Determination of the oenological maturity of dark-berry grape varieties based on sensory analysis and amino acid profile

A.V. Prakh*, *V.M.* Redka, *O.N.* Sheludko, *N.M.* Ageeva, and *A.A.* Prakh

Federal State Budgetary Scientific Institution «North Caucasus Federal Scientific Center for Horticulture, Viticulture, Winemaking», 40-letiya Pobedy st., 39, 350901 Krasnodar, Russian Federation

Abstract. In this work, the harvest date was determined based on the organoleptic characteristics of the Kurchansky and Granatovy grape varieties. At the same time, the appearance, aroma, and taste of berries, as well as the condition of the skin, pulp, and color of seeds were evaluated. The dynamics of the main yeast-consumed amino acids, as well as proline, were analyzed, considering that the degree of berries ripening affects the nitrogen profile and, as a consequence, the aromatic composition of grapes and the taste characteristics of the future wine. A correlation was obtained between the organoleptic parameters determined in berries and in the wine samples obtained from them. It was found that grape ripening has a noticeable effect on the composition of the wine, and allows to establish further the key parameters that need to be considered in the berry during ripening to determine the optimal harvest date.

1 Introduction

Choosing the optimal point of grape harvesting with the greatest potential for obtaining wines with the desired organoleptic properties is an urgent problem for winemakers. Measurement of the main physical and chemical parameters of grapes, such as sugar content, pH, total acidity, to determine the degree of berries ripeness before harvest is a standard industry practice. Nevertheless, conventional measurements are often not enough to predict the characteristics of the future wine. It is known that phenolic and nitrogenous compounds of grapes, together with organoleptically active volatile compounds, are usually considered the main determinants of the quality of red wines, which should be monitored and considered before processing [1, 2, 3].

It should be noted that under the influence of climatic features of recent years, there is a shift relative to each other of technological and phenolic maturity – a high mass concentration of sugars and a low supply of phenolic substances, which leads to the production of non-characteristic and unrecognizable samples of wines of common grape varieties [4]. The analysis of literature sources indicates the absence of uniform data on the optimal

* Corresponding author: aprakh@yandex.ru

characteristics of grapes when harvesting for red wines, depending on the grape variety, place and conditions of its cultivation.

In addition, despite the generally accepted control of the main physical and chemical indicators of grape ripening, the characteristics of organoleptic indicators of grapes in the oenological period of maturity have not been established at present, the intervals of the content of nitrogenous and phenolic substances in fresh grape must have not been determined. The search for optimal values of these indicators during the maturity period is an urgent task for the wine industry.

The purpose of this work was to identify the conditions for the formation of organoleptic characteristics of grapes, to determine the relationship between them at the time of oenological harvesting, as well as to establish optimal harvest dates based on data on the composition of the nitrogen profile of grapes for the production of red wines.

2 Materials and Methods

The experiment was carried out on two grape varieties of the selection of the North Caucasus Federal Scientific Center for Horticulture, Viticulture, and Winemaking - Kurchansky (Muscat Kubansky × Saperavi Severny) and Granatovy (Saperavi Severny × Cabernet Sauvignon), growing in the Central zone of viticulture of the Krasnodar Territory, city of Krasnodar. Harvest 2022

The scheme of the experiment included the selection of grapes in different periods from the beginning of the harvest ripening to the full ripening of the berries with an interval of 7-14 days; sensory assessment of the degree of harvest maturity according to the algorithm proposed in the work; obtaining fresh grape must; determination of physical and chemical parameters and mass concentrations of free amino acids in the must; production of dry red wines by the classical technology and evaluation of organoleptic parameters of young wines.

The research was carried out on the basis of the Scientific Center "Winemaking". The grape physical and chemical parameters must were determined according to standardized and original methods using laboratory equipment of the Center for Collective Use of High-Tech Equipment of the FSBSI North Caucasus Federal Scientific Center for Horticulture, Viticulture, and Winemaking. Sensory analysis was carried out by the tasting commission of the FSBSI North Caucasus Federal Scientific Center for Horticulture, Viticulture, and Winemaking, the passing score for young dry wines was 7.3 points. Free amino acids were determined by high-efficiency capillary electrophoresis [5].

