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Study of the influence of the number of clusters retained in the vine on the mechanical composition of grapes, the productivity and the quality of the product

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Abstract

The research objects were the grape cluster, berry, skin, seed, comb, juice, and wine material. In the foothills and mountainous areas, the effect of the number of clusters in the vine on the yield and quality of the crop in the autochthonous Madrasa variety has not been studied. The research was conducted on four variants of the Madrasa variety by retaining 8, 12, 16, and 20 clusters in the vine. The highest structural indicator was detected when 8 clusters were retained in the vine (27.66), the least was observed with 20 (23.68) clusters, and the most rational when 12 (27.00) clusters were retained. The amount of comb in the cluster ranged between 3.48 and 4.05%, and the amount of seeds changed between 3.5 and 4.1%. When 8 clusters were retained, 1.4 kg of product was obtained from one vine, and 3707.2 kg of product was obtained from 1 hectare. As the number of clusters increased in the variants, a corresponding increase in yield per vine and per hectare was noticed. Increasing the number of clusters from 8 to 20 enhanced yield per vine and hectare but decreased water-soluble solids, phenolic compounds, antioxidant activity, and ultimately grape juice quality.

Keywords: Antioxidant activity, Autochthonous, Berry, Cluster, Color, Madrasa, Solid residue, Structural index.

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1. Introduction

Studies show that high-quality wine can only be obtained from grape varieties that possess all the necessary quality indicators. Therefore, the variety is of great importance for the quality of grapes. Although some varieties retain their properties quite firmly despite environmental conditions, others change their properties to such an extent that it is not considered appropriate to cultivate them under those conditions. Sometimes, it is necessary to change the direction of use of such varieties; in other words, to use them for other categories and types of wines.

The potential quality level of the wine varies depending on the grape variety, the soil and climate conditions of the area, and the cultivation and processing technology of the grapes. Hundreds of components passing through the grapes and formed during the winemaking process are involved in the formation of the organoleptic properties (quality) of wine. It should be noted that the residues formed during processing also play a fundamental role [1].

Not all of the large number of grape varieties available produce quality wine. Whether the soil and climate conditions are favorable or not also plays a fundamental role in this matter. All this proves that the grape variety has a decisive role in the formation of the quality of the wine.

Each variety requires an individual approach. Its advantages or disadvantages depend to a different degree on local soil-climate conditions, natural humidity, lighting, etc. In this chain, the agrotechnical measures applied in the vineyard, the cultivation systems, especially the pruning carried out on the grape plant, and the load given to the vine play a fundamental role. If this work is not regulated at the proper level, the vines are productive every other year, which negatively affects the quality of both the plant and the product. The amount of load given to the vine depends on the terroir, cultivation technology, etc. It should be carried out in a differentiated manner for each individual case. Along with other factors, the load given to the vine plays a fundamental role in the quality of the future juice and wine. This means that the quality of the wine cannot be higher than that reflected in the processed grapes.

In the Flame Seedless grape variety grown in the subtropical climate of North India, berries have non-homogeneous fruiting and color problems. It is known that reducing the load and applying abscisic acid allows for obtaining a quality product from grapes [2].

The research was conducted on 7-year-old grapevines, and the thinning of grape berries was repeated for 3 years. 30, 45, 60, and 75 berries were retained in each cluster. Clusters with 30 berries had the highest berry length and diameter. Increasing the number of berries from 30 to 75 led to increased yield but reduced berry sizes [3].

The research aimed to assess the effect of pruning on the mechanical composition of the clusters in 3 grape varieties. The study was carried out in 3 variants, retaining 28, 32, and 40 cuttings. The weight of the clusters, combs, and berries, as well as the width of the berries, were greatest in variant II (Alphonse Lavallee variety). The longest cluster (Black Magic variety) was in variant II, the largest cluster and the longest berry were in variant III, and the greatest number of berries per cluster was in variant II (Muscat Bleu variety) [4].

The main purpose of this study was to determine the effect of reducing the number of grapes in each cluster by 25-50% on the quality and organoleptic properties of grapes and wine. It was found that thinning the berries, especially by 50%, significantly increased the total amount of dry matter and phenols [5].

Two different pruning systems (Royat and Guyot) were studied to clarify the effect of the grape cultivation system on phenolic content. The quality of the produced grapes was determined according to three analytical parameters: anthocyanin content, tannin content, and procyanidin structure [6].

This study aimed to determine the effect of early leaf and cluster thinning on berry growth, wine phenolic profile, and color characteristics under Mediterranean Sea climate conditions. For this purpose, two grape varieties were used. The Vranac variety showed average flavonoid accumulation properties, while the Cabernet Sauvignon variety exhibited very good polyphenol accumulation properties [7].

The study aimed to assess the effect of grapevine cultivar compatibility with stocks on grape yield and fruit characteristics in the San Francisco Valley, Northeast Brazil. In the experiments, five seedless table grape varieties and six stocks were used. Significant positive correlations were observed with yield, number of clusters, length of clusters, amount of soluble dry matter, and titratable acidity in each grape, while a negative correlation was observed with the length of the berry [8].

This research was devoted to the effect of different stocks on the growth, yield, and quality of grapes using "Superior Seedless" grapes grown on sandy soil with salinity. It was found that 1103 Paulson stock improved photosynthesis pigments, K^+ accumulation, Na^+ uptake, and cell membrane recovery in grapes compared to other stocks [9].

In this study, the effect of diversity in the biophysical characteristics of vineyards (for example, soil and topography) on the composition of grapes and wine was examined. The main goal was to determine the relationship between the chemical and organoleptic properties of wines from different locations and the biophysical properties of vineyard areas [10]

An experiment was conducted to evaluate the effect of leaf thinning on cluster rot and fruit composition, as well as yield, in the Chardonnay grape variety grown in the state of Georgia, USA. The experiment was performed in seven variants. It was found that reducing the leaves in the fruiting zone to zero after fruit set helps control rot. It reduces the amount of titratable acids and increases the amount of soluble dry matter while preserving the yield compared to full thinning of the leaves [11].

It is known that early leaf thinning can reduce cluster rot and improve berry production by changing cluster structure and the microclimate of the cluster zone. In this study, quality improvement was achieved through early leaf thinning and yield reduction in the high-yielding Grüner Veltliner grape variety of the *Vitis vinifera* species grown in the eastern United States [12].

The effect of the change in cluster load per unit area on the quality of the Cardinal table grape variety was evaluated. It was found that the cluster load in the Cardinal variety had a significant effect on the mass of the cluster and the berries, transportability, ripening dynamics, and the amount of packed grapes [13].

The impact on the yield and quality components of table grapes was studied by giving different loads to the vine (40, 50, 60, 80 clusters/vine). The experiments were conducted comparatively with the 5-year-old Taj-A-Ganesh grape variety grown on the Dog-Rich stock. The average size of the clusters in the grafted vine was larger than that of those grown on their own roots, and the productivity increased by 44-93%. With the increase in productivity, the amount of water-soluble dry matter decreased [14].

