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DETERMINING THE INFLUENCE OF SOME FACTORS ON IMPROVING THE QUALITY OF SHERRY WINE MATERIAL

The object of research is the production of Sherry must and wine materials, as well as the processes that occur during this production.

Factors affecting the quality of Sherry wine material – particularly the amount of juice yield, different combinations of fining agents, the duration and course of fermentation, and the role of the grape variety – have not been sufficiently studied. It was found that increasing the juice yield per ton of grapes from 50 to 75 decaliters led to an increase in aldehydes from 61.2 mg/dm^3 to 86.1 mg/dm^3, esters from 67.3 mg/dm^3 to 86.7 mg/dm^3, higher alcohols by 40 mg/dm^3, and terpenes by up to 100 mg/dm^3 in the resulting wine material. An increase in phenolic compounds and oxidation-reduction potential (ORP) caused oxidation uncharacteristic of Sherry wine material, leading to a decrease in quality. Sensory analysis showed a decline in quality scores by 0.02–0.10 points. The effect of fining agents reduced the content of phenolic compounds and titratable acids, while color values shifted positively. Juice samples were fermented both with (experimental) and without (control) the addition of nutrient supplements. Compared with the control, fermentation in the experimental samples was completed 2 days earlier. Increasing the dose of sulfur dioxide added to the juice from 50 mg/dm^3 to 120 mg/dm^3 resulted in a decrease in alcohol content and an increase in titratable acidity in the fermented samples. Wine materials prepared from Bayan, Fetyaska, and Rkatsiteli grape varieties are suitable for Sherry production; however, in terms of optimal composition, Fetyaska wine material was considered superior.

The obtained results can be applied in family-owned vineyards and winemaking enterprises.

Keywords: *juice, Sherry wine material, phenolic compounds, nitrogenous substances, ethyl alcohol, yeast solution.*

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1. Introduction

Currently, the main directions of winemaking development include improving quality, ensuring the competitiveness and export orientation of the produced product. In the globalized world, winemaking, along with other production sectors, is facing a deep crisis and competition. The marketing of processing products manufactured under such conditions requires special attention and responsibility. The current state of the world market does not allow the sale of any wine variety here. A stable presence in the market can be secured solely by offering premium-quality wine varieties that appeal to the consumer's taste. In this regard, the production of Sherry wines made with special technology seems to be quite relevant. However, despite the above-mentioned facts, Sherry wines are almost not produced in our country. One of the main reasons hindering the production of Sherry wines is the absence of a raw material base in the country. It is known that white neutral grape varieties or their blends are used to make Sherry wine.

Based on the above, it can be stated that these studies are relevant, as they are devoted to determining the optimal juice yield for high-quality Sherry wine material, the treatment with fining agents, fermentation conditions, and the investigation of composition and quality indicators according to grape varieties.

The production of Sherry wines is a unique and strictly regulated process that encompasses all stages-from grape harvesting to quality control of the finished product. This process involves a dynamic biological aging phase and is mainly carried out through the "criadera-solera" system or other specialized technologies. A key role in the production process is played by special flor yeast strains belonging to the species Saccharomyces cerevisiae. As a result of the activity of these yeasts, Sherry wines acquire a distinctive chemical composition, which determines their organoleptic characteristics such as color, aroma, and taste, and distinguishes them from other types of wines [1].