3 Results and Discussion

According to world experience, the evaluation of the taste and aroma of fresh technical grapes is given a great interest. Thus, Australian researchers associate the taste and appearance of Shiraz grapes with the quality of the finished wine. In addition, special attention is paid to such an indicator as the pulp separation from the skin, which further affects the taste and color characteristics of wines. The ripening of berries and readiness for processing by French specialists are considered in more detail. The authors propose to determine the maturity degree by assessing the color and condition of berries, tasting berries and pulp. In turn, each stage is divided into additional descriptors – the separation of the berry from the stem, the ability to crush, the color of the skin, taste, aroma and harmony, the condition of the seeds [1, 6, 7].

In this regard, an organoleptic analysis of fresh grapes of the studied varieties was carried out in the work to determine the degree of its maturity, assessing the characteristics of the

appearance, aroma, and taste of the berry components – the condition of the skin, pulp, seed color.

To assess the degree of maturity of grape berries, the listed characteristics as they ripened were described by the following descriptors:

- **skin maturity evaluation**: hard, poorly browned, with small fragments, homogeneous, pasty mass; aromas (herbaceous, fruity, jam, spicy), tannins (taste – from tart to soft, "melting" in the mouth, concentration – strong, moderate, weak), color and appearance when compressed (ease degree of crushing berries with fingers);

- **pulp evaluation**: acid/sugar ratio, flavors (vegetable/herbaceous, fruit, formed), consistency – "dense pouch", homogeneous dense, soft ripe;

- **seed maturity evaluation** – color (from light green to dark brown), strength (soft, hardened, very hard).

Based on the data obtained for each berry component, the degree of maturity from 1 to 4 units was awarded, then a conclusion was made about the overall degree of grape harvest ripening.

The results of determining the dynamics of the main indicators of pulp, peel**,** seeds and the established maturity indices for them during the ripening of the crop of the studied varieties are shown in Tables 1, 2.

Table 1. Evaluation of the maturity degree by external signs, aroma and taste indicators of the Kurchansky grape variety, the Central viticulture zone of the Krasnodar Territory, harvest 2022.

Pulp maturity	Skin maturity	Seed maturity	Maturity degree	Mass concentration of sugars, 100mg/cm^3	Mass concentration of activated acids, g/dm^3
harvest date 24.08					
1	1	1	weak degree	14.9	11.7
harvest date 02.09					
3-4	3	2	medium degree	17.0	10.5
harvest date 12.09					
4	3	4	mature	21.1	7.8
harvest date 27.09					
4	4	4	mature "+"	23.4	4.9
harvest date 03.10					
4	4	4	mature "–"	25.3	4.9

Based on the conducted studies, it can be noted that the full ripening of the Kurchansky grape variety was observed at the end of September. When harvesting on September 27, the full degree of maturity of the skin, pulp, and seeds was established, the accumulation of a sufficiently high mass concentration of sugars 23.4/g/100 cm^3 and a decrease in the mass concentration of titrated acids were noted (Table 1). Subsequent ripening of grape berries on bushes and control after a week (October 3) caused the appearance of bitter tones in the skin of fresh grapes and a decrease in the sensory characteristics of young dry red wine (Fig. 1, Table 4).

From the data in Table 2 it can be seen that, unlike the Kurchansky grape variety, in the Granatovy variety, the accumulation of the mass concentration of sugars and the decrease in the mass concentration of titrated acids occurred more slowly. The ripening of grape berries on bushes at the end of October positively affected the sensory characteristics of young dry red wine (Fig. 1, Table 4). At the same time, at the end of the ripening of the crop (the collection date is October 28) both in fresh grapes and in ready-made young wine, shades of bitterness were noted.

Table 2. Evaluation of the maturity degree by external signs, aroma and taste indicators of the Granatovy grape variety, the Central viticulture zone of the Krasnodar Territory, harvest 2022.