The production of various wines from the autochthonous Madrasa grape variety in the Mountainous Shirvan region of Azerbaijan was studied. Under these conditions, some factors affecting the optimal ripening period of grapes were investigated, and wines made from the same variety in three different colors were retained and grown in containers that differed in material. Besides, the effect of maceration temperature and duration on the quality of wines was studied [15-17].

2. Materials and Methods

The research objects were grapes, juice, wine material, and the wine maturation process. A description of their chemical composition, auxiliary materials, and generally accepted, new, and modified methods of analysis was used during the research.

In the Madrasa grape variety, the vine was loaded with different numbers of clusters according to the following variants: Variant I - 8 clusters; Variant II - 12 clusters; Variant III - 16 clusters; Variant IV - 20 clusters.

The experiments were carried out on 10-year-old vines in the mountainous areas of the Aghsu region under rainfed conditions. The row spacing was 2.50 m, the distance between plants was 1.50 m, and the nutritional area was 2.50 x 1.50 = 3.75 m^2. The vines are given a double-sided Gyo shape.

Short and medium winter pruning was performed as follows: To retain 8 clusters in the vine, pruning was done to 2 buds on 4-5 twigs. 3-4 buds were retained on 3-4 twigs to retain 12 clusters. To retain 16 clusters, 4-6 buds were retained on 3-5 twigs. To retain 20 clusters, 5-6 buds were retained on 4-5 twigs.

After pruning, clusters were thinned by leaving 8, 12, 16, and 20 clusters per vine according to the number of eyes. Each experimental variant was performed on 15 vines.

After harvesting, the mechanical composition indicators of grapes were determined for each variant. The weight, length, and width of the cluster; the weight, length, width, and color of the berry; the amount of dry matter in juice; titratable acidity; ripeness index; phenolic compounds; etc. were determined.

The mechanical composition of the grape is characterized by the ratio of the mass of the individual structural elements of the cluster and the berry. These elements are berry, comb, skin, pulp, and seed.

The specified constituent elements of the cluster differ in their structure, chemical composition, and physical-mechanical properties. Each of them has a specific role in the formation of the quality of processing products.

The mechanical composition of the cluster is a typical structural indicator of each grape variety, and it predetermines its use and technological task with great expediency. Based on the mechanical composition, it is possible to determine the maximum juice output from the raw material, the amount of received waste, and whether individual parts of the cluster are involved in processing or not.

For each grape variety, an average value of several years under certain regional conditions was accepted as the mechanical composition indicator of the cluster. However, this indicator can change significantly depending on a number of factors (meteorological conditions, the size of the cluster, its location on the vine, the ripeness of the grapes, etc.).

The wine samples were prepared by applying different technologies depending on the presence or absence of solid elements of the berry (skin and seeds). Enzyme preparations and heat treatment were also used. Using the Rohavin VR-C pectolytic enzyme preparation (3 g/hl), phenolic compounds and antioxidant activity were studied through fermentation in the mash, alcoholic fermentation, resting, dilution, and storage operations.

The juice was macerated in mash for 48 hours and 96 hours. Each sample was divided into two equal parts after the maceration period. In one of them, natural fermentation (NF), and in the other, fermentation with cultured yeasts (FCY) were carried out. Then, the samples were comparatively analyzed by performing physicochemical analysis.

3. Results and Discussion

3.1. Study of the İnfluence of the Number of Clusters Retained in the Vine on the Mechanical Composition İndicators of Grapes

The composition and structure of the grape cluster in the studied variety were analyzed. The structure of the cluster is characterized by the average mass, the number of berries, the mass and percentage of berries and comb, and the ratio of the mass of the berry to the mass of the comb (Table 1).

Table 1.
The effect of the number of clusters retained in the vine on the structure of the cluster in the Madrasa variety.

Control variant	Average mass of a bunch of grapes. g	The number of berries in the bunch. number	Weight. g		Present. %		Structural indicator
			Grape berry	Grape stalk	Grape berry	Grape stalk	
8 bunches of grapes	178	108	171.5	6.2	96.30	3.48	27.66
12 bunches of grapes	168	103	162.0	6.0	96.42	3.57	27.00
16 bunch of grapes	163	104	156.5	6.5	96.01	3.98	24.07
20 bunches of grapes	158	102	151.6	6.4	95.94	4.05	23.68

As seen, the structure index decreased with the increasing number of clusters retained in the vine. The highest index (27.66) was when 8 clusters were retained; the lowest was in the case of 20 clusters (23.68), and it was rational when 12 clusters were retained.

The whole cluster is characterized by the mass of 100 berries and 100 seeds, the number of seeds in 100 berries, the mass of seeds, skin, and juice in 100 berries, and the total indicator of the cluster (the ratio of the mass of the pulp with juice to the mass of the skin). The results for the whole cluster are presented in Table 2.

Table 2.
The whole clusters in the studied variants of the Madrasa grape variety.

Control variant	Weight. g		Amount of seeds in 100 grape berries. pieces	Mass in 100 grape berries. g			Final indicator
	100 grape berries	100 seeds		Seed	Peel	Pulp with juice	
8 bunch of grapes	164	3.0	193	5.79	12.04	145.81	12.11
12 bunch of grapes	163	3.1	192	5.95	11.13	145.92	13.11
16 bunch of grapes	156	3.0	196	5.88	13.21	136.91	10.36
20 bunch of grapes	154	3.2	198	6.33	12.45	135.22	10.86

As it is known, one of the important indicators in technical grape varieties is the whole clusters. A greater number and mass of berries are observed in large clusters and fewer in small clusters.

As observed, the largest mass of seeds in 100 berries was noted when 20 clusters were retained on the vine, and the largest mass of the skin was observed in the variants where 16 clusters were retained on the vine.

However, in the processing of grapes, the percentage of combs and berries in the cluster is important. The amount of comb in the clusters varied from 3.48 to 4.05 according to the studied variants. The lowest indicator was observed in the first variant, and higher indicators were observed in the last variants.

According to the studied variants, the amount of berries in the cluster ranged between 95.94% and 96.42%. As observed, there is not much difference between the variants.

The ratio of the mass of the berry to the mass of the comb (an indicator of the structure of the cluster) was the highest in the first variant (27.66) and the lowest in the last variant, that is, when 20 clusters were retained on the vine (23.68).

The structure of the grape cluster indicates the percentage of the component parts of the cluster - comb, skin, seeds, pulp, and solid residue (the sum of comb, skin, and seeds). Additionally, structural indicators of the berry were also determined.

The structural indicators of the cluster in the studied variants are given below (Table 3).

Table 3.
Structure of the cluster in the variants studied.

