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STUDY OF THE EFFECT OF VARIOUS FACTORS ON THE PHYSICOCHEMICAL COMPOSITION INDICATORS OF MARSALA WINE MATERIAL

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Abstract. The traditional methods used in the preparation of high-extract blending components for Marsala-type wines are characterized by high labor, energy, and financial demands. Moreover, the absence of more advanced technological schemes and insufficient research on the influence of certain factors on the physicochemical composition of Marsala wine material remain unresolved issues. The aim of this study was to investigate the effect of various technological factors on the physicochemical composition of Marsala wine material. The use of Selloviridin QZX, Sellofoetidin, and Pektofoetidin Q10X enzyme preparations, as well as different extracts, in the preparation of Marsala blending components contributed to the intensification of the process. Compared with traditional methods, this approach required fewer vessels, less energy and labor input, and a smaller production area. Using the pure Rkasiteli grape variety ensured the production of wine samples with higher extract content compared to the blend of Rkasiteli and Bayanshira varieties. The greatest increase in the amount of phenolic compounds was observed when the Selloviridin QZX enzyme preparation was applied, whereas a relatively smaller increase occurred with the Pektofoetidin Q10X preparation. The Sellofoetidin preparation showed intermediate results. In comparison with the control samples produced by the "white method," the wine samples prepared with the addition of enzyme preparations contained significantly higher amounts of extracted substances. The experimental samples were rated 0.21–0.30 points higher than the control, with wines produced from pure Rkasiteli grapes being considered superior to those obtained from the Rkasiteli-Bayanshira blend. To further enrich the composition of blending components, grape stem and pomace extracts were used. A comparative analysis of different extractants showed that fortified musts with 26.1% alcohol strength and fortified acidic wine extractants of the same strength were evaluated as the most effective. The samples containing extracts were distinguished by significantly higher concentrations of aromatic compounds, such as vanillin, jasmine aldehyde, and others, compared with the analogous samples.

Keywords: pomace, stem, enzyme preparations, Marsala, extracted substances, mistelle, alcohol

Introduction. Formulation of the problem

Marsala is a fortified original wine whose homeland is located in the western part of the island of Sicily, Italy-specifically in the cities of Marsala, Trapani, and Castellammare.

Unlike other fortified wines, Marsala is distinguished by its high concentration of extractive substances. The components contributing to extract formation are mainly glycerol, nitrogenous compounds, phenolic substances, and the products of the Maillard (melanoidin-forming) reaction, the amounts of which depend on the raw material and the winemaking conditions.

In these wines, the melanoidin content is significantly higher than in other types of wines. At the same time, the concentration of aldehydes-particularly formaldehyde, furfural, hydroxymethylfurfural, acetic aldehyde, and isovalerian aldehyde-is also notably elevated. As can be seen, the products of the carbonyl-amine (Maillard) reaction play a fundamental role in the production of Marsala-type wines, determining their specific color, bouquet, and taste. These characteristics are strongly influenced by the composition and processing scheme of the raw material and semi-finished wine material.

It should also be noted that Marsala is a blended wine, obtained by mixing several components in well-defined proportions. The grape varieties used for its production must accumulate high levels of sugars and dry matter, while containing low titratable acidity. In addition, the winemaking process should ensure the maximum extraction of nitrogenous, phenolic, and other extractive compounds from the solid parts of the grape berry. The wine material should also be enriched with products of sugar–amine reactions, as these compounds are crucial for the development of the typical flavor and bouquet characteristic of Marsala wines.

Taking into account the above-mentioned factors, the correct preparation of blending components capable of expressing these specific properties in the final wine is of great importance. For this purpose, the grape varieties used should possess high sugar-accumulating capacity, allowing the production of wine materials with sufficient extract content during must fermentation. The extractive substances can be derived either from oak wood or from the solid parts of the grape cluster. Considering that oak wood is an expensive and limited resource, special attention was given to the solid parts of the grape bunch (stems, skins, and seeds).

Extraction of the necessary compounds from these solid parts can be achieved through prolonged contact (e.g., "maceration," "thermovinification," or "red fermentation" methods). However, these traditional approaches are labor and energy-intensive, require large storage capacities, and are time-consuming.

It has been established that the use of enzyme preparations and extracts derived from the solid parts of grape clusters can effectively overcome these drawbacks. Wine samples obtained through this method exhibited a richer composition and superior organoleptic properties compared with their traditional counterparts.

Analysis of recent research and publications

This review presents a description of the main characteristics of the most important fortified wines in the world, structured into three sections. It is noted that, considering the popularity and economic significance of these wines, extensive research-particularly regarding the stages of oxidation and thermal aging- remains necessary [1].

Today, the most well-known fortified wines worldwide, including Marsala, Madeira, Port, and Sherry, are classified as dessert wines due to their high alcohol content, sweet taste, and intense aromatic profile, and are sometimes also served as aperitifs. The winemaking process plays a key role in forming the volatile organic compounds (VOCs) that define the aromatic characteristics of each fortified wine, providing them with a unique organoleptic signature and terroir expression. The final part of this review focuses on the volatile and aromatic compounds typically found in fortified wines during oxidative aging [2].

Research conducted over the past 13 years has explored the application of commercial enzymes in the production of red, white, and sweet wines. Particular attention has been given to safety concerns related to potential allergenic effects of enzymes. Future research should focus on enzyme immobilization and the use of microorganisms with potential enzymatic side activities during winemaking [3].

The results indicate that the Sihazym Extro enzyme is more effective in enhancing the extraction of phenolic compounds, while both tested enzymes improved the extraction of anthocyanins during maceration. The most common phenolic compounds identified were malvidin derivatives, whose concentrations increased steadily during vinification—representing 82% of total anthocyanin derivatives in the control wine and 81% in both enzyme-treated wines. The antioxidant activity of the samples followed the same trend as phenolic content, showing higher values in the enzyme-treated wines [4].