Pulp maturity	Skin maturity	Seed maturity	Maturity degree	Mass concentration of sugars, 100g/cm^3	Mass concentration of activated acids, g/dm^3
harvest date 24.08					
1	1	1	weak degree	12.9	14.9
harvest date 02.09					
2	1	1	weak degree	13.8	11.5
harvest date 12.09					
2	2	2	medium	16.1	11.0
harvest date 27.09					
2-3	3	4	medium	21,4	8.7
harvest date 03.10					
3	3	4	mature	23,3	6.9
harvest date 15.10					
4	3	4	mature	24.1	6.6
harvest date 28.10					
4	4	4	fully mature	24.7	6.1

The results of sensory analysis of fresh Granatovy berries showed that the maturity of the pulp and skin occurred in late September – early October. It was noted that the pulp became more homogeneous, softened easily, the pouch disappeared, the fruitiness in the aroma was saturated with prune tones, the taste became sweet with a pleasant freshness; the skin was chewed easily and had a prune flavor and a moderately astringent consistency.

It is known that the composition of nitrogen-containing organic compounds of grape berries, as well as the sugar content, are key factors determining the composition and biochemical value of grape must. Nitrogen-containing compounds of grape must are necessary for the development and growth of yeast during fermentation, fermentation kinetics, and flavor addition [6]. The main sources of nitrogen in the grape berry are free amino acids. Some amino acids are precursors of important volatile compounds in wines formed as a result of the enzymatic metabolism of yeast during alcoholic fermentation. It is known that many factors can affect the nitrogen composition of grapes – soil management, the rate of assimilation of nitrates by the vine, the timing or rate of application of nitrogen-containing fertilizers, the rootstock type. Nevertheless, a number of researchers [7] reported that the maturity of grapes and its varietal characteristics are the most determining variables in the content of free amino acids accumulating in the grape tissues. Therefore, to obtain additional information about the optimal harvest time, it is important to evaluate the change in the concentration of amino acids during grape ripening. In addition, many scientists note a correlation between the arginine synthesis and the accumulation of soluble solids during the ripening of this variety berries. A team of researchers [1,2,8,9] studied the evolution of amino acids and ammonium ion during the ripening of grapes in different varieties and growing systems (organic and conventional). It was reported that the technological maturity of the grapes coincided with the maximum content of nitrogen compounds. There was a correlation with the accumulation of amino acids in grapes in parallel with soluble dry substances during the ripening of berries, up to overripe. In further studies, it was reported that the most common amino acids contained in the vine are proline and arginine. The proline and arginine ratio reflects the proportion of indigestible nitrogen (proline) to digestible

nitrogen (arginine) and serves as a useful indicator of the probable nutritional value of grape must of a certain variety for yeast [4].

To assess the effect of the grape ripening degree on the dynamics of the amino acid profile formation, the following nitrogen-containing compounds were identified as the main ones – easily consumed by wine yeast – arginine, serine, threonine, and non-consumed in normal, anaerobic fermentation conditions - proline (Table 3).

Table 3. Mass concentration of free amino acids in grape must of the studied varieties, mg/dm^3. The central viticulture zone of the Krasnodar Territory, harvest 2022.

Amino acid	Harvest date						
	24.08.	02.09.	12.09.	27.09.	03.10.	15.10.	28.10.
Kurchansky							
Arginine	65	74	126	186	201	-	-
Serine	32	63	86	87	99	-	-
Threonine	89	101	145	188	198	-	-
Proline	488	786	902	1605	1809	-	-
Granatovy							
Arginine	45	68	91	152	183	202	211
Serine	12	35	46	51	59	67	74
Threonine	44	74	89	105	149	165	171
Proline	161	456	501	720	871	952	1105

The study of the amino acid profile in the varieties showed that an increase in the content of controlled amino acids in the berries occurred during the entire period of active ripening of the grapes. It is noted that the degree of berries maturity had a great influence on the evolution nature of all amino acids. The dynamics of the accumulation of all amino acids was higher in the Kurchansky variety – at the time of the entire crop harvesting, the mass concentration of proline was 1809 mg/dm^3, while in the Granatovy variety this indicator was 871 mg/dm^3 on the same harvest date (03.10), which confirms the earlier ripening of the Kurchansky grape berries. A similar pattern was noted in the amino acids easily consumed by yeast – arginine, serine, and threonine (Table 3).