This bibliographical review aims to collect the various scientific achievements discovered to date regarding the aroma of oenological products (sour, sweet wines, vinegars and cognacs) from the Jerez region. The focus here is mainly on the various analytical methodologies used and key literature of interest [2]. Brandy de Jerez is an alcohol produced in southern Spain and is characterized by its aging in casks that previously held Sherry wine, called Sherry Casks®. The aging process depends on the presence of compounds left over from Sherry wines in Brandy de Jerez. Neither the duration nor the type of aging has been thoroughly studied. A complete analytical characterization of Brandies de Jerez aged in Sherry Casks® for 3, 6, 12, 18 and 60 months was carried out with Fino, Oloroso and Pedro Ximénez Sherry wines [3]. This study is dedicated to the production of a new dark drink from casks that were previously used for Sherry wine. Aging in such casks enriches the cognac spirit not only with compounds from the wood, but also with compounds from the Sherry wines previously aged in them. As a result, it becomes possible to create a drink called Sherry Cask®. The quality of cognac depends on the conditions in which it is grown, as well as on the distilled wine and the distillation process. It is also determined by the physicochemical composition and properties of the distillate. It has been found that high sulfur dioxide and distillate pH significantly affect the extraction of phenolic compounds and organic acids from wood, as well as reactions such as hydrolysis or esterification between compounds in alcohols [4]. This study can be considered beneficial in terms of determining which parameters are most effective in aging Pedro Ximénez Sherry wine. The organic acids, volatile compounds (higher alcohols, esters, aldehydes and acetals) and phenolic compounds of this wine develop during aging, mainly through physicochemical reactions and the addition of wood compounds. This allowed the development of a model that led to the determination of the ages of wine samples with more than 97% confidence by using only 8 of the variables considered in the study. Accordingly, this represents an effective means for controlling the aging processes of Pedro Ximénez Sherry wine [5]. A low-cost biosorbent derived from Palomino Fino grape seeds, a by-product of the Sherry wine industry, has been proposed to evaluate this material. A combination of physical and chemical sorption mechanisms has been proposed for chromium removal with a high maximum sorption capacity (g_{max} = 208.3 mg · g^{-1}). Thermodynamic parameters indicated the spontaneous and endothermic nature of chromium removal. Successful biosorption was based on specific grape seed components with appropriate content in antioxidant and lignocellulosic compounds [6]. The aim of this work is to improve an industrial yeast strain that allows for reduced hydrogen sulfide (H_2S) production. In order to achieve this, two different improvement approaches were used in the aforementioned yeast: mass pairing and hybridization by adaptive laboratory evolution, both of which are carried out through spores and conjugation, thus increasing genetic variation. Three improved variants with lower H_2S production were obtained and used as a starting point to carry out industrial-scale fermentation. At the industrial level, not only were organoleptic defects reduced, but an even greater volume of Sherry wines was produced [7]. Here, an alternative method is proposed, aimed at producing a distinct type of more efficiently Sherry wine without fortification. For this, Sherry yeast strain is pre-adapted to glycerol consumption versus ethanol and then fixed in a fungal-based immobilization system known as "microbial biocapsules" to facilitate its inoculation. Immobilization of flor yeasts in microbial biocapsules appears to be a cost-effective technique that can be used to produce high-quality differentiated Sherry wines [8]. Casks previously used for Sherry wine and cognac spirit have been studied. The results showed that aging in both types of casks caused significant changes in the composition of volatile compounds, with a noticeable increase in phenol and furfural compounds. Sherry casks contributed compounds specific to Sherry wine, enriching the aromatic profile of the distillates, such as a greater increase in ethyl esters of organic acids. Sensory analysis confirmed that while aging significantly alters the organoleptic characteristics of all distillates, Sherry casks are characterized by a greater accumulation of oak, vanilla, spicy, and wine-like notes [9]. In this study, the characterization of oak casks storing three Sherry wines, namely Fino, Oloroso, and Pedro Ximénez, was carried out by DTD-GC-MS. It was found that some compounds in wood either disappear, decrease, or, conversely, increase during aging. This fact shows that as Sherry wines age, certain interesting compounds are transferred to the wood of the cask, which in turn is transferred to the distillate [10]. This study examines the selection and consumption of Sherry wine varieties. For this purpose, 1502 participants (1407 wine consumers) were recruited; among the consumers, 58.5% were female, and 74.3% had little knowledge about wine (mean age 22.6; SD = 3.07; range 18–30). Data were collected through an online survey. The results show that among Sherry wines, Fino and Manzanilla were the most preferred varieties [11]. A methodological approach has been proposed for the search for natural strains of *S. cerevisiae yeasts* that are promising for Sherry production. According to the results of genetic studies and the evaluation of enological characteristics, five strains were selected, characterized by the presence of Sherry alleles for three loci and with the ability to produce fluorine. Two strains were selected as the most promising for further production selection on the basis of micro-winemaking [12]. The presence of mycoviruses in the *Saccharomyces genus* of membrane yeasts that confers dominance and evolutionary advantages in the placement of Fino and Manzanilla wines, is studied. How these yeasts affect the stability of fluorous yeast under different temperature and ethanol conditions is being investigated, and alternative methods for regeneration membrane by using amino acids as nitrogen sources or inert supports are being explored [13]. This study carried out the genetic identification, morphological characterization and analysis of grape genotypes obtained from four autochthonous varieties (Cañocazo, Castellano, Mantúo de Pilas and Palomino Fino). This genetic analysis allowed to identify autochthonous varieties with different genotypes. They all have adequate physicochemical composition to produce premium-quality white wines. For all the reasons mentioned above, these local varieties should be considered suitable for cultivation in areas with warmer and drier climates, such as Andalusia (Spain) [14]. This review highlights the importance of yeast ecology and yeast metabolic reactions in determining the quality of Sherry wine and the richness of untapped indigenous microorganisms that coexist with the film-forming yeast strains. This covers the complexity of the veil that forms the genetic characteristics of wine yeasts and the genetic methods often used in strain selection and monitoring during fermentation or biological aging [15]. In this study, mistelas and natural sweet wines were produced from the "Pedro Ximénez" grape variety, pre-ripened by sun-drying and fermented with or without grape skins. No significant differences were observed in the content of organic acids and low molecular weight polyphenols and furans depending on the presence or absence of grape skins. In this regard, this study proves that the production of sweet wines from sun-dried grapes with/without grape skins during alcoholic fermentation may be a feasible option in areas where agroclimatic conditions are suitable [16]. A process and technological scheme has been developed for the production of wines from the Madrasa grape variety that differ in color and quality. This technological scheme, based on the existing red wine production line, allows for the production of wine types with different aging durations [17].

The study focused to investigate the effect of maceration regime on the amount of phenolic compounds and color parameters in autochthonous Madrasa wine samples. In the initial wine sample, the total amount of phenolic compounds was 520 mg/dm^3, and the amount of anthocyanins was 83 mg/dm^3. After treatment with PVPP, these indicators decreased by 14.4% and 20.5%, respectively. Bentonite was found to be the second most effective clarifying agent in terms of its influence on phenolic compounds [18]. Samples of Madrasa wine subjected to 48 and 96 hours of maceration were divided into two parts: one fermented with natural yeasts (NY) and the other with cultured yeasts (CY). The NY samples contained lower amounts of phenolic compounds and phenolic acids compared to the CY samples; however, the amount of aromatic compounds was higher in the wines obtained through natural fermentation [19]. Technological methods for making wine from autochthonous grape varieties Madrasa and Bayan Shira [20], extractant and rational modules for mixing it with solid parts to obtain rich extracts from the solid parts of the bunch are given [21]. At the same time, studies have been conducted on the biochemical and physicochemical compositional properties and basic regularities of obtaining juice, wine and other products [22]. The physicochemical composition of wine samples, as well as the quantity and quality of volatile compounds, were investigated. The highest amount of dry matter was found in Goranboy (76.7 g/dm^3), the lowest in Goygol (38 g/dm^3), and the average value in Ganja (51.3 g/dm^3). These differences are attributed to the soil and climatic conditions of these regions [23]. This article presents the results of an extensive study of productive clonal forms (based on

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morphological, biological, and economic-technological characteristics), as well as the main principles of clonal selection and vegetative changes occurring in grapevines. It was determined that clonal variations exhibit higher productivity compared to their parental forms [24].

Analyzing the literature, it can be concluded that, under local conditions, the effects of grape variety, the amount of juice obtained, the pectic substances in the juice during clarification, and fermentation on the quality of Sherry wine material have not been determined and remain an unresolved issue.

Investigating the choice of variety, the optimal juice yield, and the effects of different combinations of pectic substances used for juice clarification on composition parameters, as well as determining the impact of fermentation duration and conditions on the quality of Sherry wine material, provides a solution to this problem.

As it can be seen, the field faces a scientific problem that requires a solution.

The object of research is the production of Sherry must and wine materials, as well as the processes that occur during this production.

The aim of research is to determine the effect of certain factors on improving the quality of Sherry wine material.

To achieve this aim, the following objectives are achieved:

– to study the effect of juice yield on the physicochemical composition of Sherry wine material;
– to study the effect of adhesive substances on the physicochemical composition of juice;
– to study the effect of fermentation conditions and grape variety on the physicochemical composition of Sherry wine material.

2. Materials and Methods

The main idea of the research is to investigate the optimal juice yield, fining schemes, and the influence of grape varieties cultivated under local conditions for the production of high-quality Sherry wine material. The application of modern processing techniques and analytical methods contributes significantly to facilitating the research tasks. The application of modern processing and analysis methods greatly simplifies research tasks.

