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IDENTIFYING THE FACTORS AFFECTING THE PRODUCTION OF JUICE AND WINE FROM THE AUTOCHTHONOUS BAYANSHIRA GRAPE VARIETY

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The object of the study is juice and wine samples obtained from the Bayanshira grape variety. A number of studies have been conducted on this variety, but the dynamics of berry ripening and the mechanical composition of the bunch, the effect of applied technological methods on the juice and wine indices have not been sufficiently explored. The analysis of berry ripening dynamics showed that the ripening index increased by the time of ripening, fluctuating within 27.46–43.92. The average bunch length is 21.93 cm, width 9.70 cm, mass 172.11 g, the average number of berries in a bunch is 61.46 pieces, and the comb weight is 6.54 g. The average berry length was 18.46 mm, width 18.40 mm, and the average berry mass was 3.67 g.

During the treatment and storage of grape juice processed by the white method in different ways, it was found that the physicochemical composition of hot-pasteurized samples was more susceptible to changes, compared to the control, and the samples treated with ultraviolet rays retained their natural color and composition almost unchanged.

The flow of nitrogenous substances into wine increased during their storage in yeast sediment from 30 to 90 days. Raising the temperature from 8–11 °C to 25–30 °C significantly increased the flow of nitrogenous substances from yeast sediment into wine compared to other options.

These studies are important for production, as they help determine the dynamics of grape ripening at different growth stages and transformations in the physicochemical composition during the storage of juice processed by different methods, as well as regulate the processes occurring during wine preparation. The results obtained can be used in family farms and wineries

Keywords: phenolic compounds, amino nitrogen, ultraviolet rays, solid residue, mass exchange

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1. Introduction

Currently, there is a fierce competition in the world, inclCurrently, there is a fierce competition in the world, including the European wine market. In such conditions, entering these markets first of all requires an understanding of product requirements set by European Union member countries. It is known that, by the European Council's decision dated April 29, 2008, starting from 2011, wines released in European Union countries are divided into three quality categories. One of these groups is called "PGI – protected geographical indication". Wines included in this group must be produced only in a certain geographical region, using mainly grape varieties native to that region (more than 85 %). It can be noted that the growing interest in autochthonous grape varieties in recent years is also related to this requirement. Autochthonous varieties are those that originate and grow in specific geographical areas. In other words, these varieties are primarily cultivated in a limited area, associated with a country or region with unbroken vineyards, and often become its hallmark. Wines made from such grape varieties possess unique originality, reflecting the characteristics of that region. Therefore, by effectively utilizing the potential of autochthonous grape varieties, it is possible to produce original wines that meet market demand and are specific to the region.

Bayanshira is a high-quality autochthonous grape variety, native to the Bayan village in the Dashkesan district of the Republic of Azerbaijan. In other regions, this variety is known as White Grape, White Juice, and Banana. It is a late-ripening grape variety that belongs to the ecological-geographical group of Eastern grape varieties. From bud opening to harvest maturity, 165 days are required at active temperatures of 3500 °C. Its yield per hectare is 120–200 s/ha, reaching up to 350 s/ha in irrigated conditions.

Despite the aforementioned, there has been insufficient research on the production of juices and wines from the Bayanshira grape variety. Therefore, it is very relevant to study the ripening process of such a valuable variety including the dynamics of berry ripening by growth stages, the mechanical composition of the bunch, and the impact of different technological methods on the quality of juices and wines, and thereby reveal the full potential of the variety.

Based on the above, we can note that research focused on the dynamics of berry ripening by growth stages, the mechanical composition of the bunch, and the impact of various technological methods on the physicochemical composition of juice and wine, is highly relevant.

2. Literature review and problem statement

The study [1] examines the polyphenol content in skin, seed, and pulp extracts of different grape varieties. The content of flavones-3-ols in the seeds of the Semederevka grape variety was higher than that of the Chardonnay variety, total phenolic compounds and flavonoids were found in higher amounts in the seeds of the Chardonnay variety. However, this study did not address key aspects such as changes in grape composition during ripening, including the ripeness index.

The work [2] is devoted to identifying grape varieties and their origin by determining the composition of soluble dry matter. For this, the results of near-infrared (NIR) spectroscopy were checked, demonstrating that NIR technology could be a valuable alternative for identifying grape variety and origin. However, this approach did not reflect the processes occurring in grapes, as well as quality changes that arise depending on technologies applied in the resulting juice and wine.

Based on colorant distribution in grape skins, a technological method for making wine from the autochthonous Madrasa grape variety is provided [3, 4]. Additionally, an extractant is proposed for obtaining rich extracts from solid parts of bunches, along with rational modules for mixing it with solid parts [5]. However, important issues related to juice pasteurization by various methods and ensuring its stability were not resolved in these studies.

A study on recent advancements in the destabilization and removal of white wine proteins has highlighted various clarification methods, advantages and disadvantages, which can better preserve product quality, environmentally friendly and efficient protein stabilization [6], the origin, mechanism, and impact factors of unstable proteins [7]. Another study focused on ensuring product safety by removing pesticides from juice and wine [8]. Although these studies addressed the issues of eliminating protein turbidity from physicochemical turbidities and ensuring safety by removing pesticide residues, an important problem related to biological stabilization remained unresolved.

The distribution of aromatic compounds in the berries of the White Muscat grape variety and its transfer to wine samples prepared with minimum loss [9], as well as the effect of grape development stages on its antioxidant properties, bioactive and total composition, have been studie [10]. However, an important issue such as determining the mechanical composition of grape varieties, remains unsolved.

A method for assessing the quality and development stages of grape varieties during ripening using Vis/NIR and NIR technologies is provided [11]. However, studies related to juice stabilization and wine were not included.

A technology for producing functional food products enriched with grape processing by-products, particularly skins and seeds, has been proposed [12]. The effect of water deficit on the secondary metabolism of white grapes was investigated, revealing a significant impact on this process [13]. To eliminate the problem, two methods such as foliar kaolin application and intelligent irrigation regimes were evaluated [14]. However, important quality issues, starting from raw materials and ending with wine, including the mechanical composition of the bunch and transformations occurring in juice and wine depending on processing methods, were not included.

The mechanical and biochemical composition of table grape varieties grown in Uzbekistan, as well as technological indicators of large-berry varieties, were studied. A comparative evaluation of varieties was conducted, identifying superior ones [15]. Additionally, research was carried out on determining the biochemical quality indicators of nine table grape varieties during long-term storage [16]. The effect of pruning on the mechanical composition of the bunch in 3 introduced grape varieties was studied [17]. However, issues related to grape processing into juice and wine, stabilization, and the impact of various technological methods on quality were not included.

The effect of bunch thinning on grape yield and quality was evaluated [18], the yield of grape varieties, the mechanical composition of the bunch, the chemical composition of the berries were examined, and sensory evaluation was carried out. The mechanical composition of 111 grape varieties under harvesting conditions was comparatively analyzed, identifying those with higher economic parameters for cultivation [19]. However, the processes involved in juice extraction, pasteurization, and storage by different methods were not considered.

The study [20] discusses mechanical and ENO carpological analyses of bunches and clusters of some technical and table grape varieties grown in Azerbaijan. It was found that parameters such as bunch size and mass, skin and pulp residue, juice yield, and solid residue content vary widely among different varieties, especially in medium, large and small bunches. Vineyard mycobiota, which affects wine quality and vineyard sanitation, was examined. The study was conducted in Croatia. 25 different fungal genera were identified in Maraština grape clusters collected from 11 vineyards, with notable differences depending on the vineyard location [21]. However, these studies did not address how the biological stabilization of juice and different technologies used in winemaking affect its physicochemical composition.

The aim of the study [22] was to review the current status of aroma enhancement in white grapes through sustainable agronomic practices in the scientific literature. However, given uncertainties regarding some biosynthesis mechanisms and their correlation, further research was deemed necessary.