The objective of another study was to investigate the effect of adding five single enzyme activities (pectin lyase, polygalacturonase, pectin methyl esterase, xylanase, and arabinase) during pellicular maceration of white grape varieties (Chardonnay, Arneis, Greco, and Falanghina) on their phenolic content, color properties, and volatile composition, without negatively affecting aroma. Standard physicochemical parameters were also determined. The results demonstrated that enzyme activity can influence the volatile composition of grape musts in different ways [5].

Anthocyanins are polyphenolic compounds found in red grapes, wines, and their by-products. This scientific paper highlights their significant impact on product quality and consumer preference, as well as their potential preventive and therapeutic applications for human health [6].

Another study examined the effect of applying plant growth regulators on the chemical composition of grapes. The best results were obtained when the growth regulators were applied twice in the vineyard, significantly affecting the sugar content and acidity of the grape clusters [7].

The aim of the current study was to provide a useful analytical platform for identifying characteristic molecular markers related to the authenticity of Italian fortified wines. For this purpose, the volatilomic fingerprints of the most popular Italian fortified wines were determined using headspace solid-phase microextraction coupled with gas chromatography–mass spectrometry (HS-SPME/GC–MS). The obtained data offer an effective means to verify the authenticity and genuineness of Italian fortified wines, while also serving as a valuable tool for detecting potential adulteration or blending cases due to their high commercial value. Furthermore, these data contribute to the advancement of scientific knowledge, wine quality evaluation, and consumer safety assurance [8].

Aroma reconstitution experiments demonstrated that blackberry, green pepper, honey, raspberry, caramel, smoke, and cinnamon aromas exhibited high similarity between the original Marselan wine and the reconstructed model wine. In addition, omission tests were performed to more precisely assess the contribution of individual odorants to the overall aroma [9].

The study revealed that the transformation patterns of aroma compounds from grapes to wine differ depending on the grape variety. This provides a theoretical framework for precise regulation of wine aroma and taste, which is of great practical importance for winemaking [10]. The research successfully established volatile compound-based aroma fingerprints of samples collected at different stages of Marselan wine production [11].

A separate study analyzed seven Chinese regions producing Marselan wines, examining their basic composition, volatile compounds, sensory properties, and antioxidant capacity. Principal component analysis (PCA) and orthogonal partial least squares–discriminant analysis (OPLS-DA) based on organic acids and anthocyanins enabled clear differentiation among regions [12].

The results also showed that applying organic amendments derived from winemaking waste affected the concentration of volatile compounds, particularly those responsible for varietal aroma expression [13]. As aroma is a critical sensory attribute influencing wine quality and consumer preference, this topic has been thoroughly reviewed. The findings provide a theoretical basis for improving winemaking technology and wine quality [14].

All vinification technologies studied led to an increase in volatile compounds compared with control wines. However, the most significant changes in aroma activity and sensory profiles were observed with pellicular maceration and supra-extraction technologies. In particular, supra-extraction resulted in the highest terpene content and consequently the most intense floral aroma notes. This method enhanced the intensity and aromatic quality of Palomino Fino white wine, revealing previously unobserved floral characteristics [15].

The grape skin is the main source of chemical compounds contributing to varietal aroma composition. Results demonstrated that extended post-fermentative maceration produced wines with the highest total volatile aroma compound concentration, especially monoterpenes, alcohols, and esters. Sensory analysis further indicated that wines with longer maceration times (M14, M21, M42) exhibited more complex aromas, varietal floral typicity, enhanced fruitiness, dry fruit notes, moderate honey, and herbal nuances. These results provide valuable insights for winemakers in selecting vinification technologies suitable for desired wine styles and may promote greater diversification of the white wine market [16].

Over the past decade, winemaking has seen the installation of numerous fermentation vessels of different shapes and materials. In one study, four differently shaped borosilicate flasks (cylindrical, conical, ovoid, and spherical) were used in triplicate for the alcoholic fermentation of white grape must. The results emphasized the importance of fermentor shape, suggesting that it should be considered not only in laboratory-scale experiments but also in industrial wine production [17].

Further studies have focused on the selection of grape varieties and the preparation of blending components for Marsala wine production. The blending was performed using three components in a 1:1:1 ratio, and the physicochemical composition and sensory characteristics of both the components and the final blend were evaluated [18]. In parallel, investigations were carried out on the preparation of extracts from grape cluster solid parts [19], their use as enrichment components [20], and in the production of functionally targeted products [21].

The main objective of the present work is to investigate the influence of various factors on the physicochemical composition of Marsala wine material.

To achieve this goal, the following tasks were set: to study the effect of enzyme preparations on the physicochemical parameters of Marsala wine material; to investigate the influence of extracts obtained from solid parts of the grape cluster on the composition of Marsala wine material; to determine the effect of different extraction and processing methods on the content of aromatic compounds in Marsala wine material.

Materials and methods.

The objects of study include grapes, juice, stems, pomace, wine materials, and auxiliary substances. During the experiments, white grape varieties were used. Grapes intended for Marsala wine production must accumulate a high amount of sugars and dry matter, while containing a low concentration of titratable acids. Furthermore, they should ensure maximum extraction of nitrogenous, phenolic, and other extractive compounds from the solid parts of the berry. This creates favorable conditions for the formation of specific characteristics typical of Marsala's taste and bouquet, through enrichment of the wine material with products of the Maillard reaction.

For this purpose, Rkasiteli grapes (at least 50%) and other white varieties cultivated under local conditions-such as Bayanshira, Chardonnay, Aligoté, and Feteasca-were used to prepare blended wine materials. The blend included fortified dry wine material, fortified juice, and fortified vacuum-concentrated juice (pekmez).

To extract the necessary compounds from stems and pomace, various extractants of different concentrations were used-including fortified dry wine material, sweet fortified wine material with residual sugar, and ethanol-water mixtures (or ethanol-juice mixtures). Their extraction efficiency from solid parts was studied under different **extraction module ratios**. Prior to use, the stems and pomace were subjected to fermentation, and the completion of fermentation was determined organoleptically by aroma and color.