Control variant	In bunch with %					Indicators	
	Grape stalk	Peel	Seed	Solid grape residues	Pulp with juice	Grape berry	Structure
8 bunches of grapes	3.48	7.5	3.5	14.48	85.52	60.7	5.9
12 bunches of grapes	3.57	6.8	3.6	13.97	86.03	61.3	6.2
16 bunch of grapes	3.98	8.4	3.6	15.98	84.02	63.8	5.3
20 bunches of grapes	4.05	8.0	4.1	16.15	83.85	64.5	5.2

As seen, there is no significant difference between the variants in the amount of comb (%) in the cluster. The smallest amount of comb (3.48%) was observed in the first variant, where 8 clusters were retained in the vine, and with the increase in the number of clusters, a slight increase in this amount was noticed. In the last variant, a greater amount of comb (4.05%) was found compared to the other variants.

The amount of seeds in the cluster varied between 3.5 and 4.1% for the studied variants.

As it is known, the most important factor for the structure of the cluster in technical grape varieties is the percentage of juice. According to that indicator, the second variant, with 86.03%, which retains 12 clusters on a vine, was in first place. After that came the first, third, and fourth variants.

The number of berries per 100 g cluster (berry index) ranged between 60.7 and 64.5 for the studied variants.

The mass share between pulp and juice was a more valuable indicator for the studied variants from a technical point of view. It varied between 83.85% and 86.03%.

For technical varieties, the ratio of the mass of juicy pulp to the mass of solid residue in the cluster (structural indicator) is important. The higher this indicator is, the higher the juice yield is when the grapes are pressed directly. According to the results of each variant, this indicator was higher in the second and first variants and relatively lower in the other variants. However, it should be noted that the difference between the variants is not very significant. In general, the structural index changed between 5.2 and 6.2. Thus, the difference between the highest and the lowest variants was 1.0.

The berry index was determined by the number of berries in 100 g of berries, and the structural indicator was determined by the ratio of the pulp mass to the skeleton (solid residue) mass.

3.2. The Effect of the Number of Clusters Retained on the Yield, The Sizes of the Cluster, and the Berry

Depending on the load given to the vine by clusters, the yield per vine and per hectare is presented (Figures 1,2).

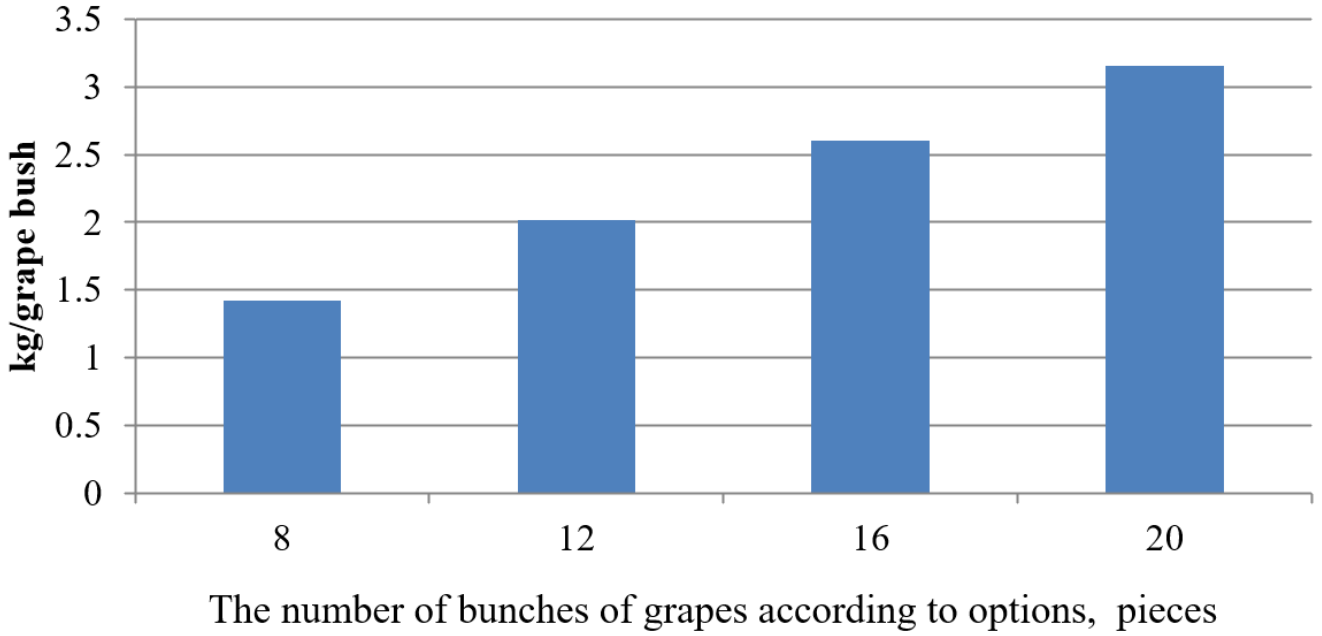

Figure 1.
Productivity per vine (kg/vine) in the studied variant.

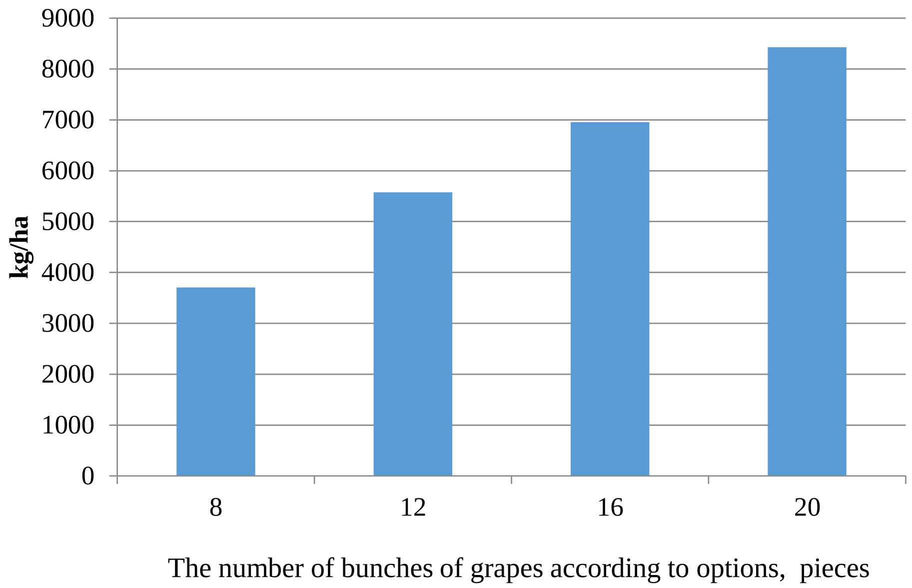

Figure 2.
Productivity per hectare (kg/ha) in the studied variants.