An electronic nose detection method was used to initially investigate and screen the characteristics of cherry aroma in 191 grape germplasm resources. The results of the work, in addition to initially clarifying aroma differences between different grape varieties, provided a database for selecting grape gene pools (with different aromas), which could be used as a source for obtaining new varieties with aromatic value for fresh grape production, as well as for creating a grape germplasm resource bank [23]. However, these studies did not provide solutions for juice and wine production from the autochthonous Bayanshira grape variety, which is crucial for biological stabilization and wine quality.

From the above, it is clear that changes in the physicochemical composition of the berries of the autochthonous Bayanshira grape variety depending on growth stages have not been studied. Furthermore, the impact of various technological methods on the quality of juices and wines remains insufficiently explored. As evident, this field faces a scientific problem that requires a solution.

3. The aim and objectives of the study

The aim of the study is to identifying the changes in the physicochemical composition of the grapes of the autochthonous Bayanshira grape variety depending on the growth stages, as well as the effect of various technological methods on the quality of juice and wine.

To achieve this aim, the following objectives are achieved:

– to determine the dynamics of ripening of berries by growth stages;

– to determine the mechanical composition of the bunch of Bayanshira grapes;

– to study transformations during storage of grape juice processed by different methods;

– to study the influence of various technological factors on the quality of wine.

4. Materials and methods of research

The object the study is juice and wine samples obtained froThe object of the study is juice and wine samples obtained from the autochthonous Bayanshira grape variety.

The main idea of the research is to study the dynamics of berry ripening and the mechanical composition of the bunch in comparison with the introduced varieties, transformations during storage of juice samples processed by different methods, as well as the impact of various technological methods on wine quality. The application of modern processing and analysis methods greatly simplifies the issues in the research.

The physicochemical and organoleptic properties of raw materials, semi-finished and finished products are determined by general analysis methods available in enochemistry [24]. However, the study employed modern analysis methods, computer technology, and statistical analyses were performed using the SPSS18 package [25, 26].

The mass concentration of phenolic compounds in wine was determined by the Folin-Ciocalteu method. The Folin-Ciocalteu reagent oxidizes phenolic groups in wine and reduces them to a blue compound. At this time, the color intensity is proportional to the concentration of phenolic compounds.

The color of wine samples was measured using the Hunterlab (Model D-9000 Color Difference Meter) analyzer. In Hunter, the a value determines redness and greenness, while the b value – yellowness and blueness. The L value indicates the degree of light or brightness ranging from 100 (full white) to 0 (black).

Grape ripening was monitored at the following stages: black, beginning of ripening, ripening, and overripeness. At these stages, compositional parameters of grape juice were determined and analyzed comparatively by varieties and stages. The mechanical composition was analyzed using the methodology of Professor N.N. Prosteserdov. Accurate ripening determination plays a crucial role in harvesting. To assess changes in the physical properties of grape varieties, the mass of 200 grapes was measured. The mass of 200 grapes increased steadily from the first ripening stage, the dark period, reaching a maximum during the ripening and overripening stages. Grapes harvested at the ripe stage were used for processing.

Changes in the chemical properties of grape varieties were determined by investigating pH, water-soluble solids (WDS), titratable acidity, ripeness index, total phenolic compounds, organic acids, sugar and resveratrol content.

To study changes in grape juice composition during storage, the following options were examined: Control – no juice processing; Juice pasteurization; Juice irradiation.

During the study, a comparison of different ultraviolet irradiation sources revealed that quartz tubes with a diameter of 0.27 cm (PPK lamp) were superior in wine material sterilization in the flow. Wine was irradiated for 8.5–12 seconds, with an extension to 20 seconds if necessary.

Juice samples for all 3 options were analyzed at the following storage intervals:

– initial juice (no storage);

– juice after 2 days of storage;

– juice after 6 days of storage;

– after the juice has been stored for 10 days;

– after the juice has been stored for 14 days.

All wine varieties are prepared using a unified technology according to the type of production. Once harvested, the the grapes are transported to the production site, separated from the stalks, and crushed. Depending on the type of wine being produced, grape skins are separated from the juice, and the juice is sulfurized to prevent oxidation and contamination.

As a result of the research, the ripening index of the grape in the autochthonous Bayanshira variety, the mechanical composition of the bunch will be studied, and changes in the physicochemical composition of juice and wine processed by various technological methods will be determined.

5. Results of the study on the impact of various technological methods on the composition of juice and wine samples

5. 1. Determination of the dynamics of ripening of the berry by growth stages

The mass of berries by growth stages in the local Bayanshira grape variety was studied in comparison with the introduced varieties. For this, the mass of 100 berries taken at each growth stage was measured (Fig. 1).

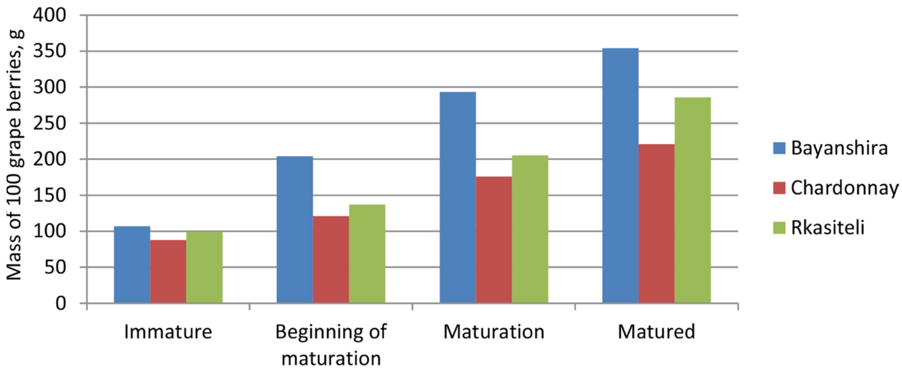

Fig. 1. Changes in grape mass by maturity stages

Fig. 1 shows that in the Bayanshira variety, the grape mass increased more than threefold in the ripening stage compared to the black period. The greatest increase occurred between the black and the beginning of ripening stages. A similar trend was observed in the other two varieties. However, the grape mass in the second and third variants was slightly lower than in the first one. When studying the pH values at these stages, it was found that this indicator increased as the grapes ripened. At the same time, a greater increase in pH was observed between the beginning of ripening and ripening stages.

One of the key quality indicators of grape juice is the amount of water-soluble dry matter (WSD). The WSD in the studied grape varieties according to berry growth stages is given below (Fig. 2).

The water-soluble dry matter content was higher in the Rkasiteli grape variety than in other varieties at all growth stages. At the final ripening stage, this indicator was 3.19 brix higher in the Rkasiteli variety than in the Bayanshira grape variety and 3.75 brix higher in the Chardonnay variety. The greatest increase in stages was observed between the beginning of ripening and the ripening stage.

Titrated acidity is one of the key quality indicators of raw materials. Therefore, the amount of titratable acids in juice samples taken at the growth stages of the studied grape varieties was determined (Fig. 3).

As can be seen, in the early stages of ripening, the titratable acidity was at the highest level for all variants. A sharp decrease occurred between the beginning of ripening and the ripening stage, which was significantly higher than in other stages. At the ripening stage, the amount of titratable acids by variant was 5.2–6.3 g/dm^3, and at the ripening and overripening stage it was 3.6–4.9 g/dm^3.

Correct determination of maturity is crucial for harvesting. The main indicator to assess maturity is the maturity index (Fig. 4).

As can be seen, in the early ripening stages (during the period of budding and the beginning of ripening), this indicator was maximum 7.71. From the beginning of ripening to ripening, the maturity index increased repeatedly, fluctuating between 27.46–43.92 for the variants. Although an increase in the maturity index was observed in the subsequent ripening and overripening stages, it was less than in the previous stage.