During the research process, yeast sediments and yeast autolysates were used, with optimization of the best variants for application. The must and wine materials were produced using the “white method” under various technological conditions: keeping the mash for different durations (12, 24, 36, and 48 hours); fermenting the mash; adding different enzyme preparations (Selloviridin QZX, Sellofoetidin, and Pectofoetidin); subjecting the mash to heat treatment at different temperatures (30–70 °C) and durations (30 min–3 h); fermenting the mash together with grape stems, and other variations.

Wine materials were prepared in different sugar concentrations (residual sugar conditions). During fortification, both rectified ethyl alcohol (96%) and raw grape spirit (25–90%) were used to obtain wine materials of different strength.

The climatic conditions of the Aran region of Azerbaijan show significant similarity to those of Sicily, making it feasible to study Marsala-type wine production under local conditions. However, identifying the optimal technological method requires the evaluation of multiple processing variants.

Grapes were harvested when the berries reached at least 20 g/100 ml sugar content and 6–8 g/dm³ titratable acidity. During harvesting, the clusters and berries were sorted, and all parts affected by diseases or pests were removed.

The physicochemical parameters of musts, wine materials, and wines were determined using generally accepted, modern, and modified analytical methods [22, 23].

Determination of Organic Acids, Glucose, and Fructose

These analyses were performed using a Shimadzu chromatograph equipped with a Phenomenex Luna C18 column (2.1 × 150 mm) filled with sorbent material.

Determination of Amino Nitrogen

The method is based on the interaction of amino groups with formaldehyde, forming methylene derivatives, which act as stronger acids and can be titrated with alkali. The permissible limit of amino nitrogen was found to be 23 mg/dm³.

Determination of Amino Acids, Aromatic Compounds, Volatile Components, Anthocyanins, and Polyphenols

The quantitative analysis of these compounds was performed using modern instrumental analytical methods.

Determination of Volatile Compounds

The major volatile components were determined by direct gas chromatography using an Agilent Technologies 6890 gas chromatograph equipped with a plasma-ionization detector.

Column: fused-silica capillary (DV-5, 60 m length, 0.33 mm diameter)

Carrier gas: nitrogen, flow rate 3 cm³/min

Injector and detector temperature: 230 °C

Oven temperature program: 70–190 °C at 4 °C/min

Sample volume: 1 µL

Quantification was carried out using the absolute calibration method.

The mathematical processing of experimental data was performed according to established statistical procedures [24, 25].

Results of the research and their discussion

During the preparation of blending components for Marsala wine, cellulolytic and pectolytic enzyme preparations were applied. Experiments were conducted using Rkasiteli and Rkasiteli–Bayanshira blends. In the control variant, the “white method” was applied without the use of enzymes. In the remaining three variants, different enzyme preparations were added to the mash (Table 1).

Table 1 – Physicochemical parameters of fortified dry wine materials obtained with the use of enzyme preparations (Rkasiteli variety), $n = 6$, $p < 0.05$

Indicators	Methods of obtaining wine material			
	Control (by the white method)	Processing of the mash with various enzyme preparations		
		Selloviridin QZX	Sellofoetidin	Pectofoetidin Q10X
Alcohol, %	19,4	20,0	19,8	19,9
Sugar, g/100 cm³	0,7	1,0	1,05	1,15
Titrləşən turşuluq, q/dm³	6,1	6,1	6,5	6,3
Volatile acids, g/dm³	0,51	0,46	0,50	0,47
Polysaccharides, mg/dm³	330	176	167,5	156
Pectin substances, mg/dm³	46	38	41	17
Saturated esters, mg/dm³	131	143	151	150
Total nitrogen, mg/dm³	210	226	234	242
Amino nitrogen, mg/dm³	72	92	104	116
Ammonia nitrogen, mg/dm³	4,5	2,8	3,0	4,5
Protein, mg/dm³	12	5,0	4,0	3,0
Glycerin, mg/dm³	7,2	7,2	7,5	7,8
pH	3,4	3,4	3,6	3,5
Turbidity	0,3	0,4	0,2	0,1

As can be seen, the wine samples were produced with almost identical alcohol strength, sugar content (virtually no residual sugar), and total acidity. The application of enzyme preparations resulted in an increase in the amount of nitrogenous compounds (excluding proteins), while the contents of polysaccharides and pectic substances generally decreased.

In fortified dry wine materials obtained from the Rkasiteli grape variety using different enzyme preparations, the content of phenolic compounds and monomeric flavonoids was investigated. A notable increase in both total phenolic compounds and monomeric flavonoids was observed compared to the control (Fig. 1).

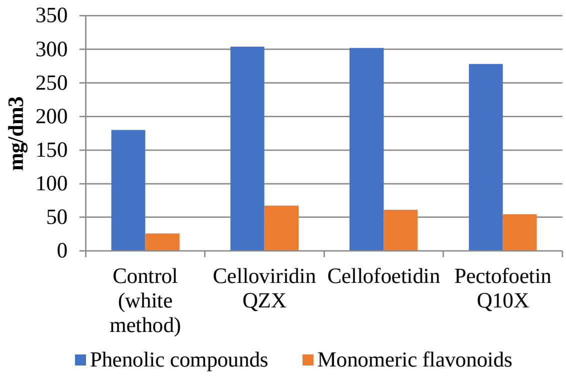

Fig. 1. The content of phenolic compounds and monomeric flavonoids in fortified dry wine materials obtained from the *Rkasiteli* grape variety using different enzyme preparations, $n = 6$, $p < 0.05$.

It was found that the greatest increase in the amount of phenolic compounds was observed when the enzyme preparation Selloviridin QZX was used. In comparison, a smaller increase in phenolic compounds was recorded in the variant where Pektofoetidin Q10X enzyme preparation was applied, while the Sellofoetidin enzyme preparation showed intermediate results.