The physicochemical and organoleptic characteristics of raw materials, semi-finished products, and finished products are determined by using common analysis methods available in enochemistry. However, the study used modern analysis methods, computer technology, and statistical processing of data [25]. Statistical analyses were performed by using the SPSS18 package [26].

The reliability of the obtained results, their theoretical and experimental consistency, was ensured by repeating the experiments at all stages of the experiment. The level of confidence constitutes $P_e = 0.95$.

The mass concentration of phenolic compounds in wine was determined by the Folin-Ciocalteu method. Folin-Ciocalteu reagent oxidizes phenol groups by adding to wine, and it is being reduced to a blue-colored compound. In this case, the intensity of the color is proportional to the concentration of phenolic compounds.

Hunterlab (Model D-9000 Color Difference Meter, Hunter Associates Laboratory, USA) analyzer was used to measure the color of wine samples. In Hunter, *a*-value measures redness and greenery, and *b*-value measures yellowness and blueness. The *L*-value measures the degree of light or brightness. The price varies between 100 – full white, 0 – black.

The harvest of Rkatsiteli, Bayan Shira and Fetyaska grape varieties harvested at the stage of technical aging was used to prepare the Sherry wine material. The grapes were processed by using the "white method" in micro-winemaking conditions. That is, the grapes are crushed, the skins are separated, and the pulp is squeezed, and the juice is immediately extracted. The obtained juice is allowed to rest after the addition of SO_2 to prevent oxidation and contamination. The fining of juice samples was carried out according to the following technological schemes (Table 1) and, after clarification, separated from the sediment by decantation. Fully fermented sour table wine is equalized.

Table 1

Dose of excipient combinations used in dilution of juice samples by variant, $n = 6$, $p < 0.05$

Reference number	Rinse aid	Doze	Temperature used (°C)
V_1	Bentonite	2000 g	35
	Gelatin	50 g	30
V_2	Gelatin	50 g	45
	Kieselsol (30%)	750 ml	
V_3	Tannin	70 g	25
	Gelatin	50 g	
V_4	Bentonite	2000 g	45
	Gelatin	50 g	
	Kieselsol (30%)	750 ml	
V_5	Bentonite	2000 g	35
	Tannin	70 g	30
	Gelatin	50 g	
V_6	Bentonite	50 g	45
	Kieselsol (30%)	750 ml	
V_7	Control	–	–

As a result of the research, the optimal juice yield, treatment with fining agents, fermentation conditions, and the influence of grape varieties on quality will be determined for producing high-quality Sherry wine material from grape varieties cultivated under local conditions.

3. Results and Discussion

3.1. Study of the effect of juice yield on the physicochemical composition of Sherry wine material

The quality of Sherry wines is influenced by the quality of the initial juice obtained from the processing of the grapes.

The effect of different juice yields from 1 ton of grapes for Sherry wines on the physicochemical composition of the wine material is given below (Table 2).

Table 2

Physical and chemical composition of wine material depending on juice yield, $n = 6$, $p < 0.05$

Indicators	Juice yield, dal/ton		
	45–50	55–60	70–75
Ethyl alcohol, h%	11.40	11.30	11.20
Mass fraction, g/dm^3			
Titrating acids	6.10	6.00	6.00
Volatile acids	0.36	0.39	0.49
Derived extract	16.80	17.00	17.40
Wine acid	1.20	1.10	1.10
Malic acid	0.50	0.50	0.50
Lactic acid	0.20	0.20	0.20
Succinic acid	0.60	0.60	0.60
pH	3.15	3.13	3.09
OR-potential	192.00	196.0	207.00
Tasting value, points	8.00	7.98	7.90

As can be seen, with an increase in the juice yield from 1 ton of grapes, a decrease in the volume fraction of ethyl alcohol in the wine material obtained, as well as a decrease in the pH indicator, is observed. An increase in OP-potential indicates oxidation that is not typical for fine wine material and thus a decrease in quality. The aforementioned observations were further confirmed during organoleptic analysis, where an increase in juice yield led to a 0.02–0.10-point decrease in quality indicators during the tasting process. Thus, for Sherry wine material, the juice yield from 1 ton of grapes exceeding 60 dal results in deterioration in quality.

There is a noticeable difference in the mass concentration of aromatic substances in Sherry wine materials prepared from different juice extracts obtained from 1 ton of grapes (Fig. 1).

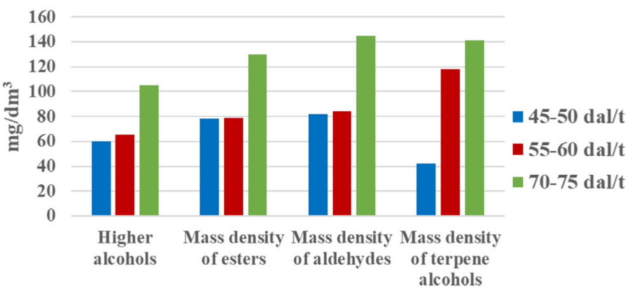

Fig. 1. Effect of juice yield on the amount of aromatic substances, $n = 6$, $p < 0.05$

As can be seen, as the juice yield increases, an increase in the mass concentration of higher alcohols, esters, and aldehydes is observed. If the amount of aldehydes in case 1 was 61.2 mg/dm^3, in case 2 it was 78.3, and in case 3 it was 86.1 mg/dm^3. A similar situation is observed in the amount of esters: I – 67.3; II – 72.1; III – 86.7 mg/dm^3. The increase in the amount of higher alcohols and especially terpenes has been more noticeable.

In the first case, this is observed with an increase of about 40, and in the second case with an increase of about 100 mg/dm^3. It has been found that as the juice yield increases, the amount of extractive substances in the composition, including phenol and nitrogenous compounds, also increases (Fig. 2).

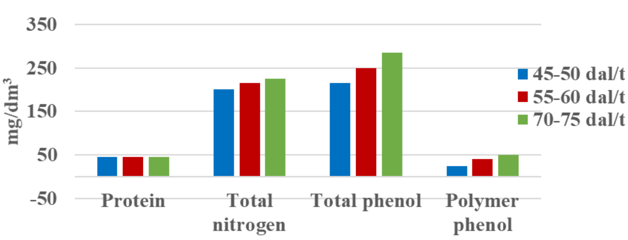

Fig. 2. Amount of nitrogen and phenolic compounds in Sherry wine material depending on juice yield, $n = 6$, $p < 0.05$

A particularly noteworthy aspect during this period was the increase in phenolic compounds, especially in their polymeric forms. This proves to be the main factor preventing Sherrying in wine material in the future. Therefore, such a situation is not considered desirable for this type of wine.