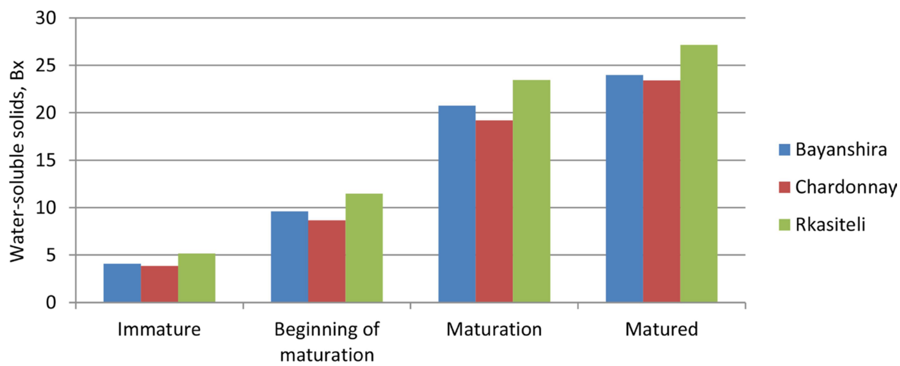

Fig. 2. Water-soluble dry matter content by varieties

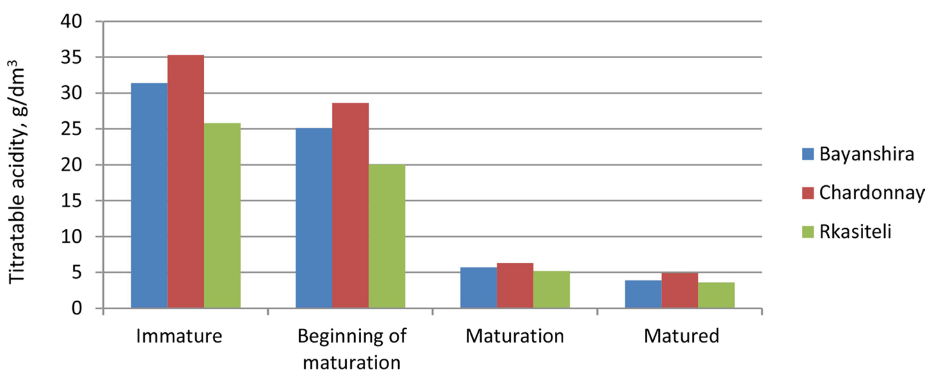

Fig. 3. Changes in the amount of titratable acids by ripening stages

Phenolic compounds play an essential role in the appearance and quality of grape berries and processed products obtained from them. Thus, these compounds and their transformation products are fundamental to the formation of product color and taste. The amount of phenolic compounds in samples at different growth stages was studied (Fig. 5).

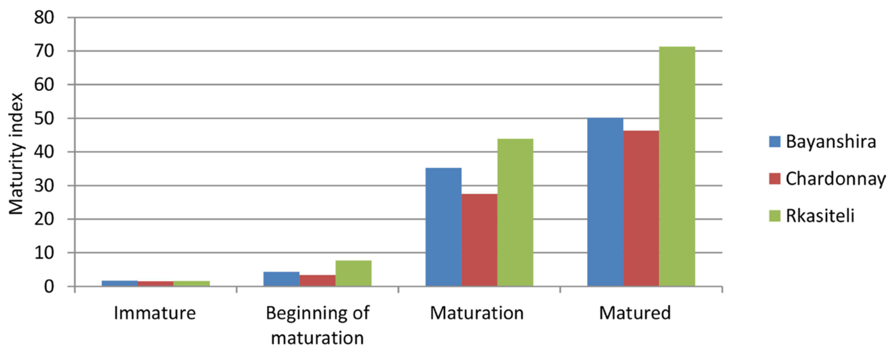

Fig. 4. Maturity index changes by maturity stage

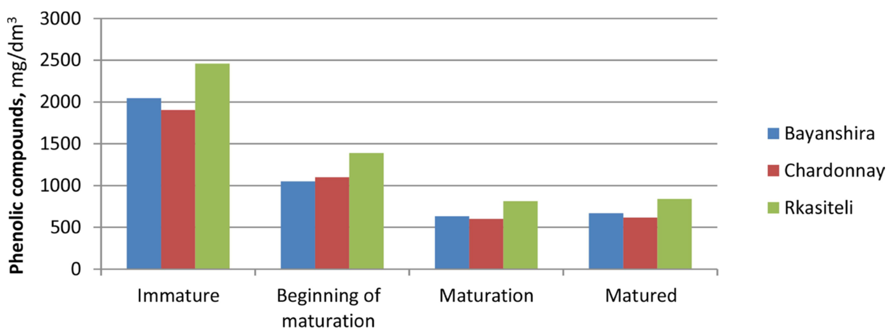

Fig. 5. Changes in the amount of phenolic compounds by growth stages

It was found that the amount of total phenolic compounds for all varieties was higher in the black stage, ranging within 1,905–2,460 mg/dm3. At the beginning of ripening, it decreased by about 70–90 %. Compared to the ripening stage, a very weak increase in the total phenolic content was observed in the ripening and overripening stage, flunctuating between 615–841 mg/dm3.

The organic acid content of the juice was studied at all ripening stages for the studied varieties. The amount of tartaric acid was higher in the black and beginning of ripening stages, with a significant decrease observed in the later stages. While the tartaric acid content in the black stage was 14.8–18.15 g/dm3, in the ripening stage it varied between 4.68–5.00 g/dm3.

In the experimental variants, the amount of malic acid was lower than tartaric acid levels. Malic acid was high in the first two stages and sharply declined in the last two stages, reaching 1.04–1.30 g/dm3 in the ripening stage.

The amount of citric acid in the studied samples was significantly lower than that of tartaric and malic acids. In the last ripening stage, citric acid decreased about tenfold compared to the black stage.

The qualitative composition of sugars by ripening stages was studied.

The amount of trans-resveratrol was determined in the juices obtained by pressing grape samples taken at different ripening stages. Starting from the black stage, a decrease in resveratrol content was observed in all three grape varieties as ripening progressed.

Observations showed that, depending on the grape variety and climatic conditions, the vines awakened between the 2nd and 4th weeks of April, full flowering began between the end of May and the first week of June, and the formation of black berries occurred in the end of July. The onset of ripening was observed from the beginning of August, and full ripening continued from mid-September to the first week of October. Considering that the studied grape varieties are mainly used in wine production, or rather, in order to achieve high alcohol and brix values, harvesting was slightly delayed and carried out after mid-September.

To assess changes in the physical properties of grape varieties, the mass of 200 berries was measured. The mass increased steadily from the first ripening stage of all grape varieties, the black stage, reaching a maximum in the ripening and overripening stage. Grapes harvested at the ripe stage were used for processing.

In order to determine the changes in the chemical properties of grape varieties, pH, SHQM, titratable acidity, ripeness index, total phenolic compounds, organic acids, sugar and resveratrol content were studied. It was observed that the pH value increased in juice samples taken for all grape varieties in relation to ripeness. This can be attributed to the decrease in organic acids as the grapes ripen.

In the studied samples, the amount of water-soluble substances increased starting from the black stage.

A decline in titratable acidity occurred in all varieties at the ripening stages, with the greatest decrease observed between the beginning of ripening and the overripe stage.

One of the most important indicators for correctly determining the harvest time of grape varieties is the ripeness index. To determine the state of ripeness, the amount of sugar and acids is measured sequentially. During the ripening period, all grape samples showed an increase in sugar concentration and a decrease in titratable acids, and the ripeness index increased.

The main organic acids found in the studied samples were tartaric and malic acids. Additionally, citric, lactic, and other acids were present, but their total amount was much lower. Starting from the black stage, the concentration of organic acids decreased with ripening in all three varieties, reaching the lowest levels in the ripening and overripe stage.

The study revealed that the main sugars found in the samples were glucose and fructose. At the same time, while small amounts of sucrose were detected, its total content was very insignificant. When looking at the samples by ripening stages, it is clear that although glucose and fructose levels increased steadily, fructose increased more significantly than glucose when reaching the ripeness stage. It was found that the juices obtained from all three variants contained more fructose. The highest increase in glucose and fructose contents was observed between the onset of ripening and the maturity stage.

