of sugar in the Cabernet Sauvignon grape variety is significantly higher than in the Madrasa grape variety. It is clear from the data in Table 4 that 3.7 % vol of alcohol is preliminarily added to the must from the Cabernet Sauvignon grape variety withered on the vine for 10–12 days and grown under the conditions of the Samukh district, and 7.1 % vol of alcohol is added to the must obtained from the Madrasa grape variety. To the must from slightly withered (for 4–5 days) Cabernet Sauvignon grape variety it is necessary to add 4.7 vol. % alcohol, and to the must from Madras 8.0 vol. % and continue the fermentation process. Taking into account the contraction coefficient during fermentation of the must obtained from ripe Cabernet Sauvignon grape varieties, 7.4 vol. % alcohol is obtained, in the 2nd variant – 11.6 vol. %, in the third variant – 10.7 vol. %, and the fermentation process stops. And this contributes to the formation of 15 % alcohol and 16 % sugar in the Tokaj wine material. In the must from the Madras grape variety, the fermentation process naturally stops after the formation of 5.2 % alcohol in the 1st variant, 8.5 % in the 2nd variant and 7.6 % alcohol in the 3rd variant. One of the main factors affecting the quality of wine is the excessive formation of natural alcohol during fermentation.

Table 5 shows that the Cabernet Sauvignon and Madrasa grape varieties grown under the conditions of the Goygol region contain significantly less total sugar than those grown in the Samukh region. When preparing sweet dessert wine material of the Tokaj type, grape varieties with a higher sugar content should be used.

Table 5

Comparative study of quality indicators of Tokaj wine materials prepared according to different variants from red technical grape varieties grown under the conditions of the Goygol region

No.	Indicator	Cabernet Sauvignon			Madrasa		
		1	2	3	1	2	3
1	Total sugar in grapes, g/100 cm^3	23.8	29.1	27.8	21.5	27.5	26.1
2	Alcohol pre-added to must, vol %	11.1	7.5	8.3	12.6	8.6	9.4
3	Contracting coefficient (k=0.08), in vol %	10.2	6.9	7.6	11.6	7.9	8.7
4	Alcohol losses during contraction, in vol %	0.7	0.6	0.7	0.8	0.7	0.7
5	Alcohol yield in wine material, in vol %	4.8	8.1	7.4	3.4	7.1	6.3
6	Alcohol in Tokaj wine material, in vol % (total)	15.0	15.0	15.0	15.0	15.0	15.0
7	Sugar in Tokaj wine material, g/cm^3	16.0	16.0	16.0	16.0	16.0	16.0
8	Titratable acidity, g/dm^3	6.5	4.5	5.6	6.8	4.7	5.7
9	Volatile acidity, g/dm^3	0.36	0.72	0.56	0.34	0.70	0.50
10	Active acidity, g/dm^3	3.2	3.4	3.4	3.3	3.5	3.3
11	Extractivity, g/dm^3	40.4	33.2	37.3	42.1	33.7	37.5
12	Phenolic compounds, g/dm^3	0.84	0.45	0.74	0.90	0.47	0.70
13	Methyl alcohol, g/dm^3	0.34	0.74	0.39	0.36	0.82	0.38
14	Evaluation, in points	8.5	8.4	8.9	8.6	8.5	9.1

The Cabernet Sauvignon grape variety grown in the Samukh district has a higher sugar content (27.8÷33.2 g/dm^3) than in Madrasa (24.3÷29.7 g/dm^3). It is important to note that when preparing sweet dessert wine, a technological mode should be chosen so that it contains at least 16 % of natural sugar, and less alcohol is used in the fortification process. From this point of view, it is more effective to use grape varieties grown in the Samukh district for the preparation of Tokaj sweet dessert wine. To prepare Tokaj wine material from ripened Cabernet Sauvignon grapes according to the condition, it is necessary to pre-add 8.3 vol. % alcohol to the must, and when preparing it from the Madrasa grape variety – 10.6 vol. %. Under the conditions of the Goygol district, the volume of alcohol varies within 14.6–12.6 vol %, respectively (Table 4).

It is evident from the data in Tables 4 and 5 that the content of natural alcohol in wines prepared from the Cabernet Sauvignon grape variety in both districts is significantly higher than in the wine material obtained from the Madrasa grape variety.

The volume of titratable and volatile acidity in the composition of wine materials prepared under the conditions of the Samukh district, with the exception of the 2nd option, corresponds to the norm. As can be seen from Table 4, the volume of volatile acidity in the wine material prepared from both grape varieties according to the 2nd option

(0.70÷0.72 g/dm^3) was almost 2 times higher. In the first and second options, the volatile acidity was below the norm, and the titratable acidity in the second option was significantly less (4.5÷4.7 g/dm^3). This indicator has a negative effect on the quality of wine. From the comparison of the indicators by regions it was found that in wines made from Cabernet Sauvignon and Madrasa grape varieties grown under the conditions of the Goy-Gol region, titratable acidity according to the 2nd variant is lower, and volatile acidity is significantly higher. The volume of extractive substances in the 1st and 3rd variants was high in wines made in both regions, and lower in the 2nd variant. Thus, under the conditions of the Samukh region, the volume of extractive substances in the 2nd variant was 32.1÷33.2 g/dm^3, and in the other variants this indicator fluctuated within 36.5÷41.2 g/dm^3.