Depending on the amount of load given to the cluster in different variants, the yield per vine and hectare was different. When 8 clusters were retained, 1.4 kg of product was obtained from one vine, and 3707.2 kg of product was obtained from 1 hectare. As the number of clusters increased in the variants, a corresponding increase in yield per vine and per hectare was noticed. Consequently, 2.0 kg per vine and 5575.8 kg per 1 ha were obtained in the second variant, which retained 12 clusters; 2.6 kg per vine and 6954.4 kg per 1 ha were obtained in the third variant, which retained 16 clusters; and 3.2 kg per vine and 8426.4 kg per 1 ha were obtained in the fourth variant, which retained 20 clusters.

During the study of the relationship between the number of clusters retained in the vine and the mass of the cluster, the smallest mass of the cluster was in the fourth variant, which retained 20 clusters in the vine, and it amounted to 158 g. In general, we can see that as the number of clusters retained in the vine increased, the mass of the clusters decreased. In this regard, the highest mass (178 g) of the cluster was in the first variant. In the second variant, this indicator was 168, and in the third variant, it was 163 g (Figure 3).

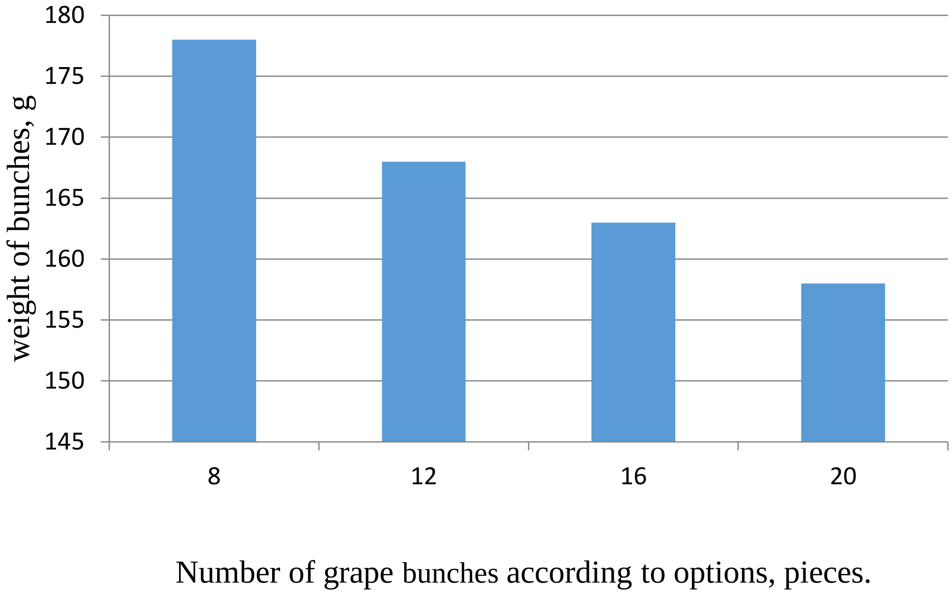

Figure 3.
The effect of the number of clusters retained in the vine on the cluster mass.

Depending on the number of clusters retained in the vine, the sizes of the clusters changed as follows (Figure 4).

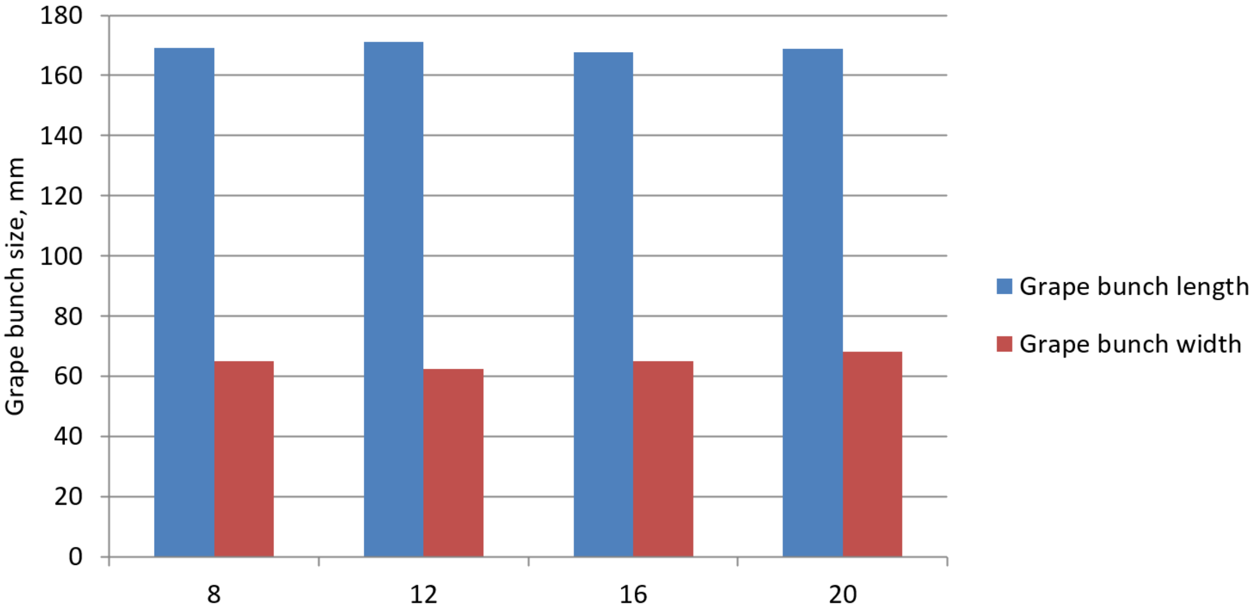

Figure 4.
Cluster sizes in the variants.

As seen, there was a slight change in the size of the clusters with the increasing number of clusters retained in the vine. The length and width of the clusters in the second, third, and fourth variants were 169.03 mm and 65.01 mm (the first variant), 171.05 mm and 62.34 mm (the second variant), 167.81 mm and 64.99 mm (the third variant), and 168.75 mm and 68.12 mm (the fourth variant), respectively. It was investigated whether there is a relationship between the number of clusters retained in the vine and the mass of the berries during pruning (Figure 5).

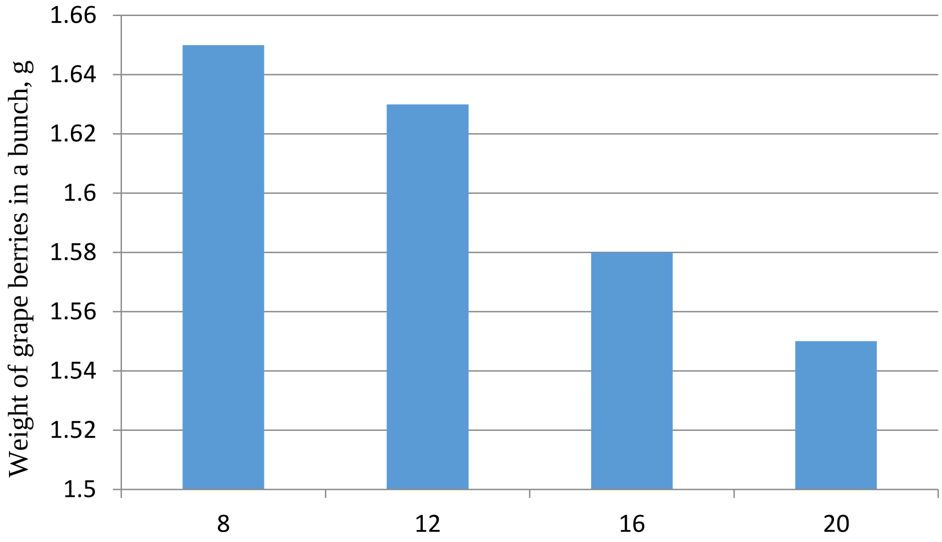

Figure 5.
The effect of the number of clusters retained in the vine on the mass of the berry.