Starting from the black stage, the amount of resveratrol decreased in the studied samples during ripening. The resveratrol content in the variants was higher in the Rkasiteli variety than in the others.

5. 2. Determination of the mechanical composition of the Bayanshira grape bunch

Observations were made on bunches taken by random sampling from the grown vineyards, their sizes, mass, etc. were determined (Table 1).

As can be seen, the sizes (length and width), mass, number of berries in the bunch, mass of the bunch in the bunch were determined separately for 15 randomly taken bunches, and the average values of each were calculated. The average length of the bunch was 21.93 cm, width 9.70 cm, mass 172.11 g, the average number of berries in the bunch was 61.46 pieces, and the mass of the bunch in the bunch was 6.54 g.

Table 1

Sizes and mass of bunches in the Bayanshira grape variety

Number of clusters	Length, cm	Width, cm	Mass, g	The number of berries in a bunch, number	Mass of comb in bunch, g
1	24.5	8.5	197.9	56	5.7
2	20	8.5	177.2	50	6.9
3	20.5	9.5	207	74	8.8
4	24	10.5	198.7	70	5.9
5	20.5	10.5	229.8	67	10.2
6	27	11.5	202.7	94	8
7	20	10.5	198.1	52	7.4
8	23	11	141.1	66	6.7
9	24.5	9	212.6	76	7
10	23	10.5	97.7	36	5.1
11	16.5	9.5	111.6	40	4.3
12	22	9	146.7	54	5.8
13	16	7	117.4	45	3.5
14	23.5	8	163	57	3.8
15	24	12	180.2	85	9
Average price	21.93	9.70	172.11	61.46	6.54

At the same time, indicators related to the cluster were also determined (Table 2).

As can be seen, the average berry length in 15 clusters was 18.46 mm and the width was 18.40 mm, indicating minimal variation. The average berry mass was 3.67 g.

Using the obtained data, the structure index of the cluster in the Bayanshira grape variety was determined (Table 3).

As can be seen, the structure index for cluster samples fluctuated between 24.52–29.00, with the average value being 27.06.

The final indicators for cluster samples for the Bayanshira variety were determined (Table 4).

At this time, the mass of 100 berries and 100 seeds, the number of seeds in 100 berries, the mass of seeds, peel, and pulp juice in 100 berries, and the final indicator were calculated based on the obtained data. The final indicator varied between 15.06–17.60, with the average value of 16.25.

To assess the grain and structural indices of the cluster, the percentage of its individual parts was determined (Table 5).

The grain indicator ranged between 10.12–11.49, with the average value of 10.75. The structural indicator showed similar values across clusters, varying between 7.01–7.44, with the average value of 7.27. In this case, the comb proportion in the bunch was 3.55 %, peel 5.64 %, seeds 2.87 %, solid residue 12.08 %, and the amount of juicy pulp was 87.92 %.

Table 2

Size and weight of berries in Bayanshira grape variety

Number of clusters	Grape length, mm	Width of the grape, mm	Mass of the grape, g
1	20	20	4.37
2	17	20	3.8
3	18	17	3.5
4	18	20	3.8
5	18	19	4
6	18	18	3.6
7	17	20	3.4
8	18	16	3.16
9	20	19	4.66
10	21	18	3.8
11	19	18	3.9
12	18	18	3.3
13	19	18	3.6
14	18	18	3.4
15	18	17	2.9
Average price	18.46	18.40	3.67

Table 3

Structure of cluster samples in the Bayanshira grape variety

Examples	The average mass of a bunch, g	The number of berries in a bunch, number	Mass, g		Mass, in %		Structure indicator
			Berry	Comb	Berry	Comb	
1	172	62	165.3	6.74	96.10	3.91	24.52
2	174	70	168.2	5.8	96.66	3.27	29. 00
3	169	74	163.2	5.9	96.56	3.49	27.66
Average price	171.6	68.6	165.5	6.14	96.44	3.55	27.06

Table 4

Final indicators for cluster samples for the Bayanshira variety

Examples	Mass, g		Number of seeds in 100 grape berries, pcs	Weight of 100 grapes, g			Final indicator
	100 grapes	100 grape seeds		Seed	Skin	Pulp with juice	
1	277.41	3.7	208	7.70	14.5	255.21	17.60
2	248.57	3.5	206	7.21	14.1	227.26	16.11
3	228.37	3.3	204	6.73	13.8	207.84	15.06
Average price	251.45	3.5	206	7.21	14.1	230.10	16.25

The amount of skeleton in the Bayanshira variety is determined by the sum of the comb and skin. The solid residue is reflected by the sum of the skeleton and seeds. The bunch structure is calculated by the amount of solid parts in the bunch, i.e. comb, skin, seeds, solid part of the pulp, and solid residue (sum of comb, skin, seeds). The berry index is determined by the ratio of pulp mass to skeleton mass (solid residue) in 100 grams of berries.

Table 5

Bunch structure of Bayanshira grape variety

Examples	In % in cluster					Indicators	
	Comb	Skin	Seed	Solid residue	Pulp with juice	Berry	Structure
1	3.91	5.22	2.77	11.93	88.07	11.49	7.38
2	3.27	5.67	2.90	11.84	88.16	10.66	7.44
3	3.49	6.04	2.94	12.47	87.53	10.12	7.01
Average price	3.55	5.64	2.87	12.08	87.92	10.75	7.27

The structure index is determined by the ratio of the mass of the berries to the mass of the comb.

5. 3. Study the transformations that occurduring storage of grape juice processed in various ways

The effect of processing by various methods on the chemical composition of juice samples was studied. It was determined that processing the juice with ultraviolet light does not cause a fundamental change in its color and composition without creating an oxidation tone. The amount of total phenolic compounds in the juice with and without processing during storage changed as follows (Fig. 6).

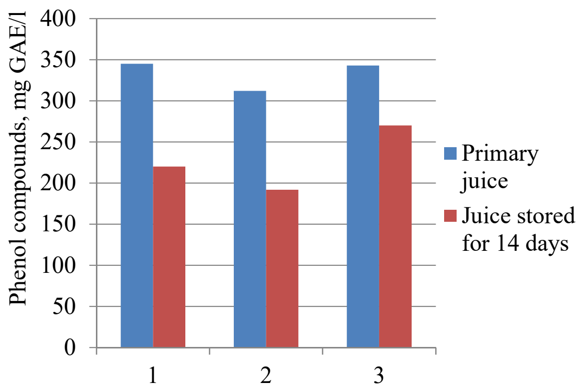

Fig. 6. Changes in the content of total phenolic compounds in stored grape juices: 1 – Control (without processing); 2 – By being pasteurized; 3 – Beam processing

As can be seen, the amount of phenolic compounds in the initial juice sample (control) was 345 mg GAE/l. A decrease was observed during storage. At this time, the greatest reduction was noticeable after 6 days, reaching 228 mg GAE/l. In subsequent periods, that is, when stored for 10 and 14 days, the decrease slowed, resulting in a total reduction of 8 mg GAE/l.

In the initial version of the samples stored by pasteurization, the amount of phenolic compounds was 312 mg GAE/l, with a greater decrease during the 2-day storage period, dropping to 234 mg GAE/l. During the 14-day storage period, the reduction reached 120 mg GAE/l compared to the control. Although this is short-term, it can be associated with the intense effect of heat on the amount of phenolic compounds. In this case, some of the phenolic compounds undergo different transformations, while others precipitate.

As a result of wine irradiation for 8.5–12.0 seconds, the amount of viable microorganisms decreased significantly, with a complete lethal effect after 20 seconds. It was found that the irradiation of juice samples was instantaneous and did not have a strong effect on phenolic compounds compared to previous options. At this time, the main decrease was observed after 2 days and amounted to 36 mg GAE/l. After 14 days of storage, the total decrease was 73 mg GAE/l, with a final result of 270 mg GAE/l.