In wine materials prepared from grape varieties grown under the conditions of the Goygol district, the extractive substances in the second variant varied within 33.2÷33.7 g/dm^3, and in the other variants – 37.3÷42.1 g/dm^3.

The content of phenolic compounds in wines prepared under the conditions of the Samukh district changed within 0.41÷0.82 g/cm^3. Under the conditions of the Goygol district, the content of phenolic compounds was slightly higher, compared to the Samukh district – 0.45÷0.90 g/dm^3 (Table 4). From Table 4 it is clear that there are fewer phenolic compounds in wine materials prepared from grape varieties grown in the Samukh district in the second variant, which is explained by a more intense respiration process in wilted grape varieties.

The data in Tables 4, 5 show that the methyl alcohol content in wines made from grapes dried for 10–12 days was significantly higher than in other wines. Thus, in wines made from Cabernet Sauvignon and Madrasa grape varieties grown in the Samukh region according to the 2nd variant, 0.72–0.78 g/dm^3 was recorded, and in the other variants within 0.32÷0.42 g/dm^3. Wines made from red grape varieties in the Samukh and Goygol regions were also tasted. Table 6 gives the tasting assessments of wine material made from the red Madrasa grape variety grown in the Goygol region.

Table 6

Tasting evaluation of wine material prepared from the red grape variety Madrasa, grown under the conditions of the Goygol region according to the third option on a 10-point system, in points

Tasters, person	Indicator					Total
	Transparency	Color	Bouquet	Taste	Typicality	
Maximum value	0.5	0.5	3	5	1	10.0
Taster 1	0.5	0.5	3	4.0	0.9	8.9
Taster 2	0.5	0.5	2	5	1	9.0
Taster 3	0.5	0.4	2.9	4.3	1	9.1
Taster 4	0.4	0.4	2.8	4.7	1	9.3
Taster 5	0.5	0.5	2.7	4.7	1	9.2
Taster 6	0.5	0.5	3	4.2	1	9.2
Taster 7	0.5	0.5	2.5	4.5	1	9.0
Average number	~0.5	0.5	2.7	4.5	0.9	9.1

As a result of the research, it was established that wines made from the Cabernet Sauvignon grape variety grown in the Samukh district according to the 1st (9.3 points) and 3rd options (9.6 points) received a high rating compared to other wines. All data obtained as a result of measurements using statistical processing of experimental data were recorded at a certain level with the reliability of the obtained estimates, taking the confidence probability value equal to 0.9 at a significance level of ε=2.13 using the variance analysis method.

5. 3. Selecting the appropriate option for preparing wine material

The reliability of our results was checked by constructing a mathematical model in several stages. The main goal was to clarify, select the correct solution to the problem, determine the quality indicators of grapes and finished wine material, construct a mathematical relationship and a mathematical model for the options, and solve these problems using computer technology. The Microsoft Office Excel 2010 computer program was used to generate reports and construct graphical dependences [25].

One of the main quality indicators of wine materials prepared from grape varieties is a high percentage of sugar. The values for the white technical grape variety Rkatsiteli are presented below.

When determining sugar in Rkatsiteli grapes by conducting n parallel analyses, the results x_1, x_2, $x_3 \ldots x_n$ were obtained. Then the average numerical value of these results was calculated using the following formula:

$$x_{or} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i, \qquad (1)$$

where n is the number of analyses.

The calculation was carried out based on the volume of total sugar in the white Rkatsiteli grape variety grown in the Samukh region for the preparation of Tokaj-type wine material. The analysis of the quantitative determination of total sugar in the Rkatsiteli grape variety by variants was carried out with a repetition of n=10.

The results of the average value of total sugar by variants are listed in Table 7.

Table 7

The volume of total sugar in the Rkatsiteli grape variety grown in the Samukh region, used for the preparation of Tokaj-type wine material

Measurement	White technical grape variety Rkatsiteli		
	Amount of total grape sugar used in different variants of preparation of Tokaj wine material, g/100 cm^3		
	I	II	III
x_1	28.9	35.3	33.9
x_2	28.6	35.3	34
x_3	28.4	35.4	34.1
x_4	28.5	35.1	33.9
x_5	28.2	35.2	33.8
x_6	28.4	35.4	33.8
x_7	28.3	35.1	33.7
x_8	28.1	35.2	33.7
x_9	28.4	35.1	33.6
x_{10}	28.9	35.1	33.6
x_{cp}	28.5	35.2	33.8

The spread of the average sugar percentage values by variants relative to the overall average value is affected by both the change in the required volume of sugar and random factors. Thus, the overall sample dispersion is divided into two parts: the factorial part $S_{ф}^2$ and the residual part $S_{ост}^2$. The factorial part refers to the intervariant dispersion, and the residual part refers to the intravariant dispersion.