When examining the content of monomeric flavonoids, it becomes clear that this indicator correlates with the trend observed for total phenolic compounds.

Wine samples were also prepared from a blend of grape varieties dominated by Rkasiteli (80%) combined with Bayanshira (Table 2).

As can be seen, in this series of experiments, the alcohol, sugar, and acidity levels of the samples were almost identical. Compared to the control variant, the experimental samples showed a decrease in the amount of polysaccharides by 154–174 mg/dm³, while the total nitrogen content increased by 16–32 mg/dm³.

It was found that the use of enzyme preparations resulted in different values of extract content in the samples prepared from pure Rkasiteli and from the Rkasiteli + Bayanshira blend (Fig. 2).

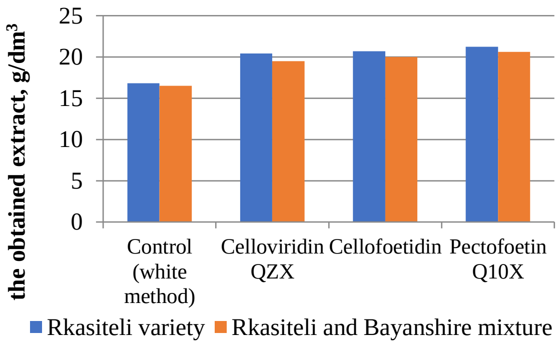

Fig. 2. The content of extract substances in fortified dry wine materials prepared from different grape varieties using enzyme preparations, $n = 6$, $p < 0.05$.

Table 2 –Physico-chemical composition indicators of fortified dry wine materials obtained with the use of enzyme preparations (from a mixture of Rkasiteli and Bayanshira grape varieties), $n = 6$, $p < 0.05$.

Indicators	Methods of wine production			
	Control (white method)	Treatment of the mash with various enzyme preparations		
		Selloviridin QZX	Sellofoitidin	Pektofoetidin Q10X
Alcohol, %	19,8	19,6	19,7	19,6
Sugar, g/100 cm²	0,3	0,4	0,3	0,5
Titratable acidity, mg/dm³	5,3	5,0	5,1	5,2
Volatile acidity, mg/dm³	0,56	0,46	0,4	0,5
Polysaccharides, mg/dm³	290	210	190	170
Pectin, mg/dm³	51	42	30	24
Saturated esters, mg/dm³	122	130	136	144
Total nitrogen, mg/dm³	190	204	210	220
Amino nitrogen, mg/dm³	60	76	84	100
Ammonia nitrogen, mg/dm³	-	-	-	-
Protein, mg/dm³	10	8	7	5
Glycerin, mg/dm³	6,3	6,6	6,7	6,9
pH	3,4	3,6	3,4	3,3
Turbidity	0,5	0,4	0,5	0,3

As can be seen, compared to the control sample (white method), the amount of extract substances was significantly higher in the samples prepared with the use of enzyme preparations.

When comparing the grape varieties, it was observed that this indicator was higher in the pure Rkasiteli variety than in the Rkasiteli + Bayanshira blend.

The content of phenolic compounds, including monomeric flavonoids, was determined in the wine samples prepared from the Rkasiteli + Bayanshira blend (Fig.3).

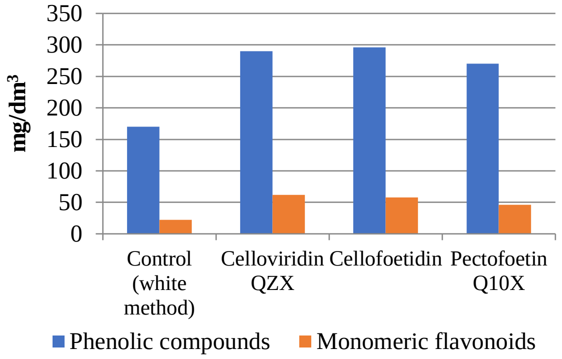

Fig. 3. Content of phenolic compounds and monomeric flavonoids in wine samples prepared from a Rkasiteli+Bayanshira grape blend using different enzyme preparations, n = 6, p < 0.05.

As can be seen, compared to the control, the experimental samples showed a significant increase in total phenolic compounds and monomeric flavonoid content.

An organoleptic evaluation of the wine samples prepared from pure Rkasiteli and from the Rkasiteli + Bayanshira blend with enzyme preparations was conducted using a 10-point scoring system (Fig. 4).

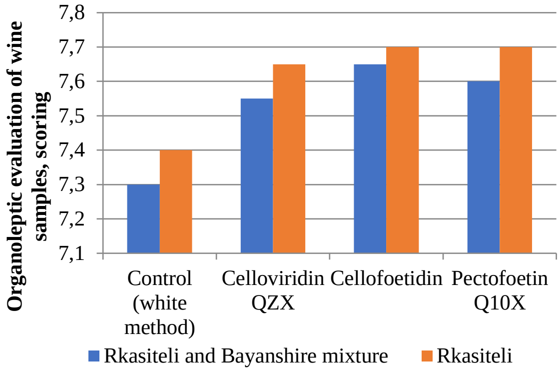

Fig. 4. Organoleptic evaluation of wine samples prepared from different grape varieties using enzyme preparations, *n* = 6, *p* < 0.05.

As shown in the diagram, the experimental samples were rated 0.25–0.30 points higher than the control. Among them, the wine material prepared from pure Rkasiteli was evaluated higher than that prepared from the Rkasiteli + Bayanshira blend.

Regarding the variants, among the wines from the Rkasiteli variety, the samples with Selloviridin QZX and Pektofoetidin Q10X enzyme preparations received the highest scores, whereas in the Rkasiteli + Bayanshira blend, the sample with Sellofoetidin enzyme preparation was rated the highest. Using enzyme preparations, another blending component-mistelle-was prepared (Table 3).