3.2. Study of the effect of adhesive substances on the physicochemical composition of juice

The brix index, acidity, maturity index, and pH of the juice obtained during the pressing to obtain grape juice were determined. It was found that the juice obtained from the Bayan Shira grape variety had a brix index of 18.9%, a titratable acidity of 6.65 g/l, an aging index of 28.6, and a pH value of 3.4. In the juice obtained from the Rkatsiteli grape variety, these indicators were 20.8%, 5.80 g/l, 35.8 and 3.2, respectively.

Juice samples from the Rkatsiteli grape variety were clarified by using various combinations of clarifying agents. The effect of these substances on the brix index was studied. The results are given in the following figure (Fig. 3).

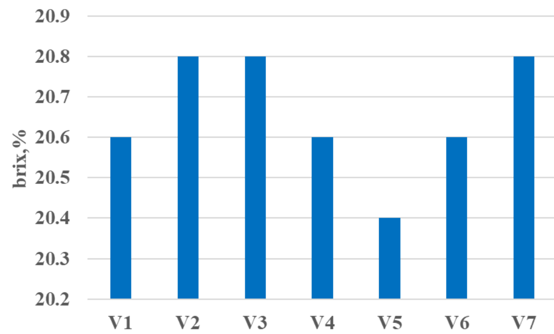

Fig. 3. Brix index in juice samples from Rkatsiteli grape variety, $n = 6$, $p < 0.05$

As can be seen, the lowest Brix value was obtained in sample V_5, i. e. when bentonite + tannin + gelatin was used, and was 20.40%. The highest was in samples V_2 and V_3, along with the control sample, V_7. The effect of finning agents on the amount of titratable acids in Rkatsiteli juice was as follows (Table 3).

Table 3

Effect of adhesives on the amount of titratable acids in Rkatsiteli juice (g/l), $n = 6$, $p < 0.05$

Samples	Adhesives	Titratable acidity, g/dm^3
V_1	Bentonite + Gelatin	5.60
V_2	Gelatin + Kieselsol	5.60
V_3	Tannin + Gelatin	5.60
V_4	Bentonite + Gelatin + Kieselsol	5.60
V_5	Bentonite + Tannin + Gelatin	5.60
V_6	Bentonite + Kieselsol	5.60
V_7	Control	5.80

The highest titratable acidity was found in B_7, i. e. in the control sample, which was 5.80 g/l. All other samples showed the same level of reduction and the titratable acidity was 5.60 g/l in all. Different results were obtained when determining the ash content in juice samples taken from the Rkatsiteli grape variety (Fig. 4).

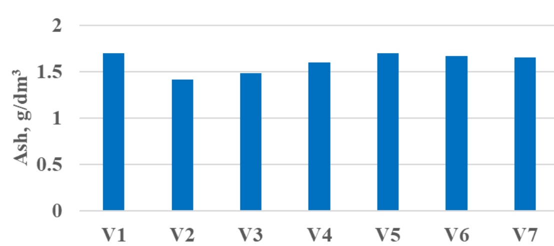

Fig. 4. Ash content in juice samples from Rkatsiteli grape variety, $n = 6$, $p < 0.05$

As it can be seen from the diagram, the highest amount of ash was found in sample V_5, and the lowest amount was found in sample V_2. Overall, there was no significant difference between the samples in terms of ash content.

The pH value of the varieties also had different values depending on the finings (Fig. 5).

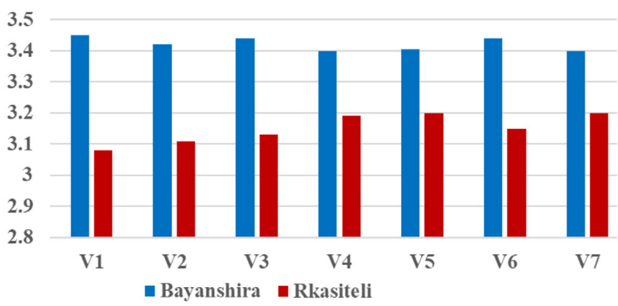

Fig. 5. Change in pH in grape juice samples due to the influence of finings, $n = 6$, $p < 0.05$

As it can be seen, different changes were observed in the pH of juice samples of Bayan Shira and Rkatsiteli varieties, depending on the adhesive substances. An increase in pH was observed in the Bayan Shira juice processing variants compared to the control. At this time, the largest increase was in sample V_1 and amounted to 3.45. In Rkatsiteli juice, a decrease in pH occurred, and here too the greatest decrease was observed in sample V_1 (3.08).

The effect of finings on the amount of phenolic compounds in juice samples is also of interest. Therefore, this indicator was investigated. It has been found that treatment with finings leads to a decrease in the amount of phenolic compounds in the samples. Depending on the components of the used fining agents, the reduction was of greater or lesser magnitude (Fig. 6).

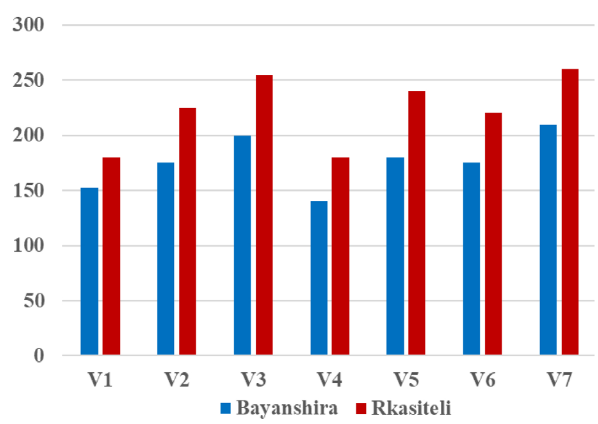

Fig. 6. Amount of total phenolic compounds in juice samples depending on their fining agents, $n = 6$, $p < 0.05$

It was found that the amount of total phenolic compounds in the Bayan Shira variety was significantly lower than in the Rkatsiteli variety. A greater decrease was observed in the fourth variant for both varieties. The color values of the samples were also examined. Here, L indicates clarity, a indicates redness in the "+" direction, green in the "–" direction, b indicates yellowness in the "+" direction, and blue in the "–" direction.

The color indicators of Bayan Shira and Rkatsteli grape juice samples were determined by clarification with various combinations of fining agents (Fig. 7).