As the number of clusters retained in the vine increased, changes in the mass of the berry, mainly weak decreases, were observed. In the first variant, the weight of the cluster was 165 g; in the second variant, it was 1.63 g; and in the fourth variant, it was 1.55 g.

The sizes of the berries in the cluster were determined (Figure 6). The length of the berry was 13.6 mm in the first variant and 13.1 mm in the fourth variant. Thus, a decrease of 0.5 mm was observed. Based on the variations, the width of the berry was also reduced by 0.1–0.2 mm.

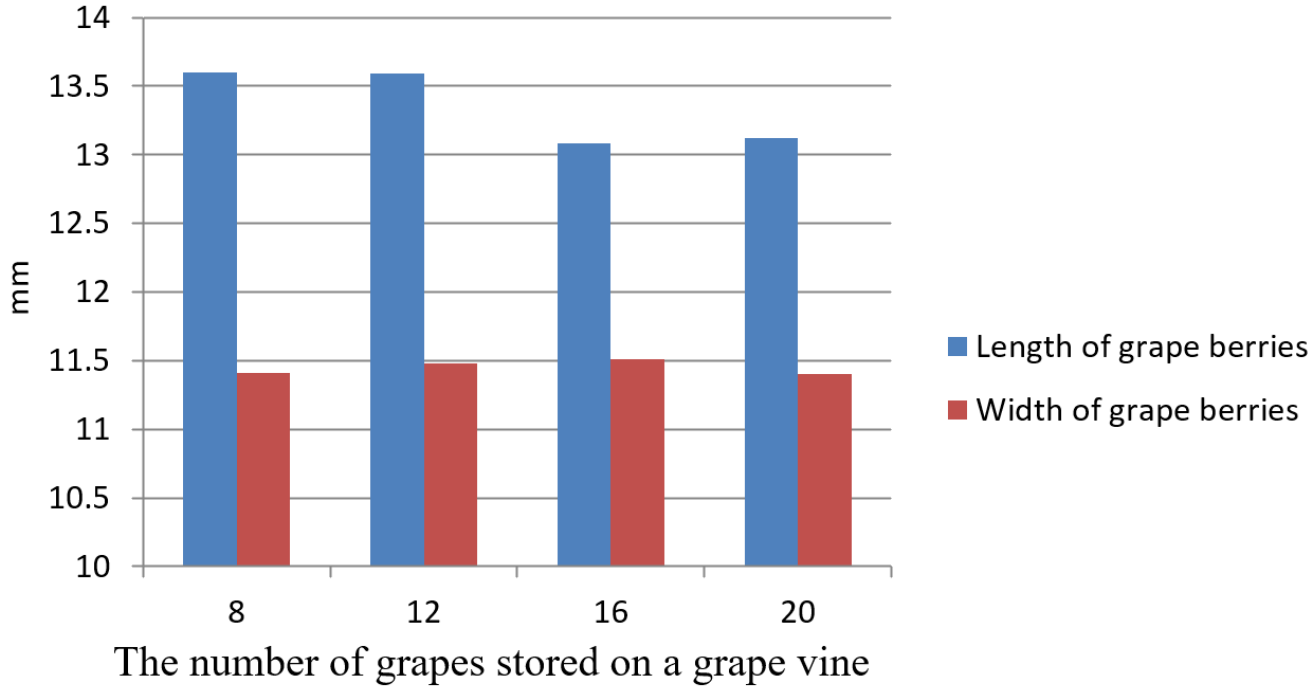

Figure 6.
Sizes of the berry in the studied variants.

Depending on the number of clusters retained in the vine, the number of berries in the cluster changed as follows (Figure 7).

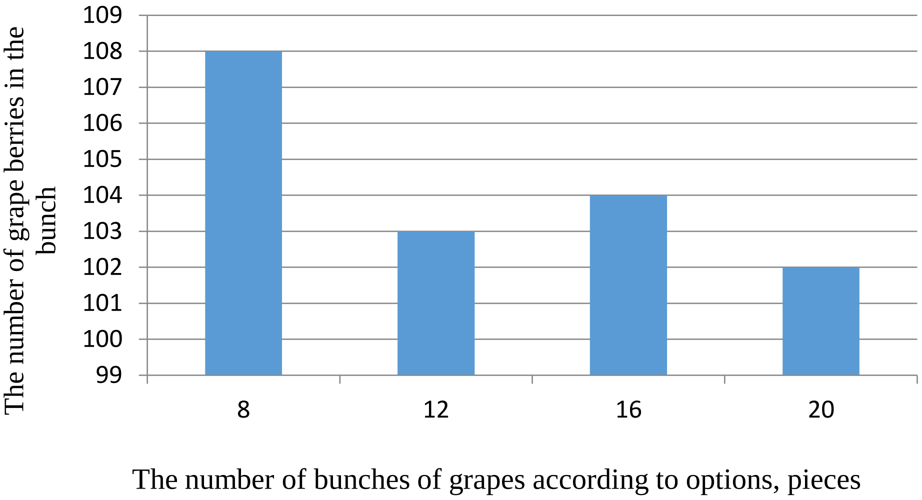

Figure 7.
The number of berries per cluster depending on the number of clusters retained in the vine.

There were 108 berries per cluster in the first variant with 8 clusters in the vine, 103 berries in the second variant with 12 clusters, 104 berries in the third variant with 16 clusters, and 102 berries in the fourth variant with 20 clusters. As seen, there were decreases in the number of berries as the number of clusters increased, with few exceptions.
The structural indicator of the cluster in the variants changed as follows (Figure 8).