Table 3 – Physicochemical and organoleptic characteristics of fortified grape juice (mistelle) prepared with enzyme preparations (Rkasiteli grape variety), n = 6, p < 0.05.

Indicators	Methods of obtaining juice samples			
	Control (by the white method)	Processing of the mash with various enzyme preparations		
		Selloviridin QZX	Sellofoetidin	Pektofeotidin Q10X
Alcohol, %	19,7	20,03	19,9	20,01
Sugar, g/100 cm³	20,03	20,01	20,02	20,02
Titratable acidity, g/dm³	5,2	5,3	5,7	5,5
Volatile acids, g/dm³	0,14	0,16	0,22	0,18
Extract, g/dm³	16,1	19,7	20,0	20,6
Polysaccharides, mg/dm³	470	300	280	280
Pectin substances, mg/dm³	94	80	76	65
Saturated esters, mg/dm³	36	38	42	34
Phenolic compounds, mg/dm³	230	346	354	324
Monomeric flavonoids, mg/dm³	46	90	86	80
Total nitrogen, mg/dm³	270	302	316	322
Amino nitrogen, mg/dm³	110	140	144	150
Ammonia nitrogen, mg/dm³	16,4	12,1	13	10,6
Protein, mg/dm³	19	12,0	11	9
Glycerin, g/dm³	0,6	0,8	0,7	0,9
pH	3,5	3,1	3,15	3,1
Turbidity	1,5	1,0	0,5	0,2
Organoleptic evaluation of wine samples, points	7,3	7,55	7,60	7,65

As can be seen, in this series of experiments, the enzyme preparations Selloviridin QZX, Sellofoetidin, and Pektofoetidin Q10X were used. Immediately after obtaining the juice, all samples were fortified to achieve an alcohol content of 20% (v/v). The samples exhibited almost identical alcohol strength, sugar content, and titratable acidity.

Compared to the control, the experimental samples showed higher levels of extract, phenolic compounds, monomeric flavonoids, and total nitrogen. In both the control and experimental samples, the glycerol content remained below one unit, which may be associated with the lack of fermentation in these mistelle samples.

In the experimental samples, a decrease in polysaccharide content was observed compared to the control (Fig. 5). As can be seen, the polysaccharide content decreased by 170–179 mg/dm³, while the content of pectic substances decreased by 14–29 mg/dm³.

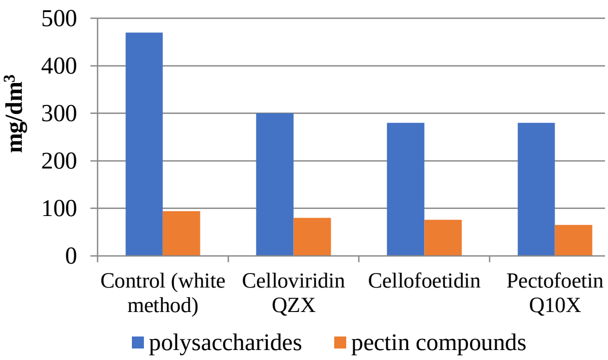

Fig. 5. Effect of enzyme preparations on the polysaccharide content in mistelle samples, *n* = 6, *p* < 0.05.

Among the samples, the variant prepared with the Pektofoetidin Q10X enzyme preparation was characterized by the highest organoleptic score**.**

Investigation of the effect of extracts obtained from grape pomace solids on the composition of Marsala wine materials

To further enrich the composition of Marsala blending components, extracts obtained from the solid parts of the grape pomace were used. Experiments were carried out using extractants of different compositions (Tables 4 and 5).

As can be seen, in these experiments, grape spirit with 62.4% alcohol, water–alcohol mixtures with 23.6% and 44.2% alcohol, as well as fortified juice with 26.1% and 45.2% alcohol were used. Both the physicochemical analyses and organoleptic evaluation indicated that the extractant of fortified juice with 26.1% alcohol provided the best extraction efficiency.

In this case, the phenolic compounds, aromatic substances, and volatile phenolic compounds reached more optimal levels. This sample was rated 0.4 points higher than the control.

As seen from Table 5, in this series of experiments, the extractants used included juice + water (1:1) + alcohol mixtures with 25.8% and 42.3% alcohol, fortified dry wine with 26.5% and 46.3% alcohol, as well as dry wine + water (1:1) + alcohol mixtures with 21.7% and 48.1% alcohol.

Both physicochemical and organoleptic evaluations indicated that the extractant of fortified dry wine with 26.5% alcohol produced the best results.

The amino acid composition of the extracts obtained with different extractants, as well as of the wine samples enriched with these extracts, was analyzed (Table 6).

Table 4 – Physicochemical and organoleptic characteristics of various extracts obtained from grape pomace, *n* = 6, *p* < 0.05.

Indicators	Composition of extracts				
	Grape spirit	Water + alcohol	Water + alcohol	Juice + alcohol	Juice + alcohol
Alcohol, %	62,4	23,6	44,2	26,1	45,2
Sugar, g/100 cm²	0,7	2,1	1,7	9,5	6,3
Titratable acids, g/dm³	1,6	2,8	2,7	3,2	2,9
pH	4,2	4	4,4	4,1	3,4
Phenolic compounds, mg/dm³	3560	4840	4030	5160	4680
Lignin	480	160	210	280	230
Tannin, g/dm³	4,6	2,1	2,7	2,2	2,5
Leucoanthocyanins, mg/dm³	260	310	290	760	370
Aromatic compounds, mg/dm³	21,6	32,3	16,4	41,4	26,5
Volatile phenolic compounds, µg/dm³	-	120	94	170	110
Total nitrogen, mg/dm³	110	90	120	410	360
Amino nitrogen, mg/dm³	40	36	44	190	160
Higher alcohols, mg/dm³	2600	1900	2310	780	1340
Turbidity	-	11	13	15	12
Sensory evaluation, points	7,3	7,5	7,4	7,7	7,5

Table 5 – Physicochemical and organoleptic characteristics of various extracts obtained from grape pomace, $n = 6$, $p < 0.05$.