The number of research variants is p=3, the number of measurements in each variant is n=10.

Table 8 gives the results of calculating the average value of total sugar in Rkatsiteli grapes X_{cp}, used to prepare wine material for different variants.

Table 8

Total average sugar value of Rkatsiteli grapes used for the preparation of wine material in different variants, g/100 cm^3

Measurement number	Total average value of grape sugar used for the preparation of wine material according to option I	Total average value of grape sugar used for the preparation of wine material according to option II	Total average value of grape sugar used for the preparation of wine material according to option III
	x_1^2	x_2^2	x_3^2
1	835.21	1246.09	1149.21
2	817.96	1246.09	1156.0
3	806.56	1253.16	1162.81
4	812.25	1232.01	1149.21
5	795.24	1239.04	1142.44
6	806.56	1253.16	1142.44
7	800.89	1232.01	1135.69
8	789.61	1239.04	1135.69
9	806.56	1232.01	1128.96
10	835.21	1232.01	1128.96
∑	8106.05	12404.62	11431.41

Using the data from Table 8, the overall average value S_t is calculated using formula (2):

$$S_{об} = \sum x_{ij}^2 - p \cdot n \cdot x_{or}^2. \quad (2)$$

The total sum of squares of deviations of variants from the overall average factor is calculated using the formula:

$$S_{ф} = n \cdot \sum_{i=1}^{n} x_{cpj}^2 - x_{cp}^2. \quad (3)$$

Next, the residual part of the total sample variance is calculated using the formula:

$$S = S_t - S_f. \quad (4)$$

Factor variance is calculated according to the formula:

$$S_{ф}^2 = \frac{S_{ф}}{p-1}. \quad (5)$$

The residual variance is calculated using the formula:

$$S_{ост}^2 = \frac{S_{ост}}{p \cdot (n-1)}. \quad (6)$$

Next, the observation factor is calculated and compared with the value of the distribution function at the critical point f_{kr} corresponding to the selected significance level α=0.05 [9].

The observation factor is calculated using the formula:

$$f_{ост} = \frac{S_{ф}^2}{S_{ост}^2}. \quad (7)$$

For the significance level α=0.05 and the degrees of freedom numbers 2 and 27, the observation factor is found from the Fisher-Snedecor distribution table:

$$f_{kr}(0.05; 2; 27) = 3.37.$$

Since for the Rkatsiteli grape variety $f_{ob} > f_{kr}$ (3336.32>3.37), the null hypothesis about the significant influence of factors on the total sugar content of grapes is accepted. As a result of calculations using the least squares method, a multiple regression equation was obtained:

$$Y = -0.00225 - 0.5401X_1 + +0.2643X_2 + 0.00585X_3, \quad (8)$$

where X_1 is volatile acidity, X_2 is extract, X_3 is sugar content in grapes (Table 9).

An economic interpretation of the parameters of model (8) is possible: an increase in X_1 by 1 unit leads to a decrease in Y by an average of 0.54 units; an increase in X_2 by 1 unit leads to an increase in Y by an average of 0.264 units; an increase in X_3 by 1 unit leads to an increase in Y by an average of 0.00585 units. The statistical significance of the equation was tested using the coefficient of determination and Fisher's criterion. It was found that in the case under study, 100 % of the total variability in Y is explained by changes in the factors X_j.

Having checked the statistical significance of the regression equation using the coefficient of determination and Fisher's criterion, it was concluded that 99.99 % of the estimated score of the wine material in the study is explained by the quantitative change in sugar in grapes, volatile acidity, and extract in the wine material. Compared to the second option, the wine material prepared according to the first and third options from the Rkatsiteli grape variety withered for 4–5 days, grown under the conditions of the Samukh district, is rich in sugar and extractive substances, it is considered the most appropriate. Compared to the third option, in the second option, the percentage of sugar in the wine material was slightly higher. However, the quality indicators of the wine materials prepared according to the third option exceeded the indicators of the wine material prepared according to the second option. This is due to the fact that, compared to the third option, the wine materials prepared according to the second option have a small volume of extractive substances, the content of highly toxic volatile acids (especially acetic acid) and methyl alcohol is twice as high. In addition, the wine materials prepared according to the second option have a lower content of phenolic compounds with antioxidant and antimicrobial properties, while the wine materials prepared according to the third option have a higher content (Table 1). Therefore, the wine material prepared from the Rkatsiteli grape variety dried for 4–5 days, grown in the Samukh region, was rated 9.8 points compared to other prepared wine materials (Fig. 5).