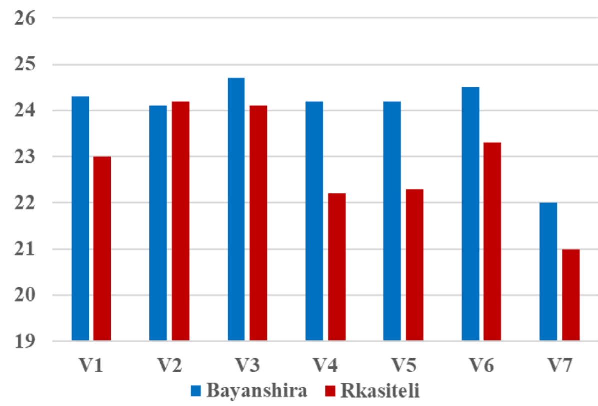

Fig. 7. L value in juice samples depending on fining agents, $n = 6$, $p < 0.05$

As can be seen, the purity index was higher in the Bayan Shira variety than in the Rkatsiteli variety. Upon reviewing the variants, the highest value was observed in the third variant. The values of grape juice samples in different combinations of fining agents were studied (Fig. 8).

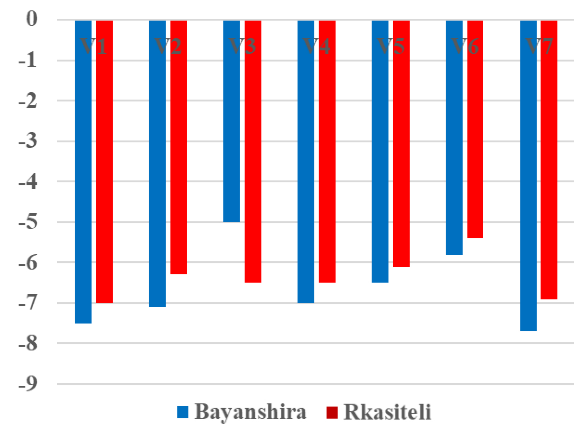

Fig. 8. Effect of fining agents on color (a values) in different juice samples, $n = 6$, $p < 0.05$

As can be seen, the prices have changed in the direction of greenness and the Bayan Shira variety has received relatively higher prices. In general, this indicator varied between –5.05 and –7.65 in juice samples taken from the Bayan Shira variety, and between –5.33 and –7.05 in juice samples taken from the Rkatsiteli variety.

The color b values for juice samples treated with fining agents are given in graphical form (Fig. 9).

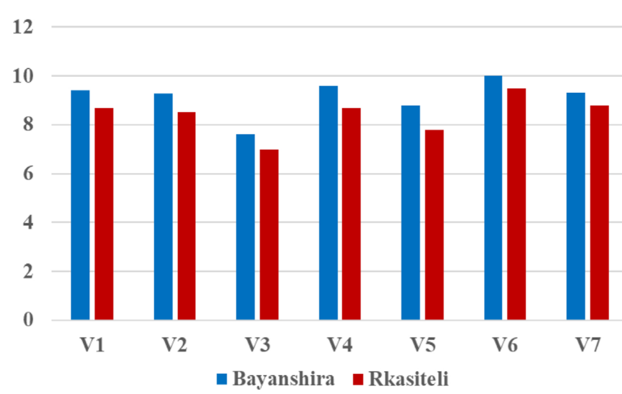

Fig. 9. Effect of fining agents on color in different juice samples (b values), $n = 6$, $p < 0.05$

As it can be seen, different combinations of the fining agents had different effects on the b value. In general, it is clear that the b values in the samples were positive and mainly changed towards yellowness. A comparative review shows that these parameters in Bayan Shira juice samples were slightly higher than those in Rkatsiteli juice samples.

In Bayan Shira, the lowest *b* value was in option 3 and was 7.64. The highest option was option 6, which was 9.96. This indicator varied between 7.10–9.45 in Rkatsiteli juice samples.

3.3. Study of the effect of fermentation conditions and grape variety on the physicochemical composition of Sherry wine material

The density of the grape juice used to make Sherry wine material fluctuated between 1.080–1.090, depending on the variety. Daily observations were made on grape fermentation. During the two weeks of fermentation, there is a gradual decrease in density. As a result of the cold fermentation produces a delicate wine with an alcohol content of 11.1–12.0% by volume. After pressing, 50 or at most 60 dal/ton of juice obtained is sulfited at a rate of 50–75 mg/dm^3. The sulfited juice is divided into 2 containers and kept at a temperature of 12°C for 19 h. Before the experimental sample is allowed to rest, 0.6 g/dal of ascorbic acid is added. The clarified juice is submitted to fermentation. The experimental variant is injected with a "Phospho-th-containing" preparation. Let's add it at a rate of 1.3 g/dal before mixing for 10 minutes. The fermentation of the experimental variant is carried out with the Sherry 20C/96 yeast strain at a temperature of 20–22°C, and in the control at a temperature of 16–17°C. The dynamics of grape juice fermentation is shown in the figure (Fig. 10). In the experimental variant, the fermentation of the juice proceeds more actively than in the control. Adding nitrogen-vitamin supplements shortens the fermentation time of the juice.

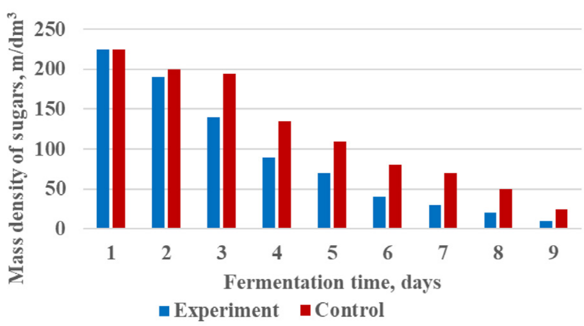

Fig. 10. Fermentation dynamics of Bayan Shira grape variety juice, $n = 6$, $p < 0.05$

Both juice and wine material were optionally supplemented with ammonium phosphate, combined vitamins, and yeast autolysate as nitrogen-vitamin supplements. It has been found that adding a nitrogen-vitamin supplement before fermentation intensifies fermentation and eliminates the possibility of incomplete fermentation. During the research, it was found that our soils are deficient in nitrogen, and this deficiency is also observed in the wine materials obtained from the vineyards cultivated here. Nitrogen is essential for fertilization Important methods for eliminating nitrogen deficiency have been reviewed. One of them is the use of nitrogen food sources. Various groups of substances can play the role of such a source. Preparations based on aqueous ammonia, yeast autolysates or ammonium salts can be applied to both the juice and the wine material before sherrying. In the first stage, the preparations were injected into the juice. This operation is performed before fermentation. The effect of the drugs on the dynamics of fermentation was studied (Table 4). Pure yeast solutions were used in fermentation.