The organoleptic analysis of young varietal wines showed that the optimal harvesting period for the Kurchansky variety was the end of September (Table 4). During this period, the wine had a bright dark ruby color, a complex, berry aroma, a harmonious taste and was rated at 8.1 points.

Table 4. Organoleptic indicators of young varietal dry red wines depending on grape harvest date of the Kurchansky and Granatovy varieties, the Central viticulture zone of the Krasnodar Territory, harvest 2022.

No.	Harvest date	Organoleptic indicators	Tasting score
Kurchansky			
1	24.08.	The color is light ruby, visible with a purple tinge. The aroma is wine, simple. The taste is sharp, with green acidity, grapefruit bitterness.	-
2	02.09.	The color is ruby, visible with a pronounced purple tinge. The aroma is wine-like, simple, with hints of thorn. The taste is sharp, with green acidity, grapefruit bitterness.	7,3
3	12.09.	The color is ruby. The aroma is fruity, wine-like, quite developed. The taste is low-extractive, very fresh with a fast-passing fruity aftertaste.	7.4

4	27.09.	The color is dark ruby. The aroma is complex, berry, fruity, with hints of thorn. The taste is clean, full, moderately fresh.	8.1
5	03.09.	The color is dark ruby. The aroma is complex, berry, fruity, with hints of thorn. The taste is full, with dessert tones, varietal shades are weakly expressed, a slight bitterness in the aftertaste.	7.8
Granatovy			
1	24.08.	The color is pink, bright, with a slight purple tinge. The aroma is fruity, wine. The taste is sharp, very fresh	-
2	02.09.	The color is red, visible, with a purple tinge. The aroma is fruity, wine. Taste with sharp freshness, simple.	7.2
3	12.09.	The color is bright red with a purple tinge. The aroma is fruity and berry. The taste is full, very fresh, clean.	7.4
4	27.09.	The color is ruby. The aroma is bright, berry. The taste is harmonious, quite full, clean, with outstanding freshness	7.9
5	03.09.	The color is dark ruby with a garnet tint. The aroma is complex, berry, with hints of spices and chocolate. The taste is full, moderately fresh, with a tannic aftertaste.	7.9
6	15.10.	The color is dark ruby with a garnet tint. The aroma is varietal, with hints of red berries and nightshade. The taste is full, moderately fresh, with a pleasant aftertaste.	8.3
7	28.10	The color is dark ruby with a garnet tint. The aroma is varietal, with hints of blackberries, dried cherries, nightshade, and Cahors undertones. The taste is full, moderately fresh, with a piquant bitterness in the aftertaste.	8.4

At a later harvesting, dessert tones appeared in the aroma and taste in the wine, a slight bitterness in the aftertaste was noted.

The maximum rating of the young Granatovy varietal wine was 8.4 points and corresponded to a sample made from grapes with a harvest date of October 28. This sample was characterized by a rich dark ruby color, with a well-pronounced varietal aroma and a full, harmonious taste. It is noted that the late harvest has improved the wine quality, which allows to conclude that it is advisable to use the Granatovy variety in the technology of dessert wines and late-harvest wines.

When comparing the results of tastings of fresh grapes and young wines of the studied varieties (Fig.1), it can be noted that the sample of Kurchansky wine with a maximum tasting rating of 8.1 was characterized by the following taste characteristics of grapes: homogeneous pulp, without a pouch, refreshing taste, absence of sharp acidity, predominance of sweetness over freshness; homogeneous, well-chewed skin, bursting with light pressure, dark purple in color with tones of overripe cherries in the aroma; the seeds had a dark brown color.