Indicators	Composition of extracts					
	Juice + water (1:1) + alcohol	Juice + water (1:1) + alcohol	Acid wine + alcohol	Sour wine + alcohol	Acid wine + water (1:1) + alcohol	Sour wine + water (1:1) + alcohol
Alcohol, %	25,8	42,3	26,5	46,3	21,7	48,1
Sugar, g/100 cm²	4,2	2,6	0,3	0,1	0,3	0,2
Titratable acids, g/dm³	3,0	2,4	3,6	3,1	2,4	2,2
pH	3,8	3,6	4,2	4,3	3,4	3,8
Phenolic compounds, mg/dm³	3780	4210	5620	3750	4930	4360
Lignin	250	202	360	450	310	390
Tannin, g/dm³	2	2,3	5,3	3,1	4,9	3,7
Leucoanthocyanins, mg/dm³	530	330	1320	360	810	310
Aromatic compounds, mg/dm³	36,2	22,4	49,8	28,1	38,1	24,2
Volatile phenolic compounds, µg/dm³	140	102	260	130	180	90,3
Total nitrogen, mg/dm³	220	180	260	220	230	170
Amino nitrogen, mg/dm³	100	92	120	104	100	80
Higher alcohols, mg/dm³	1060	1290	3120	2710	2150	2430
Turbidity	16	14	17	19	21	20
Sensory evaluation, points	7,55	7,45	7,85	7,75	7,6	7,45

Table 6 – Amino acid composition of extracts obtained with different extractants and wine samples enriched with these extracts, $n = 6$, $p < 0.05$.

Amino acids	Content in samples, mg/dm³			
	Acid wine + alcohol		Extract + wine	
	Obtained from comb	Obtained from grape pomace	Comb extract + wine	Pomace extract + wine
Lysine	25,4	26,1	20,3	21,2
Histidine	8,6	9,3	24,2	25,1
Arginine	85	81	187	176
Aspartic acid	52,1	48,7	46	53
Threonine	13,6	14,2	56,1	59,2
Serine	17,3	16,8	62,0	71
Glutamic acid	65,1	61,9	112,4	87,3
Proline	210	230	262	258
Glycine	13,3	12,9	10,2	11,3
Alanine	56,3	61,5	76,8	81,0
Leucine	8,4	9,2	4,1	3,7
Valine	8,0	11,0	27,1	25,2
Methionine	7,7	7,1	5,1	4,6
Isoleucine	10,6	11,4	15,4	17,3
Lysine (note: “Leysin” is a duplicate of Lysine)	12,9	14,6	20,0	17,1
Tyrosine	9,6	7,4	3,8	3,2
Phenylalanine	42,9	34,0	59,1	51,7

As can be seen, 17 amino acids were detected in the wine samples enriched with extracts obtained from grape pomace and marc. The wine–spirit extracts obtained from grape stems and grape pomace were added separately to the wine samples. As a result, a significant increase in the content of several amino acids was observed. This is particularly evident in the amounts of histidine, arginine, threonine, serine, glutamine, alanine, valine, and phenylalanine.

Investigation of the effect of processing methods on the content of aromatic compounds in Marsala wine materials. The aromatic compound composition of Marsala blending components obtained using different methods was analyzed (Tables 7 and 8).

Using the "white method" (control), as well as the methods "24-hour maceration", "punching down the pomace", "heating the pomace up to 65°C, and "punching down with fresh pomace", and after the addition of pomace and marc extracts, the wine samples were analyzed for aromatic compounds. The analyses revealed the presence of aromatic aldehydes, complex and simple volatile esters, and higher alcohols.

The quantities of these compounds varied depending on the processing method, with the samples enriched with pomace and marc extracts showing the most pronounced effects.

During the application of various technological methods, it was found that the samples showed the most pronounced differences in the content of vanillin and jasmine aldehyde (Fig. 6).

It was found that the samples enriched with pomace and marc extracts exhibited a richer aromatic profile. In these samples, the contents of vanillin, jasmine aldehyde, and simple volatile **esters** were significantly higher compared to the other samples.

Table 7 – Effect of juice contact with pomace and thermovinification on the content of aromatic compounds, mg/dm³, n = 6, p < 0.05.

Indicators	Methods of obtaining wine material			
	Control (by the white method)	Mash stored for 24 hours	Fermentation in the mash	Heating the mash up to 65 °C
Aromatic aldehydes:				
Coniferol	0,07	0,1	0,4	0,8
Sinapaldehyde	0,06	0,1	0,3	0,9
Total complex esters	101,6	124	156,4	190,6
Easily volatile esters	42,8	48,6	59,8	88,6
High-boiling esters	58,8	75,4	96,6	102,0
Higher alcohols	125	188	283	296

Table 8 – Effect of pomace and marc extracts and punching down with pomace on the content of aromatic compounds, mg/dm³, n = 6, p < 0.05.

Indicators	Methods of obtaining wine material			
	Control (by the white method)	Fermentation of the mash with fresh comb	After adding comb extract	After the ginger extract is added
Aromatic aldehydes:				
Coniferol	0,07	1,2	1,7	1,6
Sinapaldehyde	0,06	1,1	1,7	1,7
Total amount of complex esters	101,6	164,6	230,3	251,3
Easily volatile esters	42,8	76,0	97,4	108,1
High-boiling esters	58,8	88,6	132,9	142,8
Higher alcohols	125	325	449	564