As it can be seen, in the control variant, that is, without adding anything, fermentation lasted 15 days, while in the other variants it was completed in 13 days at the latest. Among the added preparations was the use of a phosphate-containing additive that accelerated fermentation, and in this case, fermentation was completed in 11 days.

Table 4

Effect of various additives on fermentation, $n = 6$, $p < 0.05$

Preparations	Fermentation time, days					
	Fermentation sugars, g/dm^3					
	1	5	10	11	13	15
Control	1.5	76.0	140.1	156.0	177.0	193.0
Phosphate composition	0.0	81.0	179.0	193.0	–	–
Autolysate	4.0	77.0	161.0	179.0	193.0	–
Ammonium phosphate	0.0	51.0	165.0	184.0	193.0	–
Ammonium solution	2.0	80.0	175.0	186.0	193.0	–

During the analysis of the composition of the wine materials, it was found that in the experimental samples, the amount of ethyl alcohol increased by 0.15–0.25 h% by volume compared to the control, and the mass concentration of titratable acids decreased. During the sherrying of such samples, a more pronounced Sherry tone is formed in the taste and bouquet, and the accumulation of acetals and higher alcohols is observed. As a result, a significant improvement in the organoleptic quality of wine materials was noted. The additives had different effects on the duration of fermentation (Fig. 11).

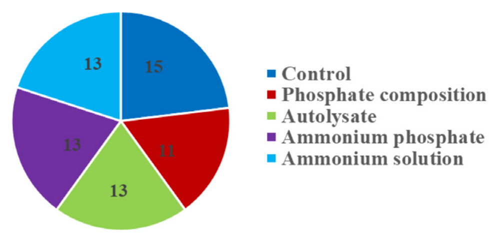

Fig. 11. Duration of fermentation (in days) depending on additives, $n = 6$, $p < 0.05$

Analysis of the physicochemical parameters of the obtained Sherry wine materials showed that as the dose of sulfur dioxide added to the juice increases, the volume fraction of ethyl alcohol in the wine material decreases (Table 5). The mass concentration of titratable acids, as well as the amount of organic acids in wine materials, does not change significantly depending on the method of sulfitation of the juice. This is also consistent with the results obtained by other researchers. The non-sulfited samples are an exception, and malolactic fermentation occurs in them, resulting in a decrease in malic acid and an accumulation of lactic acid. The data obtained allow to conclude that sulfitation of the juice at a concentration of 50 mg/dm^3 is sufficient to obtain stable wine material.

Table 5

Physicochemical parameters of wine materials depending on the sulphiting regime, $n = 6$, $p < 0.05$

Experiment options	Volume fraction of ethyl alcohol, %	Mass density, g/dm^3				
		Organic acids				
		Titrating acids	Wine	Malic	Lactic	Succinic
Control- without SO_2 addition	12.1	5.7	3.0	0.7	1.5	1.0
Experiment- with SO_2 addition, mg/dm^3						
50	11.9	6.0	3.1	1.2	0.8	0.8
75	11.9	6.1	3.3	1.1	1.0	0.7
100	11.5	6.3	3.4	1.2	1.0	0.8
120	11.3	6.4	3.3	1.3	1.1	0.7

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The fermentation of the juice was carried out by using natural microflora and cultured yeast solutions (3% solution). The compositional indicators were as follows depending on the variety, harvest year, and yeast, Tables 6–8.

Looking at Tables 6–8, it is clear that the density varied between 0.9221–0.9942 in Bayan Shira wine materials, 0.9931–0.9942 in Fetyaska wine materials and 0.9917–0.9929 in Rkatsiteli wine materials. It is known that the density was suddenly lower in sour wines. It is known that this indicator is related to the amount of alcohol and dry matter. Since fermentation in the wine materials proceeded to completion, the obtained values remained within a range considered normal for acidic wines.

The alcohol content in Bayan Shira wines ranged from 11.30–11.50% by volume, in Fetyaska from 11.30–11.60% by volume, and in Rkatsiteli from 11.60–11.80%. As can be seen, the Rkatsiteli wine materials had alcohol contents that were 0.30% by vol. and 0.20% by vol. higher than those of Bayan Shira and Fetyaska wine materials, respectively.

When looking at the total amount of dry matter, it is clear that this indicator varies between 20.8–21.3 g/dm^3 in Bayan Shira and Fetyaska wine materials, and 21.6–22.1 g/dm^3 in Rkatsiteli, and the latter is 0.8–0.9 g/dm^3 higher than the previous two wine samples. The different values of dry matter and ethyl alcohol content can be explained by the different sugar content of the original juice.

The lowest pH value was observed in Bayan Shira and Rkatsiteli wine samples (3.51–3.63), and slightly higher in Fetyaska (3.61–3.66). The amount of glycerin was higher in Rkatsiteli wine materials than in other samples (6.5–6.6), followed by Fetyaska and Bayan Shira wine samples. In this regard, it should be taken into account that the amount of glycerin is an indicator that reflects the amount of fermentable sugar and plays an important role in quality.

Table 6

Physico-chemical parameters of wine materials obtained from Bayanshira grape variety, $n = 6$, $p < 0.05$

Composition indicators	Amount in wine materials, by years					
	2017		2018		2019	
	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*
Density, g/cm^3 (20/20°C)	0.9933	0.9927	0.9923	0.9921	0.9927	0.9942
Alcohol content, h%	11.30	11.35	11.50	11.45	11.30	11.35
Dry matter, g/dm^3	21.1	20.8	21.2	21.3	20.9	21.0
Sugar-free dry matter, g/dm^3	19.3	18.9	19.4	19.4	19.6	19.4
pH	3.62	3.51	3.60	3.54	3.63	3.59
Volatile acids, g/dm^3	0.35	0.40	0.37	0.42	0.30	0.39
Titratable acids, g/dm^3	4.9	4.8	5.0	5.0	4.9	4.8
Ash, g/dm^3	1.865	1.933	1.781	1.801	1.789	1.762
Phenolic compounds, g/dm^3	0.315	0.305	0.318	0.310	0.312	0.327
Glycerin, g/dm^3	5.4	5.5	5.6	5.8	5.6	5.9
2–3 butanediol, g/dm^3	0.35	0.36	0.43	0.45	0.33	0.30
Total nitrogen, g/dm^3	0.140	0.138	0.154	0.162	0.166	0.170
Total SO_2, mg/dm^3	77	67	79	66	70	78
Free SO_2, mg/dm^3	10	11	13	9	14	8