Table 9

Description of input variables

Option	Volatile acidity, X_1	Extract, X_2	Sugar content in grapes, X_3
I	0.4	36.1	28.5
II	0.88	32.4	35.2
III	0.44	37.3	33.2

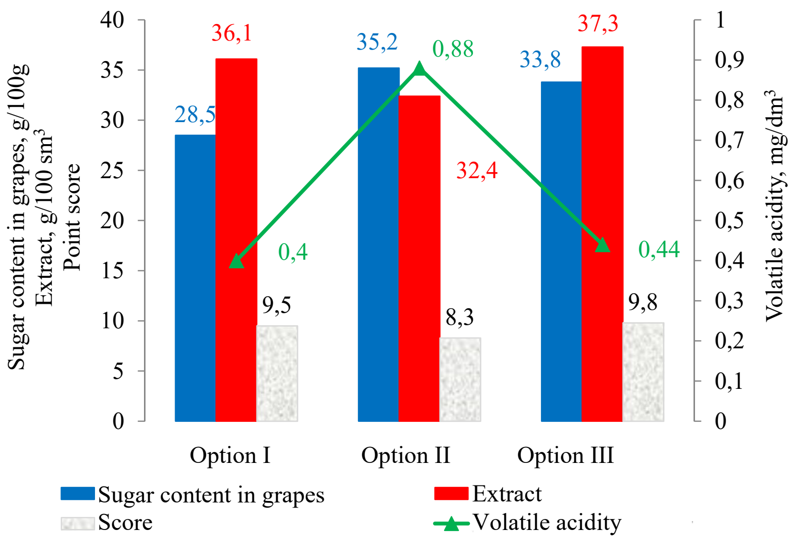

Fig. 5. Diagram of the dependence of the tasting evaluation of wine material prepared from the Rkatsiteli grape variety on volatile acidity, extract, and sugar content

6. Discussion of the experimental results from a comparative study of the chemical composition of Tokaj-type wine materials

The preparation of high-quality Tokaj wine requires reasonable development of a technology for the preparation of wine material using local raw materials rich in nutrients. This can be achieved if wine material is produced from local raw materials taking into account varietal characteristics and the place of zoning and rich in chemical composition using innovative technology [10, 26].

To prepare Tokaj wine materials, bunches of grapes withered on the vine for more than 12 days or botrytized berries are usually used [27, 28]. During this time, the sugar content in the berries artificially reaches 40 %. However, during this time, many bunches dry out and fall to the ground, and the content of components of the chemical composition of the berries decreases due to their use in metabolic processes. To prepare wine material according to the second option, grapes withered on the vine for 4–5 days are used. This time is enough to achieve sugar and nutrients in an optimal ratio. Continuing withering is not advisable, as enzyme activity increases and important nutritional components of the berries decompose [29, 30]. Pre-fermentation methods used in white wine production, such as skin maceration or grape pressing, can directly affect the quality of the final product. There is a constant search for methods that can improve sensory characteristics such as aroma and phenolic composition of white wines [27]. Therefore, the proposed option is considered one of such methods, in which the addition of must to alcohol promotes a natural cessation of fermentation, saturation with phenolic and extractive substances.

From the analysis of Table 1 it became clear that the total sugar content in the wine material prepared according to the first option from the Bayan-shirei grape variety grown in the Samukh district was lower than in Rkatsiteli. In the wine material prepared according to the second option, the sugar content was again higher in the Rkatsiteli grape variety (Fig. 1). This pattern was also observed in the third option.

There is no significant difference in the percentage of sugar in grape varieties withered for 10–12 days and withered for 4–5 days (Table 1).

As noted above, reducing the volume of alcohol added to the must during fermentation is an important task of the research work. Research has shown that more alcohol is required for must with a lower sugar content. The volume of alcohol added to the wine material from the white grape variety Bayan-shirei, prepared according to the 1st option was 12.5 vol. %, according to the 2nd option – 7.9 vol. %, and according to the 3rd option – 8.5 vol. %. When preparing wine material from the Rkatsiteli grape variety, the alcohol consumption was lower, which is due to the high sugar content. It is important to note here that in the lowland zone, grapes accumulate more sugar and other nutrients [31, 32]. From the comparison of varieties, it became known that in all options, less alcohol is added to the wine material prepared from the Rkatsiteli grape variety compared to Bayan-shirei. The analysis of Fig. 1 shows that the lowest alcohol consumption was recorded in the Tokaj type wine material prepared from the Rkatsiteli grape variety according to options II and III. Thus, in the 3rd variant, 8.5 % alcohol is added to the must obtained from the Bayan-shirei grape variety, and 4.3 % alcohol is added to the must from Rkatsiteli. This indicator is identical to other variants. As a result of the must fortification, the alcohol consumption (contraction coefficient) in both variants was much lower compared to the 1st (Table 1).