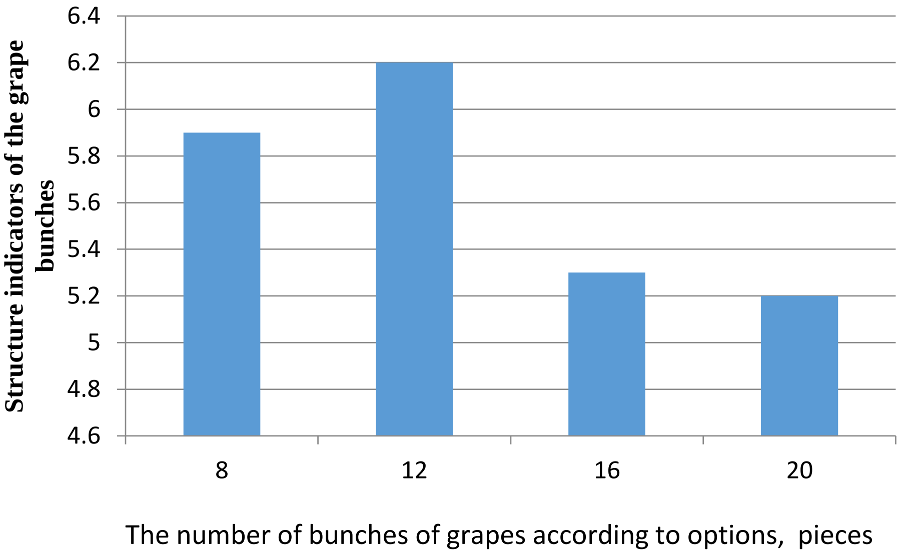

Figure 8.
Variations in the cluster structure index in the studied variants.

The structural index of the cluster was the smallest-5.2 in the fourth variant, and the greatest-6.2 in the second variant. The structure index of the cluster (Figure 9) and the amount of solid residue (Figure 10) are given below.

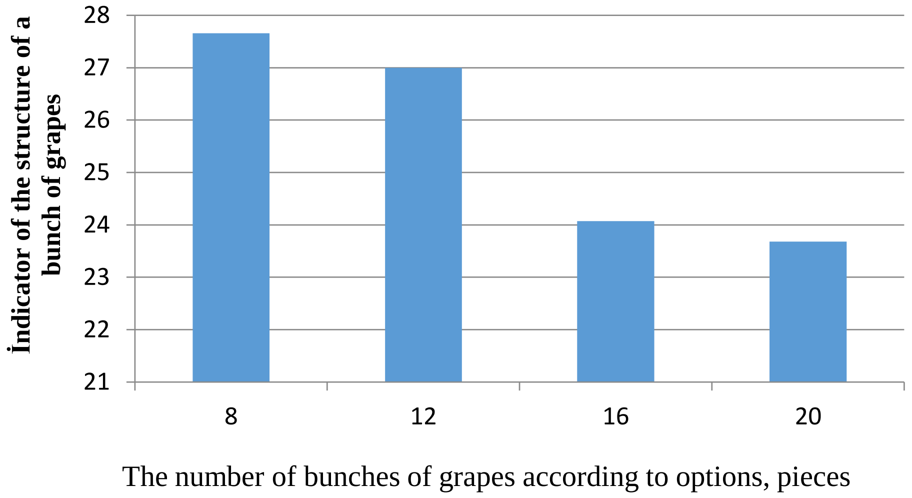

Figure 9.
Changes in the structure indicator of the cluster depending on the variants.

The cluster structure indicator tended to decrease as the number of clusters in the vine increased. While the structure index was 27.66 in the first variant, it was equal to 27 in the second variant, 24.07 in the third variant, and 23.68 in the fourth variant.

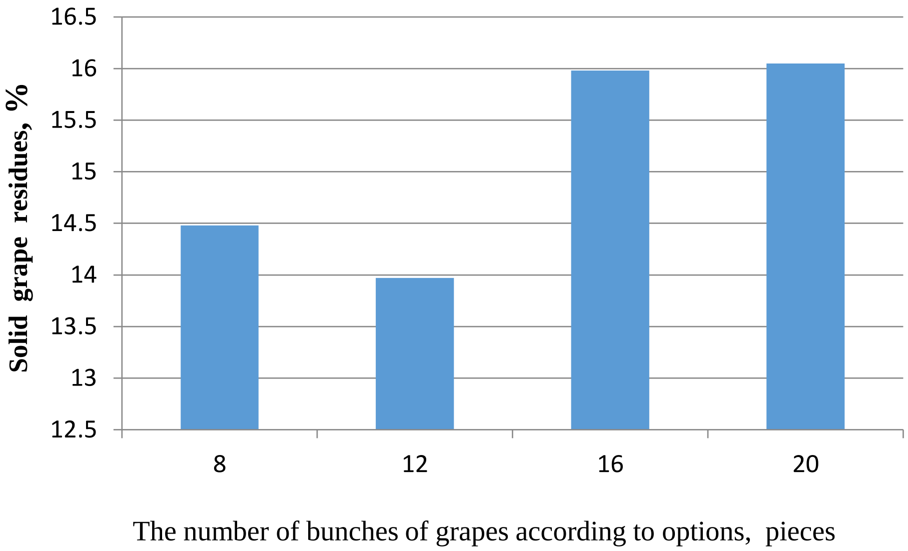

Figure 10.
The percentage of solid residue depending on the number of clusters.

The amount of solid residue in the cluster is a factor that significantly affects the juice yield. As the number of clusters in the vine increased (according to the variants), an increase in the percentage of solid residue was observed, with a few exceptions. The solid residue was 14.48% in the first variant, while this indicator was 16.05% in the fourth variant.

The color indicators of the berry were studied in the experimental variants (a, b, and L indicators). As it is known, values greater than zero indicate that the color changes to red in the berries.

As seen, the highest value of “a” was observed when 16 clusters were retained. An increase in the negative value of “b” indicates an increase in the blue color. Among the variants, the highest negative “b” value was observed when 12 clusters were retained. There was no statistically significant difference in the brightness index - L value. The highest L value was observed when 12 clusters were retained.

L, a, and b values of the color of the berry are given in the form of a diagram (Figures 11-13).

Figure 11.
Color values of the berry (L value).

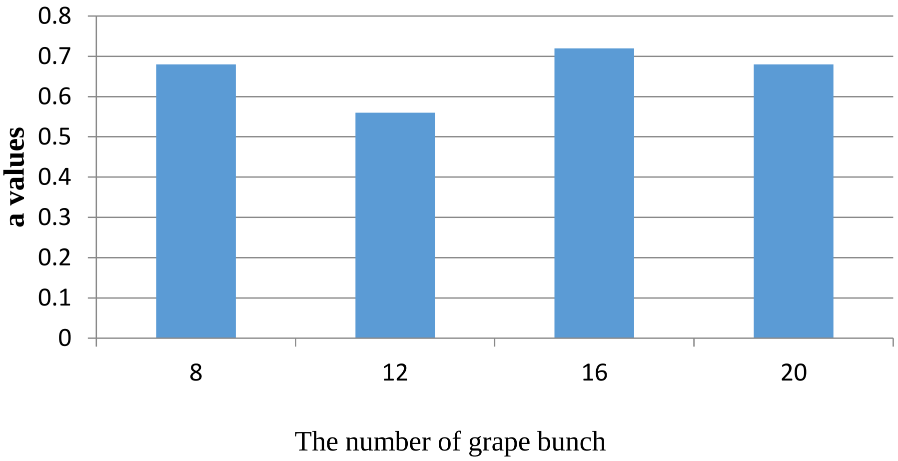

Figure 12.
Color values of the berry (a value).