Table 7

Physico-chemical parameters of wine materials obtained from the Fetyaska grape variety, $n = 6$, $p < 0.05$

Composition indicators	Amount in wine materials, by years					
	2017		2018		2019	
	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*
Density, g/cm^3 (20/20°C)	0.9936	0.9932	0.9940	0.9933	0.9942	0.9931
Alcohol content, h%	11.45	11.50	11.55	11.60	11.30	11.35
Dry matter, g/dm^3	21.1	21.3	21.1	21.3	21.0	20.8
Sugar-free dry matter, g/dm^3	19.8	19.8	19.3	19.6	19.5	19.5
pH	3.63	3.61	3.64	3.64	3.61	3.66
Volatile acids, g/dm^3	0.43	0.47	0.40	0.42	0.43	0.50
Titratable acids, g/dm^3	5.5	5.5	5.5	5.5	5.6	5.5
Ash, g/dm^3	2.116	2.110	2.200	2.180	2.221	2.210
Phenolic compounds, g/dm^3	0.307	0.310	0.307	0.316	0.311	0.305
Glycerin, g/dm^3	5.8	5.8	5.5	5.7	5.5	5.6
2–3 butanediol, g/dm^3	0.52	0.53	0.47	0.49	0.49	0.48
Total nitrogen, g/dm^3	0.132	0.129	0.138	0.141	0.141	0.146
Total SO_2, mg/dm^3	69	78	73	84	77	84
Free SO_2, mg/dm^3	9	7	10	7	8	9

Table 8

Physico-chemical parameters of wine materials obtained from the Rkatsiteli grape variety, $n = 6$, $p < 0.05$

Composition indicators	Amount in wine materials, by years					
	2017		2018		2019	
	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*	With natural microflora	With *S. cerevisiae yeasts*
Density, g/cm^3 (20/20°C)	0.9919	0.9929	0.9921	0.9927	0.9917	0.9920
Alcohol content, h%	11.70	11.75	11.60	11.65	11.75	11.80
Dry matter, g/dm^3	21.8	21.8	22.1	22.1	21.6	21.8
Sugar-free dry matter, g/dm^3	20.5	20.3	20.9	20.5	20.7	20.2
pH	3.62	3.51	3.60	3.54	3.63	3.59
Volatile acids, g/dm^3	0.39	0.42	0.33	0.39	0.36	0.39
Titratable acids, g/dm^3	5.7	5.7	5.6	5.6	5.7	5.7
Ash, g/dm^3	2.363	2.431	2.367	2.316	2.421	2.401
Phenolic compounds, g/dm^3	0.317	0.301	0.329	0.324	0.355	0.350
Glycerin, g/dm^3	6.5	6.5	6.5	6.5	6.5	6.6
2–3 butanediol, g/dm^3	0.56	0.57	0.56	0.56	0.56	0.57
Total nitrogen, g/dm^3	0.166	0.147	0.167	0.158	0.161	0.160
Total SO_2, mg/dm^3	79	82	74	77	87	69
Free SO_2, mg/dm^3	9	9	12	10	9	7

The amount of titratable acids fluctuated between 4.8–5.0 g/dm^3 in Bayan Shira wine samples, 5.5–5.6 in Fetyaska wines, and 5.6–5.7 g/dm^3 in Rkatsiteli wines. The amount of volatile acids in all wine samples was generally within the normal range, varying between 0.35–0.50 g/dm^3.

The highest ash content was in Rkatsiteli wine samples – 2.316–2.461 g/dm^3, and the lowest in Bayan Shira wine samples – 1.762–1.933 g/dm^3. In this regard, wine samples made from the Fetyaska grape variety were in the middle position.

The sequence from least to most according to the amount of phenolic compounds was as follows: Phenolic compounds in Fetyaska wine material ranged from 0.305–0.316, in Bayan Shira 0.305–0.327, and finally in Rkatsiteli wine material samples 0.301–0.355. Since phenolic compounds, particularly their polymeric forms, negatively affect the Sherry-type development process, the sequence of wine material samples by variety (Rkatsiteli-Bayan Shira-Fetyaska) reflects the increasing order of Sherry development. The amount of total nitrogen in wine samples was similar to the sequence of changes in phenolic compounds across varieties.

If to look at the tables, it becomes clear that although there were some changes in all wine material samples over the years, these were not at a level that significantly affected the results. As can be seen, wine materials made from different grape varieties are suitable for Sherry. However, in terms of optimal compositional indicators, the wine material obtained from the Fetyaska grape variety was slightly superior.

When comparing the compositional indicators of wine samples by year, it is clear that in Bayan Shira wine samples in 2017, the alcohol content was 11.30–11.35% by volume, the total dry matter content was 20.8–21.1 g/dm^3, and the glycerin content was 5.4–5.5 g/dm^3, while in 2018 these indicators were 11.45–11.50% by volume, 21.2–21.3 g/dm^3, and 5.6–5.8 g/dm^3, respectively. In 2019, these indicators varied between 11.30–11.35% by volume, 20.9–21.0 g/dm^3 and 5.6–5.9 g/dm^3, respectively. As can be seen, a slight increase was observed in the mentioned compositional indicators in 2018 and 2019 compared to the 2017 samples. If to compare 2018 with 2019, in the first case it is possible to see that there was an increase of 0.15% by volume and 0.3 g/dm^3 in the amount of alcohol and dry matter in the samples, respectively; and a decrease of 0.1 g/dm^3 in the amount of glycerin.

A similar situation to the Bayan Shira samples was observed with some deviations in the Fetyaska and Rkatsiteli wine samples. In Fetyaska wine samples, the amount of alcohol, dry matter, and glycerin was slightly higher in 2017 and 2018 compared to 2019, while in Rkatsiteli wine samples, a similar situation was observed in the amount of dry matter. The Rkatsiteli samples taken in 2019 differed in terms of alcohol and glycerin content, being slightly higher than those from previous years.

If to compare the fermentation yeasts, it becomes clear that the samples fermented with natural microflora differed slightly from the samples fermented with cultured yeast solution. Thus, samples fermented with cultured yeast solution were characterized by higher amounts of a number of substances compared to those fermented with natural yeast microflora. In this regard, the amount of alcohol, dry matter, and glycerin can be noted. However, the superiority of samples fermented with natural microflora in terms of taste and other organoleptic indicators has clearly distinguished. Taking into account the above mentioned, wine samples from different years were blended according to the varieties.