According to the instructions, titratable acidity in the production of sweet dessert and Tokaj wines should not be lower than 5 g/dm^3. In the wine material prepared from ripened Bayan-shirei grape varieties, titratable acidity was 6.4 g/dm^3, while in the 2nd variant this figure was 4.2 g/dm^3, and in the 3rd – 5.7 g/dm^3. However, titratable acidity was lower in the wine materials prepared according to the 2nd variant from the Rkatsiteli grape variety and was 5.8 g/dm^3 in the wine material prepared according to the 1st variant, 3.9 g/dm^3 according to the second variant, and 5.6 g/dm^3 according to the 3rd variant. One of the main factors negatively affecting the quality of wine is its high volatile acidity. Volatile acids, especially acetic acid, have a negative effect on the quality of wine and human health [33, 34]. Volatile acidity in wine occurs when the fermentation process is not carried out correctly [35]. With prolonged fermentation and reduced immunity of the grapes, volatile acidity increases. This is due to the composition of the grapes, which is caused by a lack of nutrients, mainly antioxidants, vitamins, and other biologically active substances [36, 37]. As studies have shown, wine materials prepared from ripe and slightly withered grape varieties have significantly lower volatile acidity than wine materials prepared from grapes withered for 10–12 days (Fig. 2). The relatively high content of volatile acidity in the wine material prepared according to the third option is explained by the large volume of added alcohol and a weak and long fermentation process. It is known that volatile acids are mainly oxidation products of ethyl alcohol [38]. Thus, in the wine material prepared according to the third option, the volatile acidity varies within the range of $0.42 \div 0.44$ g/dm^3, and in the wine material prepared according to the second option, it varies within the range of $0.86 \div 0.88$ g/dm^3 (Fig. 2).

From the analysis of Fig. 3, it can be concluded that the wines prepared from the Bayan-shirei grape variety according to the 1st and 3rd variants have a higher content of phenolic compounds compared to the second, which are 0.56, 0.61 g/cm^3 and 0.32 g/cm^3, respectively. This indicator was identical to the indicators of wine materials prepared from the Rkatsiteli grape variety (Fig. 3).

As indicated above, during the production of wine materials, such conditions must be created under which the content of methyl alcohol, which has a highly toxic effect, is significantly less than the norm. The presence of methyl alcohol in wine, close to the norm or even exceeding the norm, negatively affects the quality of wine and is very dangerous for human health.

It is known from literary data that food products with a high content of methyl alcohol negatively affect vision. Methyl alcohol has a toxic (poisonous) effect and is not a fermentation product, but a product of hydrolysis of pectin substances. Depending on the grape variety, soil and climate conditions, processing technology and other factors, it may contain more or less of it [39–41].

The comparatively large volume of methyl alcohol in wine materials prepared according to the second option is due to excessive hydrolysis of pectin substances as a result of prolonged withering of grape varieties (Fig. 4).

The tasting evaluation showed that the quality of wine made from the Rkatsiteli grape variety is significantly higher compared to wine made from the Bayan-shirei grape variety. The main reason for the low score of wine materials made according to the 2nd option compared to other options is due to the fact that the content of extractive substances and phenolic compounds in them is significantly less than the norm, and volatile acids and methyl alcohol are much higher.

During the preparation of wine material, the volume percentage of alcohol added to the must from the Bayan-shirei grape variety was significantly higher than from Rkatsiteli, which is due to the high content of total sugar in the Rkatsiteli grape variety compared to the Bayan-shirei variety (Table 1).

During the study, wine material was also prepared from the Bayan-shirei and Rkatsiteli grape varieties grown in the Goygol district according to the above options. The analyses showed that the percentage of sugar in wine materials prepared from white grape varieties grown in the Samukh district was significantly higher than in the Goygol district. For this reason, more alcohol was used in wine materials prepared from white grape varieties grown in the Goygol district (Table 3).

Wine materials produced in the Goygol district had a low alcohol yield, and the total acidity was significantly higher. Compared with the 2nd option, the volume of volatile acids in the 1st and 3rd options exceeded, and the volume of extractive substances and phenolic compounds was less. Thus, the volume of volatile acidity in wine materials prepared from both grape varieties according to the 2nd option was $0.76 \div 0.80$ g/dm^3. In the 1st and 3rd options, this indicator varied within $0.58 \div 0.60$ g/dm^3. The titratable acidity of wine materials prepared according to the 2nd variant from the Bayan-shirei and Rkatsiteli grape varieties grown under the conditions of the Gey-Gol region was below the norm and amounted to $4.4 \div 4.6$ g/dm^3. A reduced titratable acidity content has a negative effect on the taste, aroma, stability, and fullness of wine [42].