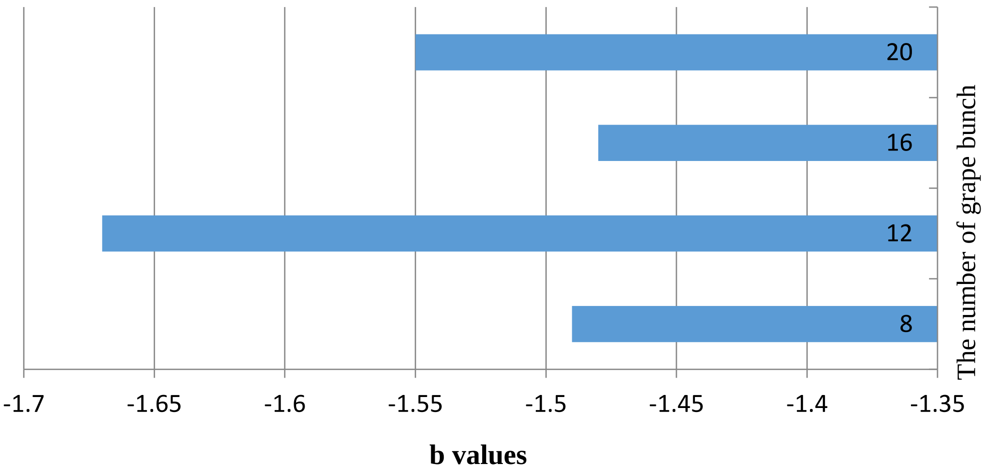

Figure 13.
Color values of the berry (b value).

3.3. The Effect of the Number of Clusters Retained in the Vine on the Quality of Juice and Wine

The effect of the number of clusters retained in the vine on the amount of dry substances and titratable acids in the juice during the ripening of grapes was studied (Figure 14).

The amount of dry matter was found to change between 20.11% and 22.21%, depending on the number of clusters. The greatest amount of water-soluble dry matter was in variant I with 8 clusters, and the smallest amount was in variant III with 16 clusters. Regarding the amount of titratable acids, a decrease in the amount of titratable acids was observed with the increasing number of clusters, except for variant IV.

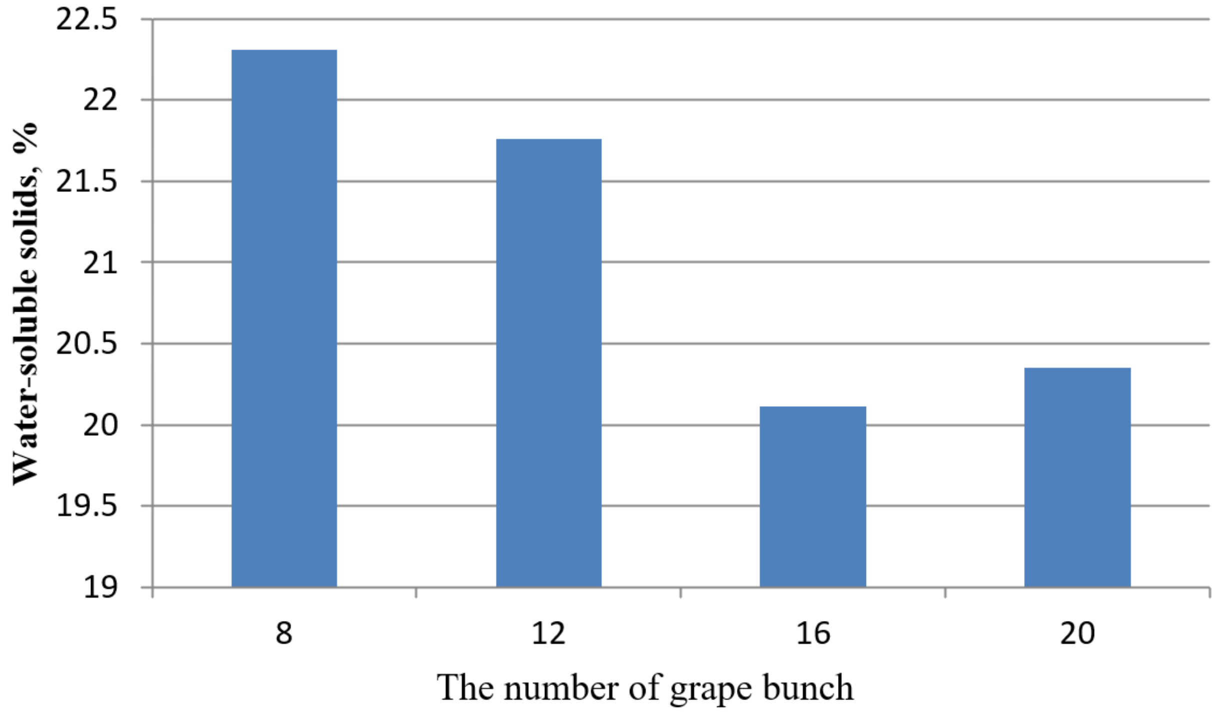

Figure 14.
Changes in the amount of soluble dry substances and titratable acidity depending on the load of the vine.

During the study of the effect of the number of clusters retained in the vine on the ripeness index, it was found that although there were rises and falls in the variants, the highest value of the ripeness index was observed in the IV variant (49.63), and the lowest value was detected in the I variant (43.75).

During the determination of the amount of phenolic compounds in grape skin, the indicators for the variants changed as follows (Table 4).

Table 4.
Effect of the cluster load on the amount of phenolic compounds in the berry.

The number of berries in a bunch of grapes	Phenolic compounds. mgGAE/100g	Total flavonoids. mg CTE/100g	Monomeric anthocyanins. mg/g
8	276.30	90.45	3.12
12	261.20	74.96	3.06
16	242.51	68.70	2.87
20	229.85	75.26	2.80

As seen, the total amount of phenolic compounds for the variants varied between 229.85-276.30 mg GAE/100 g and tended to decrease with the increase in the number of clusters on the vine. The amount of flavonoids changed between 68.7-90.45 mg CTE/100 g, and the smallest amount was observed when 16 clusters were retained, while the greatest amount was found when 8 clusters were retained on the vine.

The amount of monomeric anthocyanins varied between 2.80 and 3.12 mg/g. A decrease in the amount of monomeric anthocyanins was observed with the increasing number of clusters retained on the vine.

Antioxidant activity values (DPPH (EC50)) of the grape berry ranged from 0.99 to 1.05 mg/ml. As the number of clusters retained on the vine increased, a decrease in antioxidant activity was observed, albeit weakly.

The smallest TEAC (ABTS) values were observed in the first variant, while the greatest indicator was detected in the fourth variant. As the number of clusters increased, a slight increase in these values was observed.