As is known, 5-hydroxymethylfurfural has a molecular structure with a 6-carbon furan ring with aldehyde and alcohol functional groups. Considering the role of this compound in juice quality, its levels were studied (Fig. 7).

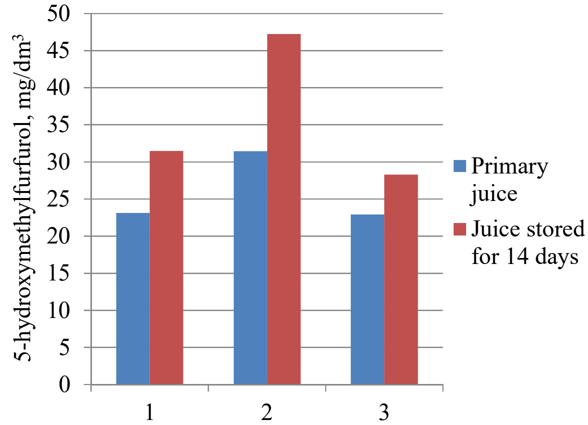

Fig. 7. Changes in the content of 5-hydroxymethylfurfural during storage: 1 – control (no processing); 2 – pasteurization; 3 – irradiation

As can be seen, the amount of 5-hydroxymethylfurfural in the control sample was 23.11 mg/dm^3, with a slight increase during storage. The most significant rise occurred after 2 days, reaching 6.05 mg/dm^3. The total increase during the subsequent storage period was approximately 2 mg/dm^3. However, a greater increase in 5-hydroxymethylfurfural content was observed during heat pasteurization compared to the control samples. Most of this rise (16.57 mg/dm^3) occurred in the first 6 days. Although there was a slight increase after 10 days, a minor decline was observed after 14 days.

The short-term effect of irradiation treatment was not observed with a significant increase in 5-hydroxymethylfurfural levels. No such increase was detected in this compound during irradiation treatment compared to either the control or heat-pasteurized samples.

The mineral content in juice samples is one of the important indicators. During the analyses, the amount of ash in the samples was determined (Fig. 8).

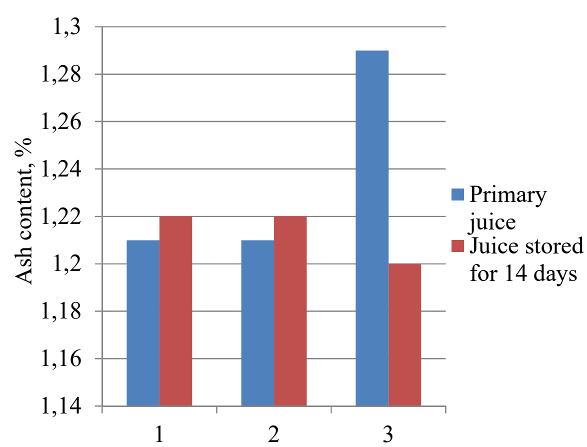

Fig. 8. Changes in ash content in juice during storage: 1 – control (no processing); 2 – pasteurization; 3 – irradiation

The ash content in the control variant was 1.21 %, with very slight changes during storage, reaching 1.22 % after 14 days. Although the ash content in the studied variants subjected to different processing methods underwent some variations, it did not change significantly in the end. While the ash content increased by 0.01 % after 14 days of storage during hot pasteurization compared to the initial sample, no changes were observed during radiation treatment.

The amount of water-soluble dry matter in the juice samples by variant was as follows (Fig. 9).

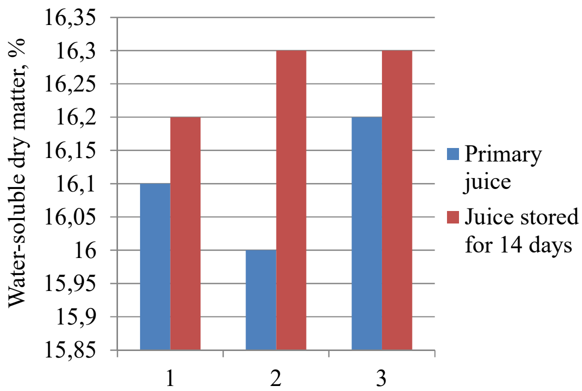

Fig. 9. Changes in the amount of water-soluble dry matter during storage: 1 — control (no processing); 2 — pasteurization; 3 — irradiation

The largest increase in water-soluble dry matter in the control samples was observed in the juice stored for 10 days, reaching 16.3 %, i.e. 0.2 % more than in the initial sample. In the others, a slight increase was noted, but it did not exceed 0.1 %. If we look at the amount of water-soluble dry matter in the juice samples stored by heat pasteurization, it is clear that this content was 16 % in the initial juice, an increase of 0.2 % was observed after 2 days of storage, and 0.3 % after 14 days.

In the samples subjected to radiation treatment, the amount of water-soluble dry matter increased by only 0.1 % over 14 days.

The pH indicator, which reflects the concentration of hydrogen and hydroxide ions in the environment, plays a certain role in juice stability. The studies found that juice treatment methods have little effect on pH levels (Fig. 10).

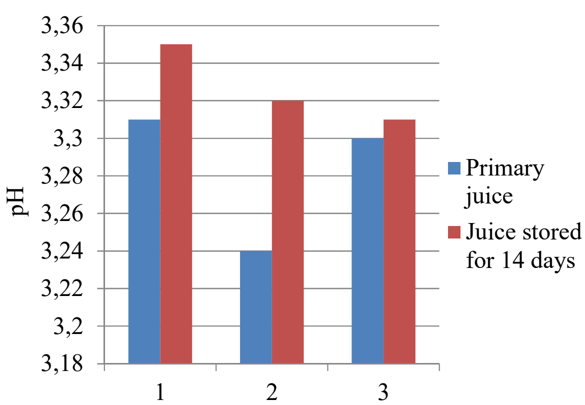

Fig. 10. Changes in pH values of stored juice: 1 — control (no processing); 2 — pasteurization; 3 — irradiation

As can be seen from the figure, the pH value changed cone sistently in both the control and experimental samples. After 2 days of storage, there was an increase in pH, followed by a slight decrease during subsequent storage periods. These changes were relatively noticeable in the heat-pasteurized samples.

The amount of titratable acids in the juice samples during storage was as follows (Fig. 11).

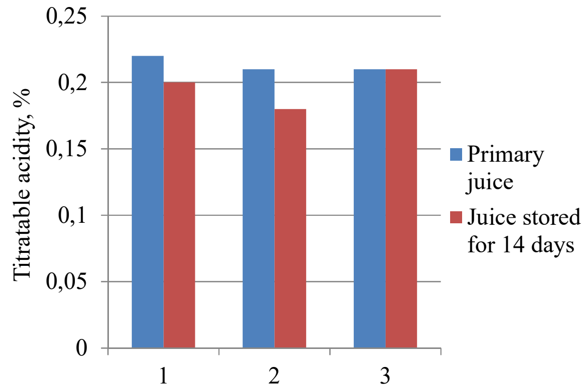

Fig. 11. Changes in the amount of titratable acids in grape juice during storage: 1 — control (no processing); 2 — pasteurization; 3 — irradiation

Compared to the control, this parameter remained almost unchanged in the radiation-treated variant, while both the control and heat-pasteurized samples showed a decrease in titratable acids during storage. This decrease was more pronounced in pasteurized juice samples, amounting to 0.03 % after 14 days of storage. This can be attributed to acids entering ester formation reactions under the influence of heat. The studies revealed that the color values of juice samples treated by different methods experienced minor changes during storage (Fig. 12).