In addition, the volume of extractive substances, which are the main indicator of wine quality, was significantly lower in wine materials prepared according to the second option. The volume of phenolic compounds with high antioxidant properties was also low in the 2nd option and almost 2 times higher in the composition of wines prepared according to the 1st and 3rd options. A smaller volume of phenolic compounds in wine material makes it more susceptible to microbiological diseases [43]. Phenolic compounds mainly affect the fullness of wine, enrichment with aromatic substances, long-term high-quality storage, as well as slowing down or stopping the activity of oxidative enzymes [4]. The volume of methyl alcohol in wine materials prepared according to the 2nd option from grape varieties grown under the conditions of the Goy-Gol region was almost 3 times higher than in wine materials prepared according to the 1st and 3rd options. Comparison of the indicators by regions confirmed that the quality of wine materials prepared from grape varieties grown in the Samukh region is much better than in the Goy-Gol region (Table 3).

Based on the results of research and tasting assessment, it was found that it is more expedient to prepare Tokaj-type wine material of higher quality, rich in extractive substances, from the Rkatsiteli grape variety grown in the Samukh region (Table 2).

From the analysis of the data in Table 2, it became clear that the percentage of sugar in ripened, withered on the vine for 10–12 days and slightly withered for 4–5 days grape varieties fluctuates within $24.3 \div 34.7$ %. From the comparison of varieties, it became known that the percentage of sugar in the Cabernet Sauvignon grape variety is significantly higher than in the Madrasa grape variety.

Calculations of the added alcohol showed that 3.7 vol % alcohol is preliminarily added to the must from the Cabernet Sauvignon grape variety withered on the vine for 10–12 days and grown in the Samukh district. Whereas 7.1 vol % alcohol is added to the must obtained from the Madrasa grape variety. 4.7 vol % alcohol must be added to the must from the slightly withered (for 4–5 days) Cabernet Sauvignon grape variety, and 8.0 vol % to the must from Madras, and the fermentation process is continued (Table 4). Taking into account the contraction coefficient during fermentation of the must obtained from ripened Cabernet Sauvignon grape varieties, 7.4 vol % alcohol is obtained, in the 2nd variant – 11.6 vol %, in the third variant – 10.7 vol %, and the fermentation process stops. And this contributes to the formation of 15 % alcohol and 16 % sugar in the Tokaj wine material. It is important to note that when preparing sweet dessert wine, a technological mode should be chosen so that it contains at least 16 % natural sugar, and less alcohol is used in the fortification process. From this point of view, it is more effective to use grape varieties grown in the Samukh region for the preparation of Tokaj sweet dessert wine. To prepare Tokaj wine material from ripened Cabernet Sauvignon grapes according to the condition, it is necessary to pre-add 8.3 vol. % alcohol to the must, and when preparing it from the Madras grape variety – 10.6 vol. %.

Under the conditions of the Goygol region, the volume of alcohol varies within 14.6–12.6 vol %, respectively (Table 5).

The content of natural alcohol in wines made from the Cabernet Sauvignon grape variety in both regions is significantly higher than in wine material obtained from the Madras grape variety. High formation of natural alcohol in wine materials means that less alcohol is added to the grape must in advance, which not only has a good effect on the quality of the finished wine material, but also allows for significant savings in alcohol. That is also cost-effective.

The volume of titratable and volatile acidity in the composition of wine materials prepared under the conditions of the Samukh district, with the exception of the 2nd option, corresponds to the norm. The analysis of Table 5 shows that the volume of volatile acidity in the wine material prepared from both grape varieties according to the 2nd option is almost 2 times higher than according to the other options, and titratable acidity is significantly lower. This indicator has a negative effect on the quality of wine. From a comparison of the indicators by regions, it was found that in wines prepared from Cabernet Sauvignon and Madrasa grape varieties grown under the conditions of the Goy-Gol district, the titratable acidity according to the 2nd option is lower, and the volatile acidity is significantly higher. The volume of extractive substances in the 1st and 3rd options was high in wines prepared in both regions, and lower in the 2nd option. Thus, under the conditions of the Samukh district, the volume of extractive substances in the 2nd variant was 32.1÷33.2 g/dm^3, and in the other variants this indicator fluctuated within the range of 36.5÷41.2 g/dm^3.

The content of phenolic compounds in wines prepared under the conditions of the Samukh district changed within the range of 0.41÷0.82 g/cm^3. Under the conditions of the Goy-Gol district, the content of phenolic compounds was slightly higher compared to the Samukh district – 0.45÷0.90 g/dm^3 (Table 5). From Table 5 it is evident that there are fewer phenolic compounds in wine materials prepared from grape varieties cultivated in the Samukh district in the second variant, which is explained by a more intense respiration process in dried grape varieties [45–47].