The greatest FRAP value was observed in the first variant and the smallest in the third variant. There was a decrease until the third variant, and a slight increase occurred (Table 5).

Table 5.
Antioxidant activity of the grape berry.

The number of berries in a bunch of grapes	DPPH (EC_{50}). mg/ml	TEAC (ABTS). µM/g	FRAP. µM/g
8	1.05	9.86	1.22
12	1.03	11.34	1.18
16	1.01	12.55	1.14
20	0.99	13.40	1.21

During this series of studies, wine samples were prepared from the Madrasa grape variety for each of the experimental variants using the traditional method. The composition indicators of the samples were studied and the results obtained are given below (Table 6).

Table 6.
Physicochemical and organoleptic indicators of wine samples.

The number of bunches of grapes on a vine	Ethyl alcohol.%	Mass concentration. g/dm^3				pH	Dequstation. Score
		Sugar	Titratable acids	Brought exstract	Residual extract		
8	12.1	0.5	4.5	22.4	17.4	3.4	7.9
12	12.0	0.6	4.1	23.4	19.2	3.5	7.7
16	11.7	0.7	4.6	18.7	14.2	3.3	7.8
20	11.4	0.8	4.5	21.0	16.5	3.3	7.5

As seen in the obtained wine samples, the alcohol content changed between 11.4 and 12.1 h%, the sugar-free extract ranged between 18.7 and 23.4 g/dm^3, and the residual extract ranged from 14.2 to 19.2 g/dm^3. The organoleptic analysis seems to complement the results of the physicochemical analysis. It is noticeable that the first variant is distinguished by the highest value. This variant is rated 0.4 points higher than the last one. Therefore, as the number of clusters retained in the vine increases, the quality of the obtained wine decreases.

3.4. Analysis of the Effect of the Number of Clusters Retained in the Vine on the Yield and the Quality of the Product

The mechanical composition of the grape cluster is expressed by the ratio of its individual parts: comb, juice, skin, and seeds. This ratio changes not only between varieties but also within varieties. Because it depends on many factors, including the degree of maturity, soil, climate, region of cultivation, and other conditions.

As the number of clusters retained in the vine increased, there was a decrease in the structure index. The highest index (27.66) was when 8 clusters were retained, while the lowest was when 20 clusters (23.68) were retained, and it was rational when 12 clusters were retained. The largest mass of seeds in 100 berries was observed when 20 clusters were retained in a vine, and the largest mass of skin was found in the variants with 16 clusters. However, in the processing of grapes, the percentage of clusters and berries in the cluster is important. The amount of comb in the clusters varied from 3.48 to 4.05 in the studied variants. The lowest indicator was observed in the first variant, and the highest indicators were observed in the last variant. The structural index changed between 5.2 and 6.2 (Table 1, Table 2, and Table 3).

As the number of clusters increased in the variants, a corresponding increase in yield per vine and per hectare was noticed. So, in the second variant with 12 clusters, 2.0 kg product per vine, and 5575.8 kg per 1 ha; In the third variant with 16 clusters, 2.6 kg per vine and 6954.4 kg per 1 ha; In the fourth variant with 20 clusters, 3.2 kg per vine and 8426.4 kg per 1 ha were obtained (Figures 1,2).

Depending on the number of clusters retained in the vine, a change in the mass of the cluster was observed. The smallest mass of the cluster was in the IV variant (158 g), and the greatest mass was observed in the I variant (178 g) (Figure 3). The highest sizes of the cluster were observed in the I variant (length 171 mm, width 67 mm).

A change in the sizes of the clusters was also noticed. In the first variant, the length of the cluster was 169.03 mm, and the width was 65.01 mm. In the second variant, this indicator was 171.05 mm and 62.34 mm. In the third variant, it was 167.81 mm and 64.99 mm, and in the fourth variant, it was 168.75 mm and 68.12 mm, respectively (Figure 4).

As the number of clusters retained in the vine increased, a regular decrease in the mass of berries occurred. Such a decrease was also observed in the sizes (length and width) of the berry (Figures 5,6).

There were 108 berries in a cluster when 8 clusters were retained in a vine (variant I), 103 berries in 12 clusters (variant II), 104 berries in 16 clusters (variant III), and 102 berries in 20 clusters (variant IV). With certain exceptions, a decrease in the number of berries was observed with the increase in the number of clusters (Figure 7).

The average mass of the cluster, the number of berries, the mass and percentage of berries and comb in the vine, as well as the ratio of the mass of the berries to the mass of the comb, are characterized by the structure index. The structure index of the cluster varied between 5.2 and 6.2, and the composition index of the cluster varied between 23.68 and 27.66 (Figures 8,9).

The amount of solid residue (comb, skin, seed) in the cluster is a factor affecting the juice yield. Variations in the amount of solid residue were also noted in the variants (Figure 10).

The color values (L, a, and b) of the experimental variants under study were determined and characterized (Figures 11-13).

The effect of the number of clusters retained in the vine on the amount of dry matter in the juice was studied. As the number of retained clusters increased, a decrease in the amount of dry matter was observed, and this indicator ranged between 20.11% and 22.21% for the variants (Figure 14).

The total amount of phenolic compounds varied between 229.85 and 276.30 mg GAE/100 g for the variants and tended to decrease with the increase in the number of clusters on the vine. A similar situation was observed in the amount of monomeric anthocyanins (Table 4).

Antioxidant activity values in the grape berry tended to decrease, albeit weakly, as the number of clusters in the vine increased (Table 5).

Physicochemical and organoleptic analysis of the wine samples prepared in various variants was carried out. Variant I (retaining 8 clusters in the vine) was more rational (Table 6).

4. Conclusions

1. In the Madrasa variety, the highest structure indicator was when 8 clusters were retained in the vine (27.66), the least when 20 (23.68), and more rational when 12 clusters were retained (27.00). The amount of combs in the cluster ranged between 3.48 and 4.05%, and the amount of seeds was between 3.5 and 4.1%. Besides, the lowest indicator was observed in the first variant, and higher indicators in the last variants. Based on the percentage of juice, the second variant with 86.03%, i.e., the variant with 12 clusters in a vine, was the first, followed by the first, third, and fourth variants.

2. When 8 clusters were retained, 1.4 kg of the product was obtained per vine, and 3707.2 kg per 1 hectare. As the number of clusters increased in the variants under study, a corresponding increase in yield per vine and per hectare was noticed. Thus, in the second variant with 12 clusters, 2.0 kg of product per vine, and 5575.8 kg per 1 ha; in the third variant with 16 clusters, 2.6 kg per vine and 6954.4 kg per 1 ha; in the fourth variant with 20 clusters, 3.2 kg per vine and 8426.4 kg per 1 ha were obtained.

3. Increasing the number of clusters retained in a vine from 8 to 20 in the Madrasa grape variety increased the yield per vine and hectare but caused a decrease in water-soluble dry matter, phenolic compounds, antioxidant activity, and ultimately quality in grape juice.

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