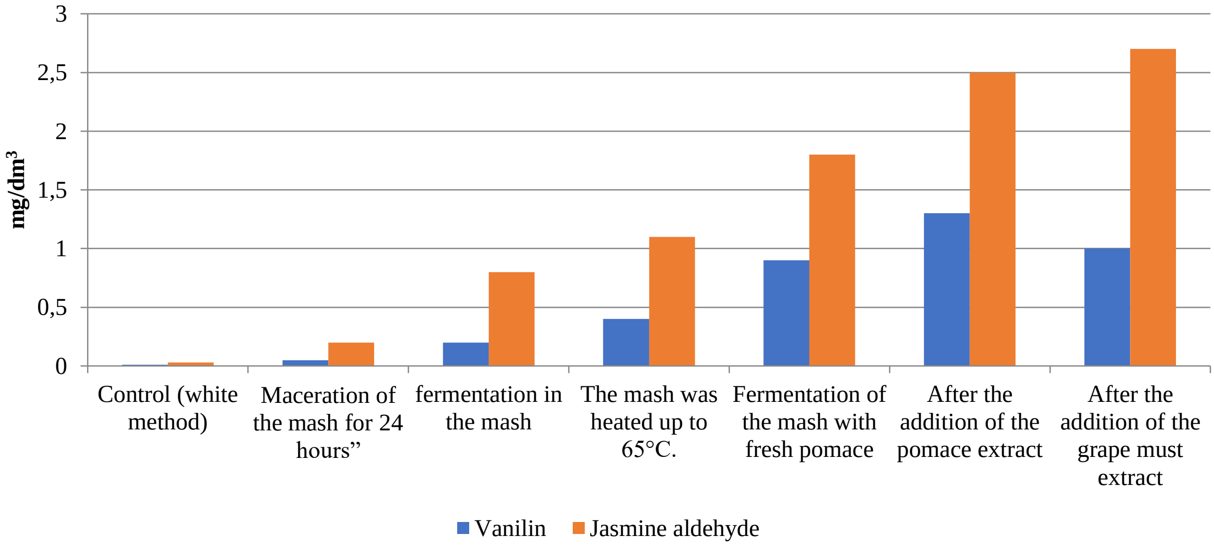

Fig. 6. Content of aromatic aldehydes-vanillin and jasmine aldehyde-in Marsala blending components, n = 6, p < 0.05.

Conclusion

1. The use of Selloviridin QZX, Sellofoetidin, and Pektofoetidin Q10X enzyme preparations in the preparation of Marsala blending components intensifies the process and provides advantages over traditional methods, including lower equipment, energy, and labor requirements. The highest increase in phenolic compounds was observed with Selloviridin QZX, while the lowest increase occurred with Pektofoetidin Q10X. The Sellofoetidin variant held an intermediate position. Compared to the white method (control), the addition of enzyme preparations to the must resulted in a significantly higher extracted content. The experimental samples were rated 0.21–0.30 points higher than the control, with wines prepared from pure Rkasiteli grapes outperforming those made from the Rkasiteli + Bayanşirə blend.

2. To further enrich the composition of the blending components, pomace and marc extracts were used. Comparative analysis of various extractants showed that 26,1% alcohol-strength fortified juice and fortified acidic wine of the same strength were the most highly rated. Wines prepared with extracts from pomace and marc showed a richer composition, including detectable amino acids, and were significantly superior to other samples.

3. Analysis of the aromatic profile demonstrated that samples enriched with extracts exhibited a richer aromatic composition. In these samples, the contents of vanillin, jasmine aldehyde, and other aromatic compounds were significantly higher than in the other analogs.