The data in Tables 4, 5 show that the methyl alcohol content in wines made from grapes dried for 10–12 days was significantly higher than in other wines. Thus, in wines made from Cabernet Sauvignon and Madrasa grape varieties grown in the Samukh region according to the 2nd option, 0.72–0.78 g/dm^3 was recorded, and in other options within 0.32÷0.42 g/dm^3.

Wines made from red grape varieties in the Samukh and Goygol regions were also tasted.

As a result of the research, it was found that wines made from Cabernet Sauvignon grape varieties grown in the Samukh region according to the 1st and 3rd options received a high rating compared to other wines.

It should be noted that the correct choice of variety and growing conditions, as well as successful practical application of raw materials in the future will stimulate the improvement of the corresponding technological parameters of Tokaj wine production to achieve greater preservation of nutritional components.

A high-quality and competitive product is an important indicator. The process parameters should be improved taking into account the use of raw materials of high nutritional value to limit the added foreign components. Such diversity will further expand the range of sweet dessert wines.

The development of new technological methods using local grape varieties rich in nutrients, especially sugars, extractive substances and phenolic compounds will modernize existing technologies for providing the population with environmentally friendly products.

To prepare environmentally friendly Tokaj wine material according to the proposed option, special equipment for cleaning, washing, and drying grapes is required, which large wineries are equipped with. However, it should be noted that at medium and small enterprises, installing such equipment requires additional labor and costs, which ultimately affects the price of the finished product. Compared to other goods, organically clean products are sold expensively in the market. Such shortcomings are inherent in this study as well. However, as statistics show, in the near future the population's demand for environmentally friendly products will increase, and products of unknown origin will be replaced by new organically clean products in the sales market.

7. Conclusions

1. It was found that the total sugar content in the Bayan-shirei grape variety grown in the Samukh district was 21.6 %, while this figure was 28.5 % for the Rkatsiteli grape variety. When the Bayan-shirei variety was withered on the vine for 10–12 days, the total sugar content was 28.4 %, while for the Rkatsiteli variety it was 35.2 %. In the 3rd variant, the sugar content in the slightly withered Bayan-shirei grape variety was 27.6 %, while for Rkatsiteli it was significantly higher – 33.8 %. From the calculations it became clear that in the 1st variant, 12.5 vol. % alcohol is added to the wine material, in the 2nd variant – 7.9 vol. %, and in the 3rd variant – 8.5 vol. % alcohol. When preparing wine from the Rkatsiteli grape variety according to the 1st option, 7.8 vol. % is added, according to the 2nd option – 3.3 vol. % of alcohol. To prepare wine material according to the 3rd option, 8.5 % of alcohol is added to the must obtained from the Bayan-shirei grape variety, and 4.3 % of alcohol is added to the must from Rkatsiteli. For wine materials prepared according to the 1st and 2nd options from the Rkatsiteli grape variety, less alcohol is consumed – 3.3÷4.3 vol. % compared to other options. The acidity of wines prepared from ripened and slightly withered grape varieties corresponded to the norm, except for the 2nd option. In the wine material prepared from ripe grape varieties, the titratable acidity was 6.4 g/dm^3, in the 2nd variant this figure was 4.2 g/dm^3, and in the 3rd – 5.7 g/dm^3. The titratable acidity in the wine material prepared according to the 1st variant was 5.8 g/dm^3, and in the wine material prepared according to the second variant it was recorded at 3.9 g/dm^3, and according to the 3rd variant – 5.6 g/dm^3. In the wine material prepared according to the third variant, the volatile acidity varied within the range of 0.42÷0.44 g/dm^3, and in the wine material prepared according to the second variant within the range of – 0.86÷0.88 g/dm^3.

In the wine material prepared according to the third variant, the volatile acidity varied within 0.42÷0.44 g/dm^3, and in the wine material prepared according to the second variant it changed within 0.86÷0.88 g/dm^3. In the wines prepared from the Bayan-shirei grape variety according to the 1st and 3rd variants, the content of phenolic compounds was 0.56 and 0.61 g/cm^3, while this indicator in the second variant was equal to 0.32 g/cm^3. The wines prepared from both grape varieties according to the 1st and 3rd variants contained less methyl alcohol – 0.21÷0.31 g/dm^3, and in the wines prepared from both grape varieties according to the 2nd variant, the content of methyl alcohol was equal to 0.76÷0.81 g/dm^3. The wine material from the Bayan-shirei grape variety grown in the Samukh district, prepared according to the 1st option was rated at 8.7 points, according to the 2nd option – 8.0 points, and according to the 3rd option – 9.1 points. The wine material prepared from the Rkatsiteli grape variety, according to the 1st option, was rated at 9.5 points, according to the 2nd option – 8.3 points, and according to the 3rd option – significantly higher – 9.8 points.