The effect of juice yield from grape varieties cultivated in local conditions on the physicochemical composition and quality of Sherry wine material was determined. It has been found that increasing the juice yield reduces the quality of Sherry wine material. This is particularly evident in the increase in the amount of aromatic and phenolic compounds, which are not particularly favorable for Sherry. The effect of fining, which is carried out to remove substances not necessary for Sherry, on the physicochemical composition of the juice was investigated. The effect of the fermentation time and conditions of the juice on the quality of the Sherry wine material has been determined. The effect of additives and sulfur dioxide on the fermentation time and quality of the obtained wine samples was noted. The effect of some white grape varieties cultivated in local conditions on the physicochemical composition of Sherry wine material has been clarified. The physicochemical composition of Sherry wine material samples prepared from Bayan Shira, Rkatsiteli, and Fetyaska varieties was comparatively analyzed. As can be seen, this research work is aimed at solving the problem related to the influence of raw materials, juice yield, various fining agents, and the duration and conditions of fermentation on the quality of Sherry wine material.

With an increase in juice yield from 1 ton of grapes, the wine material undergoes oxidation that is not typical for fine wine material, and thus, the quality decreases. During organoleptic analysis, there was a decrease in the overall score of 0.02–0.10 points with an increase in juice yield (Table 2). At the same time, with the increase in juice yield,

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the amount of aromatic compounds (Fig. 1), phenolic compounds, and nitrogenous substances (Fig. 2), which are considered unacceptable for future Sherry-type development, also increases. The brix index, acidity, maturity index, and pH value of juice samples taken from grape varieties were characterized by different values. The juice samples from the Rkatsiteli grape variety were clarified by using various combinations of clarifying agents. The effects of these substances on the Brix index (Fig. 3), the amount of titratable acids (Table 3), and the amount of ash (Fig. 4) were investigated.

While the processing of Bayan Shira juice in the variants led to an increase in pH compared to the control, and a decrease was observed in Rkatsiteli juice (Fig. 5), a reduction in the amount of phenolic compounds occurred in both samples. In this case, the level of reduction varied depending on the combinations of used fining agents (Fig. 6).

The color indices, i. e. *a*, *b* and *L* values, of grape juice samples in different combinations of fining agents were studied (Fig. 7–9). A comparative review shows that these parameters in Bayan Shira juice samples were slightly higher than those in Rkatsiteli juice samples, and that the mentioned juice sample differed from its counterpart by being clearer and more greenish.

It is noteworthy that the fermentation of juice samples in the experimental variant was more active than in the control. It was found that the addition of nitrogen-vitamin supplements (experiment) resulted in a shorter fermentation time of juice samples compared to samples without supplements (control), Fig. 10, Table 4, Fig. 11.

It has been found that as the dose of sulfur dioxide added to the juice is increased, the volume fraction of ethyl alcohol changes and mainly decreases compared to other components of the wine material. In order to obtain stable wine material, sulfiting of the juice at a level of 50 mg/dm^3 was considered acceptable (Table 5).

Juice samples taken from different years from the Bayan Shira, Rkatsiteli, and Fetyaska grape varieties were individually fermented with natural and cultured yeasts (3% solution). Significant differences in compositional parameters were observed depending on the variety, harvest year, and yeast. It has been found that wine materials made from different grape varieties meet the requirements for making Sherry wine. However, in terms of optimality of compositional indicators, wine samples from the Fetyaska grape variety were superior, Bayan Shira was average, and Rkatsiteli was at the last level (Tables 6–8).

The results of the study can be applied in the fields of viticulture and winemaking. The obtained results can be used in scientific research on winemaking, family farms, and winemaking enterprises. It is planned to apply the results of the research at "Shirvan Wines" LLC.

3.4. Limitations of research and future directions

The limitation of this research is that it is primarily suitable for white grape varieties, particularly those with a delicate composition such as Fetyaska and Bayan Shira. Extracted red juices and wines produced using the "red method", as well as fortified juices and wines, are not covered by this study.

In addition, prior to Sherry-type development, the regulation of acidity in the wine material requires specialized research, materials, and laboratory equipment.

Future research could be expanded to investigate various methods for the Sherry-type development of wine materials. It is also considered promising to study several aspects in wine samples that have undergone Sherry-type development and subsequent storage, including changes in antioxidant properties.

4. Conclusions

1. There is an increase in extractive substances, especially phenolic compounds and their polymer form with an increase in juice yield from 1 ton of grapes (about 60 branches). The OP-potential increases and it leads to oxidation that is not typical of fine wine material, and thus to a decrease in quality. An increase in the amount of aromatic compounds, including higher alcohols, esters, aldehydes and terpenes, also supports this process. During organoleptic analysis, there was a decrease in the quality of the samples by 0.02–0.10 points with an increase in juice yield. All of these factors appear to be factors that prevent Sherry-type development in wine material in the future.

2. Grape juice samples were clarified by using various combinations of clarifying agents (6 variants) and without (control). It was found that Bayan Shira and Rkatsiteli grape juice samples were subject to one or another level of change compared to the control in all variants treated with thinners. In this case, the reduction in the amount of phenolic compounds and titratable acids made those samples more suitable for Sherry-type development. The color values were more optimal compared to the control, and at this time the Bayan Shira samples were distinguished by their superiority over Rkatsiteli.

3. Addition of nitrogen-vitamin supplement leads to shorter fermentation time compared to control (without supplements). In non-sulfited samples, the accumulation of lactic acid occurs due to biological malolactic fermentation. The samples fermented with cultured yeast solution were characterized by higher levels of alcohol, dry matter, and glycerin compared to those fermented with natural yeast microflora. However, in terms of organoleptic indicators, the advantage of samples fermented with natural microflora was evident. Although each of the studied varieties was appropriate for Sherry wine material, Fetyaska wine material was superior in terms of optimal composition indicators.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship or other, which could affect the research and its results presented in this article.

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The research was performed without financial support.

Data availability

The manuscript has no linked data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the submitted work.

Authors' contributions

Hasil Fataliyev: Writing – review and editing, Project administration, Writing – original draft; ***Natavan Gadimova***: Validation, Investigation, Writing – review and editing; ***Azer Taghiyev***: Conceptualization, Investigation, Writing – original draft; ***Konul Baloghlanova***: Investigation, Methodology, Conceptualization; ***Alakbar Alakbarov***: Conceptualization, Methodology, Investigation.

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