References

1. Teresa Abreu, Rosa Perestrelo, Matteo Bordiga, Monica Locatelli, Jean Daniel Coïsson, José S. Câmara. The Flavor Chemistry of Fortified Wines-A Comprehensive Approach. *Foods* 2021, *10*(6), 1239; https://doi.org/10.3390/foods10061239.
2. Rosa Perestrelo, Yassine Jaouhari, Teresa Abreu, Mariangie M. Castillo, Fabiano Travaglia, Jorge A. M. Pereira, José S. Câmara, Matteo Bordiga. The Fingerprint of Fortified Wines—From the Sui Generis Production Processes to the Distinctive Aroma. *Foods* 2023, *12*(13), 2558; https://doi.org/10.3390/foods12132558
3. Francisco Espejo . Role of commercial enzymes in wine production: a critical review of recent research. J Food Sci Technol. 2020 May 2;58(1):9–21. doi: 10.1007/s13197-020-04489-0
4. Ivana Generalić Mekinić, Živko Skračić, Ana Kokeza, Barbara Soldo, Ivica Ljubenkov, Mara Banović, Vida Šimat. Effect of Enzyme-Assisted Vinification on Wine Phenolics, Colour Components, and Antioxidant Capacity. Pol. J. Food Nutr. Sci. 2020;70(2):113-123. DOI: https://doi.org/10.31883/pjfns/115461
5. Susana Río Segade, Mattia Malabaila , Domen Škrab, Maria Alessandra Paissoni, Simone Giacosa,Carlo Montanini, Luca Rolle. Variety effect of distinct enzyme treatments during prefermentative maceration of white winegrapes on volatile organic compounds and chromatic traits. https://doi.org/10.1016/j.fbio.2024.103915
6. Katarina Delić, Danijel D. Milinčić, Mirjana B. Pešić, Steva Lević, Viktor A. Nedović, Anne-Laure Gancel, Michael Jourdes, Pierre-Louis Teissedre. Grape, wine and pomace anthocyanins: winemaking biochemical transformations, application and potential benefits. Vol. 58 No. 4 (2024): OENO One. https://doi.org/10.20870/oeno-one.2024.58.4.8039
7. K.S. Sultanov, P.E. Egamberdiev, I.S. Jolbekov. The influence of the use of growth substances on the chemical composition of sultanas' grape juice. February 29,2024, https://theusajournals.com/index.php/ajahi/article/view/2525/2434
8. Gonçalo Jasmins, Gonçalo Jasmins, Rosa Perestrelo, Jean Daniel Coïsson, Patrícia Sousa, José A. Teixeira, Matteo Bordiga, José S. Câmara. Tracing the Volatilomic Fingerprint of the Most Popular Italian Fortified Wines. *Foods* 2023, *12*(10), 2058; https://doi.org/10.3390/foods12102058
9. Jiaheng Lyu, Yue Ma, Yan Xu, Yao Nie, Ke Tang. Characterization of the Key Aroma Compounds in Marselan Wine by Gas Chromatography-Olfactometry, Quantitative Measurements, Aroma Recombination, and Omission Tests. *Molecules* 2019, *24*(16), 2978; https://doi.org/10.3390/molecules24162978
10. Yi-Lin Ge, Nong-Yu Xia, Ya-Chen Wang, Hua-Lin Zhang, Wei-Ming Yang, Chang-Qing Duan, Qiu-Hong Pan. Evolution of Aroma Profiles in *Vitis vinifera* L. Marselan and Merlot from Grapes to Wines and Difference between Varieties. *Molecules* 2024, *29*(14), 3250; https://doi.org/10.3390/molecules29143250.
11. Lei Fang, Ningli Qi, Tinghui Chen, Xiao Gong. Changes in the physicochemical and volatile profiles during the winemaking of Marselan in the Eastern Foot of Helan Mountain, China (2024). *Food Innovation and Advances* 2024, 3(4): 396−404 . https://doi.org/10.1016/j.fochx.2024.101606.
12. Yue Wang, Caihong Li, Qian Ge, Xingsan Huo, Tingting Ma, Yulin Fang, Xiangyu Sun. Geographical characterization of wines from seven regions of China by chemical composition combined with chemometrics: Quality characteristics of Chinese 'Marselan' wines. Food Chemistry: X. Volume 23, 30 October 2024, 101606. https://doi.org/10.1016/j.fochx.2024.101606
13. María Osorio Alises, María Osorio Alises, Eva Sánchez Palomo, Miguel Ángel González-Viñas. Wine Waste Compost Addition to a Vineyard of Chelva Grape of Central Spain: Effect on Wine Volatile Compounds. *Horticulturae* 2025, *11*(2), 219; https://doi.org/10.3390/horticulturae11020219
14. Yang He, Xinyuan Wang, Penghui Li, Yingchi Lv, Hailong Nan, Liankui Wen, Zhitong Wang. Research progress of wine aroma components: A critical review. Food Chem. 2023 Feb 15:402:134491. doi: 10.1016/j.foodchem.2022.134491.
15. Ana M. Roldán, Ana M. Roldán, Fini Sánchez-García, Luis Pérez-Rodríguez, Víctor M. Palacios. Influence of Different Vinification Techniques on Volatile Compounds and the Aromatic Profile of Palomino Fino Wines. ***Foods*** 2021, ***10***(2), 453; https://doi.org/10.3390/foods10020453.
16. Sanja Radeka, Sanja Radeka, Ena Bestulić, Sara Rossi, Fumica Orbanić, Marijan Bubola, Tomislav Plavša, Igor Lukić, Ana Jeromel. Effect of Different Vinification Techniques on the Concentration of Volatile Aroma Compounds and Sensory Profile of Malvazija Istarska Wines. ***Fermentation*** 2023, ***9***(7), 676; https://doi.org/10.3390/fermentation9070676
17. Paloma Córdova-Palominos, Carla Jara, V Felipe Laurie, Álvaro Peña-Neira, Mariona Gil i Cortiella. The Impact of Fermenter Shape on the Performance of White Wine Alcoholic Fermentation and the Composition of the Resulting Wines in Laboratory-Scale Trials. J Food Sci.2025 Jul 21;90(7):e70395. doi: 10.1111/1750-3841.70395.
18. Fataliyev.H.K. ,Huseynova.Sh.İ. , Aghazada Y. E. , Aghayev G. U., Musayev T.M. Study of the influence of different technological methods on the composition and quality of marsala coupage components Food science and technology. 2025. Vol. 19, Issue 1. P. 45-53. https://doi.org/10.15673/fst.v19i1.3119
19. H.Fataliyev; N.Gadimova; Sh.Huseynova; S.Isgandarova; E.Heydarov; S.Mammadova. Enrichment of functional drinks using grape pomace extracts, analysis of physicochemical indicators. Eastern-European Journal of Enterprise Technologies ISSN 1729-3774.

Technology and Equipment of Food Production: food technology. 3/11 (129) 2024. 37-45. DOI: 10.15587/1729-4061.2024.307039 https://journals.uran.ua/eejet/article/view/307039

20. .Fataliyev H.K., Qadimova N.S., Allahverdiyeva Z.C., Musayev T.M., Akhundova Nazilya, Babashli Aynur. Obtaining and investigation of the chemical composition of powdered malt and polymalt extracts for application in the production of nonalcoholic functional beverages. Eastern-European Journal of Enterprise Technologies ISSN 1729-3774, 5/11 (119) 2022, p. 66-74. DOI: 10.15587/1729-4061.2022.265762

21.Fataliyev H.K., Mammadova S.M., Gadimova N.S., Aliyeva G.R., Tagıyev A.T., Baloglanova K.V. Production of functional products using grape processing residuals. Food Science and Technology, Campinas, Ahead of Print, Braziliya, 2020. P.1-7. DOİ:https://doi.org/10.1590/fst.30419

22..Fataliyev H.K. Winemaking practicum. Baku: Elm, 2013, 328 s.

23.Fataliyev H.K Wine technology. Baku: Elm, 2011, 596 p.

24.Sheskin D.J. Handbook of Parametric and Nonparametric Statistical Procedures. Chapman and Hall/CRC, 1928. 2020. https:// doi.org/10.1201/9780429186196

25.Gadimova N., Fataliyev H., Heydarov E., Lezgiyev Y., Isgandarova S. Development of a model and optimization of the interaction of factors in the grain malting process and its application in the production of functional beverages. Journal "Eastern-European Journal of Enterprise Technologies", Vol.5, №11 (125) 2023: Technology and Equipment of Food Production. p. 43-56. https://journals.uran.ua/eejet/article/view/289421