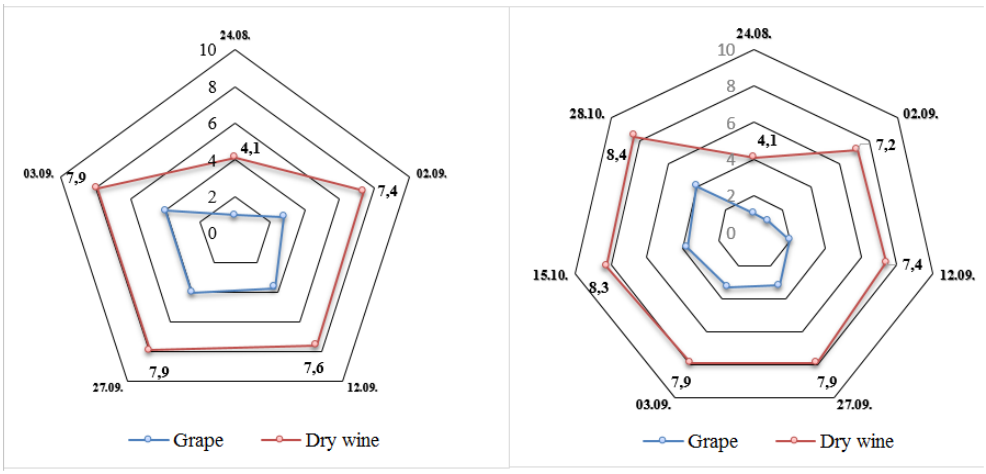

Fig. 1. Diagram of organoleptic evaluation of fresh grapes and young wines of the Kurchansky (a) and Granatovy (b) varieties, city of Krasnodar, harvest 2022.

The characteristics of fresh berries in the Granatovy variety for wines with a maximum tasting score (8.4) were identical to the Kurchansky variety, but began to manifest themselves later – in the second and third decades of October (Table 2, Fig. 1). The grapes of this variety are characterized by a gradual skin ripening – until the moment when "its phenols became soft", less noticeable, and the taste is sweeter.

4 Conclusions

As a result of the conducted research, it was found that the terms of grapes ripening considered in the work (technical and nitrogen) are not achieved simultaneously, on the contrary, they tend to be divided depending on the grape variety.

Sensory analysis, in contrast to the traditional analysis of physical and chemical indicators, allows to assess the organoleptic aromatic and technological maturity of grapes, which correlates with the organoleptic indicators of wine quality.

Thus, sensory evaluation of grapes and control of the free amino acids proposed in the work can be used as an effective tool for determining the degree of oenological maturity of a grape berry and establishing the optimal harvest date in accordance with winemaking objectives.

Acknowledgements

The research is carried out with the financial support of Kuban Science Foundation in the framework of the scientific and innovation project No. NIP-20.1/22.25.

References

1. J. Rousseau, D. Delteil, French Journal of Oenology, **183** 10-13 (2000)
2. O. Mantilla, S. Milena, Relationships between berry sensory assessment and wine quality in Vitis vinifera L. Shiraz. Thesis (Ph.D. - University of Adelaide, School of Agriculture, Food and Wine, 2015)

3. E.A. Vernovsky, S.Yu. Geneev, V.F. Ponomarev, E.P. Scholz, Technology of grape cultivation and use (Moscow: Agropromizdat, 1990) 320.
4. T. Garde-Cerdán, et al. Scientia Horticulturae, **239** 9-16 (2018).
5. M.V. Zakharova, I.A. Ilina, G.V. Lifar, Yu.F. Yakuba, *Method for determining the mass concentration of free amino acids,* Methodological and analytical support of horticulture research. Krasnodar: SSI North Caucasus Federal Scientific Center for Horticulture, Viticulture, and Winemaking, 289-295 (2010).
6. S.J. Bell, P.A. Henschke, Australian journal of grape and wine research **11(3)** 242-295 (2005)
7. M. Le Moigne, et al. Food Quality and Preference, **19(2),** 220-231 (2008)
8. A.A. Shirshova, et al. Fruit growing and viticulture in the South of Russia, **70,** 336-345 (2021)
9. A.V. Prakh, N.M. Ageeva, D.V. Dergachev, Polythematic online electronic scientific journal of the Kuban State Agrarian University, **159,** 212-223 (2020)