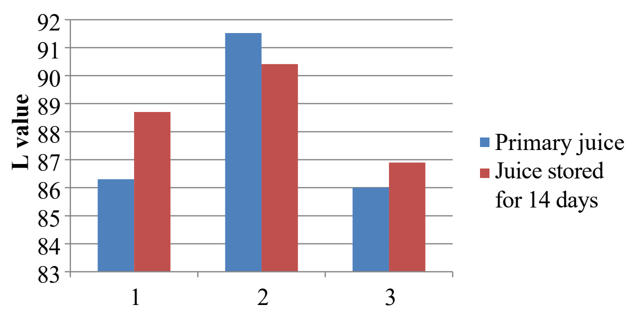

Fig. 12. *L* value in grape juice during storage: 1 — control (no processing); 2 — pasteurization; 3 — irradiation

As can be seen from the diagram, this indicator remained almost unchanged in the radiation-treated variant compared to the control, while an increase was observed in the heat-pasteurized juice samples. This increase was more pronounced in the pasteurized juice samples than in the others within 14 days (Fig. 13).

The diagram shows that in the control samples, the *a* value in the initial and 2-day stored juice samples was the same at 0.6, while in the others it decreased.

In the heat-pasteurized juice samples, the highest value was minus 0.08 in the juice samples stored for 14 days, while the lowest was minus 0.16 in the initial stored juice samples. In the others, no significant difference was observed.

In the samples subjected to radiation treatment, the *a* value of grape juice increased by only 0.1 over a period of 14 days (Fig. 14).

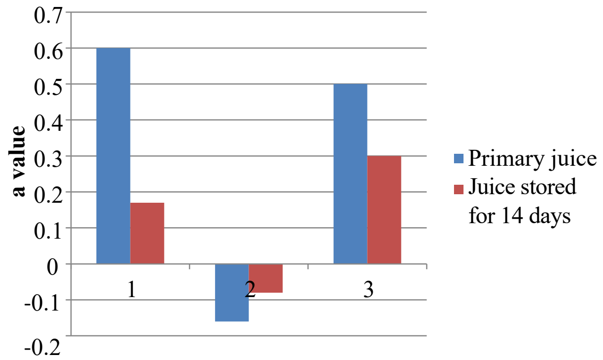

Fig. 13. *a* value in grape juice during storage: 1 – control (no processing); 2 – pasteurization; 3 – irradiation

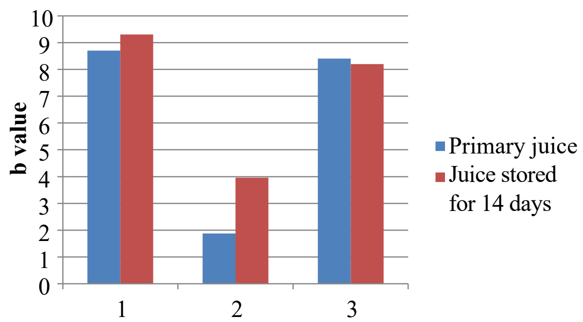

Fig. 14. *b* value in grape juice during storage: 1 – control (no processing); 2 – pasteurization; 3 – irradiation

As can be seen, the greatest increase in the *b* value of grape juice in the control samples occurred in juice stored for 2 days, amounting to 11.3. A slight increase was noticeable in the other samples.

Looking at the *b* value of grape juice in samples stored by hot pasteurization, it is clear that this indicator was the lowest at 1.88 in the initial juice and reached the highest value of 3.96 in the 14-day storage period. In the samples subjected to radiation treatment, it was the highest at 8.4 in the initial stored juice and the lowest at 6.7 in the 10-day period.

5. 4. Study of the impact of various technological factors on wine quality

After fermentation, the second stage of table wine preparation begins, that is, maturation in yeasts. Studies show that during maturation in yeast sediment, table wines are enriched with yeast autolysis products. "Autolysis" is a Greek word, meaning "auto" – self and "lesis" – dissolution. The effect of yeast cell enzymes continues even after fermentation. As the cell membrane breaks down, the internal enzymes of the yeasts pass into the wine material. The substances released during yeast autolysis are called autolysates.

The effect of the storage period on the yeast sediment on the amount of amino nitrogen in white table wine made from the Bayanshira grape variety is as follows (Fig. 15).

The amount of amino nitrogen in the initial wine sample (control) was 110 mg/dm^3. As the storage time in the yeast increased, this amount rose noticeably, reaching 170 mg/dm^3 after 30 days, 260 mg/dm^3 after 60 days, and 320 mg/dm^3 after 90 days.

The effect of mass exchange between yeast and wine material stored in the yeast sediment on the dynamics of amino nitrogen release into the environment in yeasts was studied (Fig. 16).

It was found that the amount of amino nitrogen in the initial wine sample without mass exchange was 110 mg/dm^3. Increasing the number of mass exchanges led to a rise in amino nitrogen levels. At this time, the highest amino nitrogen content, compared to the control, was observed with mass exchange carried out every 5 days, i.e., 6 times a month. A reduction in amino nitrogen occurred as the number of mass exchanges decreased. At this time, the minimum amount was 350 mg/dm^3 in the wine sample with mass exchange carried out every 90 days. This amount was 356 mg/dm^3 in the wine sample with mass exchange every 60 days and 392 mg/dm^3 in the sample with mass exchange every 30 days.

A study was conducted to determine the effect of storage conditions on the transfer of nitrogenous substances from yeast sediment to wine (Fig. 17).

For this purpose, the wine material prepared from the Bayanshira grape variety was divided into 4 equal parts. One of them was taken as the starting wine material (control), the second was stored in a basement, the third was stored at room temperature, and the fourth at 25–30 °C.

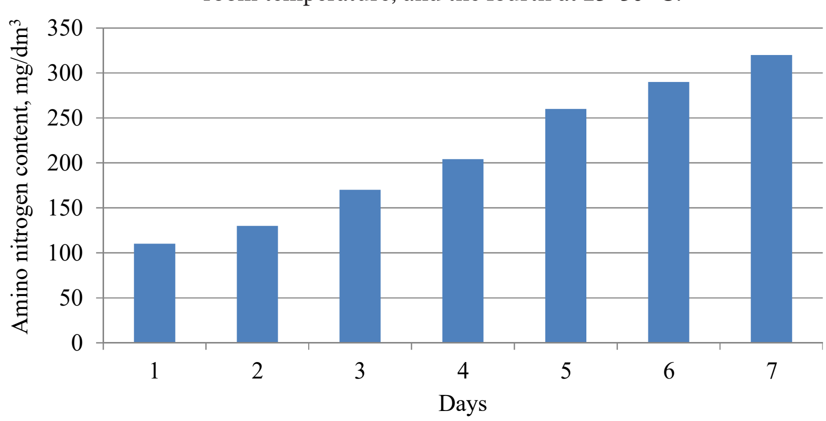

Fig. 15. Effect of storage time on yeast sediment on the amount of amino nitrogen in wine: 1 – control; 2 – 15 days; 3 – 30 days; 4 – 45 days; 5 – 60 days; 6 – 75 days; 7 – 90 days

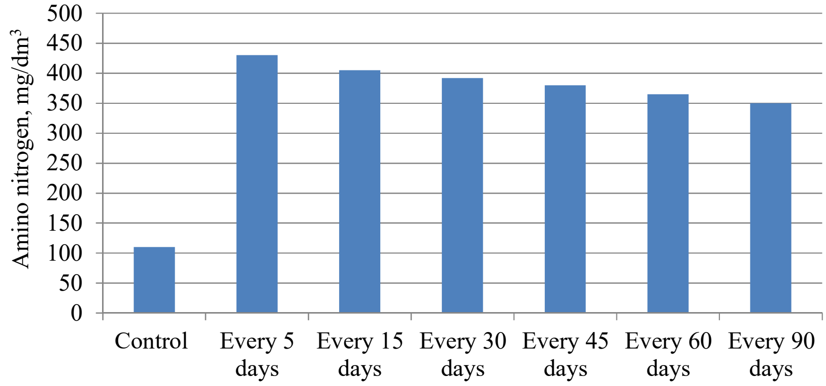

Fig. 16. Variation in the amount of amino nitrogen in wine depending on the number of mass exchanges performed