The titratable acidity of the wine materials prepared according to the 2nd option from the Bayan-shirei and Rkatsiteli grape varieties grown in the Gey-Gol district was below the norm, within 4.4÷4.6 g/dm^3. The extractivity of wine materials from white grape varieties grown under the conditions of the Goygol region varied within the range of 30.8÷37.1 g/dm^3 for the Bayan-shirei variety and 31.7÷39.2 g/dm^3 for the Rkatsiteli variety. The volume of phenolic compounds was also low in the 2nd variant (0.25÷0.30 g/dm^3) and almost 2 times more in the composition of wines prepared according to the 1st (0.54÷0.62 g/dm^3) and 3rd variants (0.54÷0.58 g/dm^3). The volume of methyl alcohol in wine materials prepared according to the 2nd option from grape varieties grown under the conditions of the Goy-Gol district was almost 3 times higher (0.80÷0.84 g/dm^3) than in wine materials prepared according to the 1st (0.21÷0.23 g/dm^3) and 3rd options (0.36÷0.37 g/dm^3). Tasting evaluation of wine materials showed that wine materials prepared from Bayan-shirei grape varieties were rated 8.2; 7.8, and 8.7 points, and wine materials from Rkatsiteli grape variety – from 9.0 to 9.2 points. Comparison of indicators by districts confirmed that the quality of wine materials prepared from grape varieties grown in the Samukh district is much better than in the Goy-Gol district. Based on the research results, it was established that it is more appropriate to prepare Tokaj-type wine material of higher quality, rich in extractive substances, from the Rkatsiteli grape variety grown in the Samukh region.

2. It has been established that the percentage of sugar in ripened grape varieties, those withered on the vine for 10–12 days and those slightly withered for 4–5 days, fluctuates within the range of 24.3÷34.7 %. 3.7 % alcohol is preliminarily added to the must from the Cabernet Sauvignon grape variety withered on the vine for 10–12 days and grown under the conditions of the Samukh district, and 7.1 % alcohol is added to the must obtained from the Madrasa grape variety. 4.7 % alcohol must be added to the must from the slightly withered (for 4–5 days) Cabernet Sauvignon grape variety, and 8.0 to the must from Madras. Taking into account the contraction coefficient during fermentation of the must obtained from ripened Cabernet Sauvignon grape varieties, 7.4 vol. % alcohol is obtained, in the 2nd variant – 11.6 vol. %, in the third variant – 10.7 vol. %. In the must from the Madrasa grape variety, the fermentation process naturally stops after the formation of 5.2 % alcohol in the 1st variant, 8.5 % in the 2nd variant, and 7.6 % alcohol in the 3rd variant. The sugar content is higher in the Cabernet Sauvignon grape variety (27.8÷33.2 g/dm^3), grown under the conditions of the Samukh district, than in Madrasa (24.3÷29.7 g/dm^3). To prepare Tokaj wine material from ripened Cabernet Sauvignon grapes according to the condition, it is necessary to pre-add 8.3 vol. % alcohol to the must, and when preparing it from Madrasa grapes – 10.6 vol. %. Under the conditions of the Goygol district, the volume of alcohol varies within 14.6–12.6 vol. %, respectively. The content of titratable and volatile acidity in the composition of wine materials prepared under the conditions of the Samukh district, with the exception of the 2nd option, complied with the norm. The volume of volatile acidity in the wine material prepared from both grape varieties according to the 2nd option (0.70÷0.72 g/dm^3) was almost 2 times higher than in the other options, and titratable acidity was significantly less (4.5÷4.7 g/dm^3). Under the conditions of the Samukh district, the volume of extractive substances in the 2nd variant was 32.1÷33.2 g/dm^3, and in the other variants this indicator fluctuated within the range of 36.5÷41.2 g/dm^3.

In wine materials prepared from grape varieties grown under the conditions of the Goygol district, the extractive substances in the second variant varied within 33.2÷33.7 g/dm^3, and in the other variants – 37.3÷42.1 g/dm^3. The content of phenolic compounds in wines prepared under the conditions of the Samukh district changed within 0.41÷0.82 g/cm^3. Under the conditions of the Goygol district, the content of phenolic compounds was slightly higher, compared to the Samukh district – 0.45÷0.90 g/dm^3. The content of methyl alcohol in wines prepared from grapes withered for 10–12 days was significantly higher than in other wines. In wines made from Cabernet Sauvignon and Madrasa grape varieties grown in the Samukh region according to the 2nd option, 0.72–0.78 g/dm^3 was recorded, and in other options within 0.32÷0.42 g/dm^3. Thus, as a result of the research, it was found that wines made from Cabernet Sauvignon grape varieties grown in the Samukh region according to the 1st (9.3 points) and 3rd options (9.6 points) received a high rating compared to wines made according to the second option.

3. The most appropriate variant for the preparation of Tokaj wine material is the option using the Rkatsiteli grape variety, ripened and dried for 4–5 days, grown in the Samukh region.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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