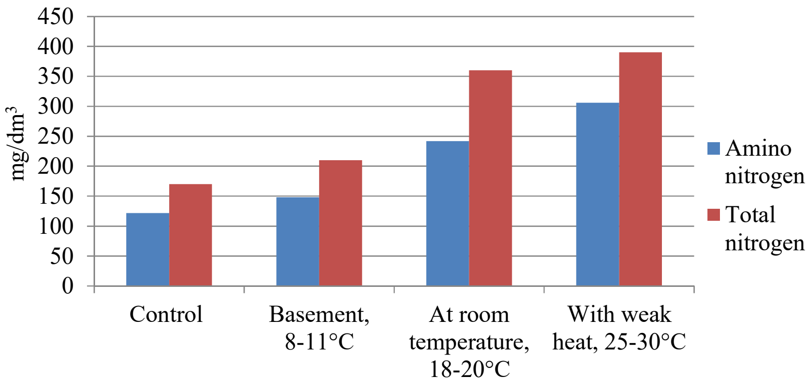

Fig. 17. Effect of storage conditions on the amount of nitrogenous substances in yeast sediment

After 2 months of storage, the amount of total and amino nitrogen was determined. It was found that during storage in the basement, the total nitrogen content increased by 40 mg/dm^3 and amino nitrogen by 26 mg/dm^3 compared to the control. A higher increase was observed during storage at a temperature of 25–30 °C, with total nitrogen substances reaching 390 mg/dm^3 and amino nitrogen 306 mg/dm^3.

6. Discussion of the results regarding the impact of various technological methods on the composition of juices and wines

The physicochemical parameters and ripening dynamd ics of grapes according to growth stages, the mechanical composition of the bunch in the autochthonous Bayanshira grape variety, including structure and berry indicators, and potential juice yield were determined. A comparative analysis was conducted on changes in the sample composig tion during 14 days of storage after processing the juice by various methods. It was found that short-term processing with ultraviolet rays surpassed other options [27] in terms of better preservation of color and composition. The study examined the amount of nitrogenous substances penetrating from the solid part to the liquid samples with an increase in the storage time of wine material in the yeast sediment. The mass exchange between the liquid part and the solid yeast mass in wine samples, as well as the course of that process depending on storage conditions, was investigated. As can be seen, this research work aims to address complex issues, considering various juice treatments starting from the raw material and the penetration of substances into the liquid part during storage in the yeast sediment in wine preparation and various technological methods affecting it.

Unlike the study focused on the polyphenol content in the peel, seed, and pulp extracts of different grape varieties [1], this research examined the berry mass of the local Bayanshira grape variety compared to the introduced varieties at different growth stages. For this purpose, the mass of 100 berries taken at each growth stage was measured. It was found that the berry mass of the Bayanshira grape variety increased more than threefold in the ripening and overripening stage compared to the black period. The greatest increase occurred between the black and the beginning of ripening stages. A similar trend was observed in the other two varieties. However, the berry mass was slightly lower in the second and third variants than in the first one (Fig. 1).

Unlike the study [2], which was based on determining dry matter composition and aimed to identify grape variety and origin, this research investigated the amount of water-soluble dry matter (WSD) at growth stages. It was found that the content of water-soluble dry matter (WSD) was higher in the Rkasiteli grape variety than in the others at all growth stages. At the final ripening stage, this indicator was 3.19 brix higher in the Rkasiteli variety than in the Bayanshira grape variety and 3.75 brix higher in the Chardonnay variety. The greatest increase was observed between the beginning of ripening and the ripening stage. In the early ripening stages, titratable acidity was at its highest level for all variants. A sharp decline occurred between the beginning of ripening and the ripening stage and was significantly higher than in the other stages. The amount of titratable acids in the variants during the ripening stage was 5.2–6.3 g/dm^3, while in the ripening and overripening stage, it was 3.6–4.9 g/dm^3 (Fig. 2, 3).

Unlike the work [11], which provided a method for assessing the quality and development stages of grape varieties during ripening using Vis/NIR and NIR technology, this study examined the dynamics of grape ripening at different growth stages, including the ripening index. The mass of 200 grapes at the black stage was measured, and this was repeated for other stages. At the same time, the ripening index was calculated based on the amount of sugar and titratable acids. It was found that although this indicator was low in the early growth stage, it increased several times from the beginning of ripening to the ripening period. In the ripening stage, the increase was somewhat weaker than in the previous one. Bayanshira is a versatile grape variety used both for processing and fresh, and it is recommended to harvest it a little later, after the second half of September (Fig. 4).

Unlike studies [3, 4], which provided a technological method for making wine from the autochthonous Madrasa grape variety, based on colorant distribution in grapes, extractants for obtaining rich extracts from solid parts of bunches, along with rational modules for mixing them with solid parts, this research investigated the amount of phenolic compounds in samples at different growth stages. It was found that the total phenolic content for all varieties was higher at the black stage, ranging within 1,905–2,460 mg/dm^3. At the beginning of ripening, it decreased by about 70–90 %. Compared to the ripening stage, a very weak increase in the amount of total phenolic compounds was observed at the ripening and overripening stage, flunctuating between 615–841 mg/dm^3 (Fig. 5).

Unlike the research work [15], which aimed to study the effect of cluster thinning on grape yield and quality, the yield of grape varieties, the mechanical composition of the cluster, the chemical composition of the berries, and sensory evaluation [18], as well as the mechanical and biochemical composition of some table grape varieties grown in Uzbekistan, especially large-berry ones, 15 clusters were randomly selected from the ripe Bayanshira grape variety for observations, and their dimensions, mass, and number were determined. The length, width, mass, number of berries in the cluster, comb mass of each of the 15 clusters were determined, and average values were calculated. The berry length, width, and mass were measured separately for each cluster. The average berry length was 18.46 mm, the width was 18.40 mm, and the average berry mass was 3.67 g (Tables 1, 2).

In contrast to the studies that involved a comparative analysis of the mechanical composition of 111 grape varieties under harvesting conditions and identified those with higher economic parameters for cultivation [19], as well as mechanical and ENO carpological analyses of bunches and berries of some technical and table grape varieties grown in Azerbaijan [20], this research determined the structure of the bunch and its average value for three samples. The average structure index was 27.06. Unlike the study [17], which examined the effect of pruning on the mechanical composition of the bunch in 3 introduced grape varieties, this work measured the mass of 100 berries and 100 seeds, the number of seeds in 100 berries, the mass of seeds, peel, and pulp juice in 100 berries. Based on the obtained data, the final index was calculated. The average final index for bunch samples of the Bayanshira grape variety was 16.25. To assess the fruit and structural indicators of the bunch, the percentage of its individual parts was determined. The average fruit indicator was 10.75, while the structural indicator was 7.27. In this case, the comb percentage in the bunch was 3.55, peel 5.64, seeds 2.87, the solid residue was 12.08, and the amount of juicy pulp was 87.92 % (Tables 3–5).

Unlike the study [22], which investigated the current status of aroma enhancement in white grapes through sustainable agrotechnical methods and deemed future research necessary given uncertainties regarding some biosynthesis mechanisms and their correlation, this work examined the effect of various processing methods on the chemical composition of juice samples. Compared to the control (no processing), heat-pasteurized samples showed a greater decrease in the amount of phenolic compounds, reaching 120 mg GAE/liter during 14 days of storage. This can be attributed to the intense effect of heat on the amount of phenolic compounds, although short-term. In this case, some of the phenolic compounds undergo different transformations, while the others precipitate. The treatment of juice samples with ultraviolet rays was instantaneous (8.5–12.0 seconds), with a much weaker effect on phenolic compounds than in previous options (Fig. 2).

The role of 5-hydroxymethylfurfural in juice quality is known. A greater increase in 5-hydroxymethylfurfural content was observed during heat pasteurization compared to the control sample. Most of this rise, i.e. 16.57 mg/dm^3, occurred in the first 6 days. Although there was a slight increase after 10 days, a minor decline was observed after 14 days. No significant increase in this compound was detected during irradiation compared to either the control or heat-pasteurized samples. The ash content in the control sample was 1.21 %, with slight changes during storage. Although the ash content increased by 0.01 % compared to the control after 14 days of storage during heat pasteurization, no changes were observed during irradiation (Fig. 6–8).

In contrast to the studies [10], which investigated the distribution of aromatic compounds in the grape berry and their transfer to wine samples prepared with minimum loss [9], as well as the effect of grape development stages on its antioxidant properties, bioactive and total composition, this research examined juice samples stored for 14 days. The greatest increase in water-soluble dry matter was observed in control samples stored for 10 days, reaching 16.3 %, i.e. 0.2 % more than the initial state. In samples stored by hot pasteurization, this amount was 16 % after 2 days of storage, i.e. an increase of 0.2 %, and reached a 0.3 % increase after 14 days. In samples subjected to radiation treatment, the amount of water-soluble dry matter increased by only 0.1 % over 14 days (Fig. 9). The pH value changed consistently in both control and experimental samples. After 2 days of storage, there was an increase in pH, followed by a slight decrease during subsequent storage periods. These changes were more noticeable in heat-pasteurized samples (Fig. 10). Compared to the control, the amount of titratable acids remained almost unchanged in the radiation-treated variant, while both the control and heat-pasteurized samples showed a decrease during storage. This decrease was more pronounced in pasteurized juice samples, amounting to 0.03 % after 14 days of storage. This, although short-term, can be attributed to acids undergoing certain reactions under the influence of heat (Fig. 11).

Unlike the study [23], which used the electronic nose detection method to initially investigate and screen the berry aroma characteristics in 191 grape germplasm resources, this research evaluated the effect of physical processing on the color values of stored juice samples. Compared to the control, the color *L* value remained almost unchanged in the radiation-treated variant, while an increase was observed in the heat-pasteurized juice samples. This increase was more pronounced in pasteurized juice samples over 14 days than in the others (Fig. 12).

In the control samples, the *a* value was the same at 0.6 in the initial and 2-day stored juice samples, while in the others it decreased. In the hot-pasteurized juice samples, the highest value was minus 0.08 in the juice samples stored for 14 days, while the lowest was minus 0.16 in the initial stored juice samples. In the others, no significant difference was observed. In the samples subjected to radiation treatment, the *a* value of grape juice increased by only 0.1 over 14 days (Fig. 13).

Looking at the *b* value of grape juice in the samples stored with hot pasteurization, it is clear that this indicator was the lowest at 1.88 in the initial juice and reached the highest value of 3.96 in the 14-day storage period. In the samples subjected to radiation treatment, it was the highest at 8.4 in the initially stored juice, and the lowest at 6.7 after 10 days (Fig. 14).

In contrast to the studies on recent developments in the destabilization and removal of white wine proteins, which focus on various clarification methods, advantages and disadvantages of protein stabilization that can better preserve product quality, ecologically friendly and efficient [6], the origin, mechanism, and influencing factors of unstable proteins, and the effects of yeast storage time, conditions and mass exchange on the amount of nitrogenous substances in wine [7].

The amount of amino nitrogen in the initial wine sample (control) was 110 mg/dm^3. As the storage time in the yeast increased, this amount rose noticeably, reaching 170 mg/dm^3 after 30 days, 260 mg/dm^3 after 60 days, and 320 mg/dm^3 after 90 days (Fig. 15).

The implementation of mass exchange between yeast and wine material stored in the yeast sediment affected the dynamics of amino nitrogen release into the environment in the yeast. It was found that the amount of amino nitrogen in the initial wine sample, not subjected to mass exchange, was 110 mg/dm^3. Increasing the number of mass exchanges led to a rise in amino nitrogen levels. At this time, the highest amino nitrogen content, compared to the control, was observed with mass exchange carried out every 5 days, that is, 6 times a month. A reduction in amino nitrogen occurred as the number of mass exchanges decreased. At this time, the minimum amount was 350 mg/dm^3 in the wine sample with mass exchange conducted every 90 days. This amount was 356 mg/dm^3 in the wine sample with mass exchange carried out every 60 days, and 392 mg/dm^3 in the sample with mass exchange every 30 days (Fig. 16).

To determine the effect of storage conditions on the transfer of nitrogen substances from yeast sediment to wine, the wine material prepared from the Bayanshira grape variety was divided into 4 equal parts. One of them was taken as the starting wine material (control), the second was stored in a basement, the third was stored at room temperature, and the fourth at 25–30 °C. After 2 months of storage, the amount of total and amino nitrogen was determined. It was found that during storage in basement conditions, the total nitrogen content increased by 40 mg/dm^3 and amino nitrogen by 26 mg/dm^3 compared to the control. A higher increase was observed during storage at a temperature of 25–30 °C, with total nitrogen substances reaching 390 mg/dm^3 and amino nitrogen 306 mg/dm^3 (Fig. 17).

The results of the study can be used in the scientific fields of viticulture and winemaking. They are particularly relevant to scientific research on winemaking, family farms, and winemaking enterprises. The findings are intended to be applied in "Shirvan Sharabları" LLC.

The study is suitable for white grape varieties, especially those with delicate compositions like Bayanshira. However, there are limitations, especially for red juices and wines with extract prepared by the "red method", as well as for alcoholic juices and wines.

The disadvantage of the study is the need for special research and equipment to correctly determine the radiation dose and the liquid layer used. Future studies could be expanded to explore the biological stabilization of liquid products of animal origin, particularly milk.

7. Conclusions

1. The ripening dynamics of the autochthonous Bayanshira grape variety was studied in comparison with the introduced Chardonnay and Rkasiteli varieties. During the ripening period, the berry mass increased about threefold compared to the black period, and the Bayanshira variety prevailed at this time. The greatest increase in the amount of water-soluble dry matter (WDS) was observed in the Rkasiteli variety, which was 3.19 times higher than in Bayanshira and 3.75 times higher than in Chardonnay. The content of titratable acids, which was high in the black stage, decreased by 5–6 times to 5.2–6.3 g/dm^3 by the ripening stage. The amount of phenolic compounds was 1,905–2,460 mg/dm^3 in the black stage and decreased by 70–90 % with the onset of ripening.

2. In the Bayanshira grape variety, the final index per 100 grapes ranged between 15.06–17.60, with the average value of 16.25. The structure index flunctuated between 24.52–29.00, with the average value being 27.06. The grape index varied between 10.12–11.49, with the average value of 10.75. The structural index showed similar values across clusters, varying between 7.01–7.44, with the average value of 7.27. The comb percentage in the cluster was 3.55, peel 5.64, seeds 2.87, the solid residue was 12.08, and the amount of juicy pulp was 87.92 %.

3. The juice samples were stored for 14 days after being subjected to control (unprocessed), hot pasteurization (as in production), and ultraviolet irradiation. It was found that during this period, a decrease in phenolic compounds and titratable acids was observed, along with an increase in water-soluble solids, volatile acids, and saturated esters. Instant ultraviolet irradiation does not cause profound changes in the juice samples, preserves the originality of the initial material, provides biological stability, and outperforms the control and traditional processing methods.

4. The transfer of nitrogenous substances from yeast sediment to wine during storage of wine samples under various conditions and technological methods was studied. Increasing the storage time on yeast from 30 to 90 days, changing the mass exchange of liquid and solid fractions to 6 times per month, and also replacing basement storage (8–11 °C) with slightly heated (25–30 °C) conditions increased the amount of nitrogenous substances penetrating the wine. However, this indicator was even more intense when the number of mass exchanges was increased to 6 times per month.

Conflict of interest

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

Financing

The study was performed without financial support.

Data availability

Data will be made available on reasonable request.

Use of artificial intelligence

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

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