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ORIGINAL RESEARCH PAPER

INFLUENCE OF SOIL AND CLIMATE ON THE BIOLOGICAL POTENTIAL OF "KARA-KOISU" DRY RED WINES FROM CABERNET-SAUVIGNON GRAPES (REPUBLIC OF DAGESTAN)

Eslanda A. Khalilova*, Svetlana Ts. Kotenko, Elvira A. Islammagomedova, Aida A. Abakarova, Dinara A. Aliverdieva

Peri-Caspian Institute of Biological Resources of the DFRC RAS, Makhachkala, Gadzhieva 45 str., Republic of Dagestan, Russian Federation

*Corresponding author: eslanda61@mail.ru

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Abstract: Climate is a modulator of the biological potential of grapes and wine products. The present study considers the climate gradient of the terroir of the Derbent district (Mugarty village) of the Republic of Dagestan, located on the terraced accumulative-coastal plain of the Caspian Lowland, extending for 160 km from north to south in a narrow strip between the coast of the Caspian Sea and the foothills. The paper studies the influence of soil and climate conditions on the physical and chemical properties; flavor characteristics; mineral, vitamin-like and phenolic substances of red dry wines from Cabernet-Sauvignon grapes of the 2019 - 2020 harvest. The vegetation period of the grapevine took place in a dry, moderately humid climate in 2019 and hot, with a large amount of precipitation climate in 2020. The conditions of recent years have contributed to the improvement of almost all the studied indicators of dry red wines. Regardless of the changing climatic conditions of this period, terroir wines had their unique feature of aroma and taste. New data show a significant role of the biochemically active *S. cerevisiae* Y-4270 strain in the creation of high-quality dry red wines.

Keywords: *climate, dry red wine, mineral substances, organic acids, phenolic, soil, vitamin-like*

INTRODUCTION

Climate plays a vital role in the terroir of the wine region, as it controls the micro-climate of the vegetation cover, the growth and physiology of the vine, the yield and the composition of the berries, which together determine the attributes and type of wine. Since the cultivation of vine is dependent on weather and climatic conditions, the problems associated with climate change can exacerbate the trends in the suitability of wine production. Such soil and climatic factors as solar radiation, temperature, precipitation, wind, soil and the frequency of extreme weather events are critical aspects for the yield of the grape plant and the quality of wine [1 – 4]. In regard to the ecosystem of the vine, the influence of the soil is often intertwined with the influence of the grape variety or climate. The effect of climatic conditions on the production of grapes and wine can be positive when the maturity of grapes is accelerated, but too warm and dry a climate can cause the opposite effect, producing grapes and wines with lower potential.

The typicality of the wine reflects the terroir of the wine region as an interactive ecosystem, including climate, soil, wine-making aspects and oenology of the wine. The Republic of Dagestan is a unique province of Russia, which has a variety of natural landscapes suitable for growing grapes of technical varieties, including Cabernet-Sauvignon. The terroir of the Derbent district (Mugarty village) [5] under study is located on the territory of the Caspian lowland of the Republic of Dagestan. The lowland is composed of ancient Caspian and tertiary sediments, covered from above by deluvial and alluvial sediments and is a terraced accumulative-coastal plain extending for 160 km from north to south in a narrow strip between the coast of the Caspian Sea and the foothills. The good quality of Derbent wines is largely due to the soil and climatic conditions of growing grapes. It also lies in the abundance of heat, a mild climate and short warm winters [6]. The control of geographical origin and climatic conditions is one of the highest priority issues regarding the authenticity and quality of wine. In order to meet the preferences of consumer markets, where the attractiveness of the terroir, the typicality and complexity of the wine dominate when making a purchase decision, the search for biochemically active wine yeast is becoming increasingly important.

Thus, taking into account the fundamental role of extractive components in the formation of typical properties of wine, in order to identify and confirm their authenticity, special attention should be paid to the qualitative and quantitative composition of organic acids, phenolic, vitamin-like and mineral substances.

The aim of the research is to study the effect of soil and climatic conditions, and the use of wine strains in the technology on some biochemical parameters of “Kara-Koisu” dry red wine.

MATERIALS AND METHOD

The objects of research were the “Kara-Koisu” wines from the 2019-2020 harvest from the variety Cabernet-Sauvignon, obtained using strains of *Saccharomyces cerevisiae* Y-4270 (test sample), which undergone experiments at JSC “Derbent Sparkling Wine Factory” for producing Cabernet-Sauvignon table wine and “Kara-Koisu” red dry [7];

and *Saccharomyces cerevisiae* D-19 (control sample) from the collection of the laboratory of biochemistry and biotechnology at the Peri-Caspian Institute of Biological Resources, DFRC RAS (Makhachkala) and the All-Russian collection of industrial microorganisms of the FSUE GosNIIGenetics (Moscow).

The heat-resistant Cabernet-Sauvignon grape variety was cultivated on the territory of the village of Mugarty, located next to the Mugartychay River (Kamyshchay River basin), 33 km southwest of the city of Derbent. The annual reports of soil and climatic characteristics of the terroir for 2019-2020 in the village of Mugarta were received by the Dagestan Center for Hydrometeorology and Environmental Monitoring – a branch of the FSBI "North Caucasian UGMS" (Figure 1). The indices of extreme climatic events were calculated both annually and monthly based on data from a weather station located within the area under study.

The system of cultivation of the light chestnut soils is a drip irrigation technology, semi-high with a tension of 70 cm, a double-sided cordon with cutting rings of fruits, a planting distance of 2.4 m × 1.2 m and a density of 3472 vines per hectare. Drip irrigation made it possible to increase the efficiency of water use by 3 - 4 times through savings compared to traditional irrigation while increasing the yield by 1.5 - 2.0 times and creating optimal water-air conditions for plants, as well as the use of fertigation.

Wine materials were prepared according to the traditional technology of red dry wines in the conditions of micro-wine production at JSC "Derbent Sparkling Wine Factory". Biotechnological and organoleptic indicators were determined in the test samples of wines according to standard methods used in enochemistry [8, 9]. The mass concentration of phenolic substances was carried out using the Folin-Ciocalteu reagent; organic acids and vitamin-like substances – using capillary electrophoresis on the "Capel-103 R" system [10, 11]. The content of cations of alkaline and alkaline earth metals was determined by capillary electrophoresis on the "Capel R-103" and "Capel-105" systems [12].

All wine samples were delivered from JSC "Derbent Sparkling Wine Factory" in glass bottles with a capacity of 750 ml with corks and were stored at a temperature of 3 - 4 °C. One bottle was used for each analysis; the identifications were performed in three replications.

RESULTS AND DISCUSSION

The results of the climatic characteristics of the terroir in 2019 - 2020 showed that the growing season of the grape plant took place in a dry, moderately humid climate in 2019 and a hot, humid climate in 2020 (Table 1).

Regarding these values and the strains of *S. cerevisiae* Y-4270 and *S. cerevisiae* D-19 used in the technology, we studied the quality indicators of dry red wine from the Cabernet-Sauvignon variety.

As is known, the duration of the vegetative season for each grape variety depends mainly on the geographical latitude and climate. At the same time, there is a direct correlation with the average air temperature and soil humidity, where the state of water in the vine depends on the texture, the percentage of stones, the depth of rooting, the total evaporation in the soil and the leaf area. It should be noted that in the conditions of low fertility of light chestnut soils and a low humus index, the presence of mineralized

groundwater (1 - 3 m) acquired a certain significance. In our study, the content of sand and clay in the soil created conditions for overcoming water stress by the grape plant due to the water level within the reach of the roots.

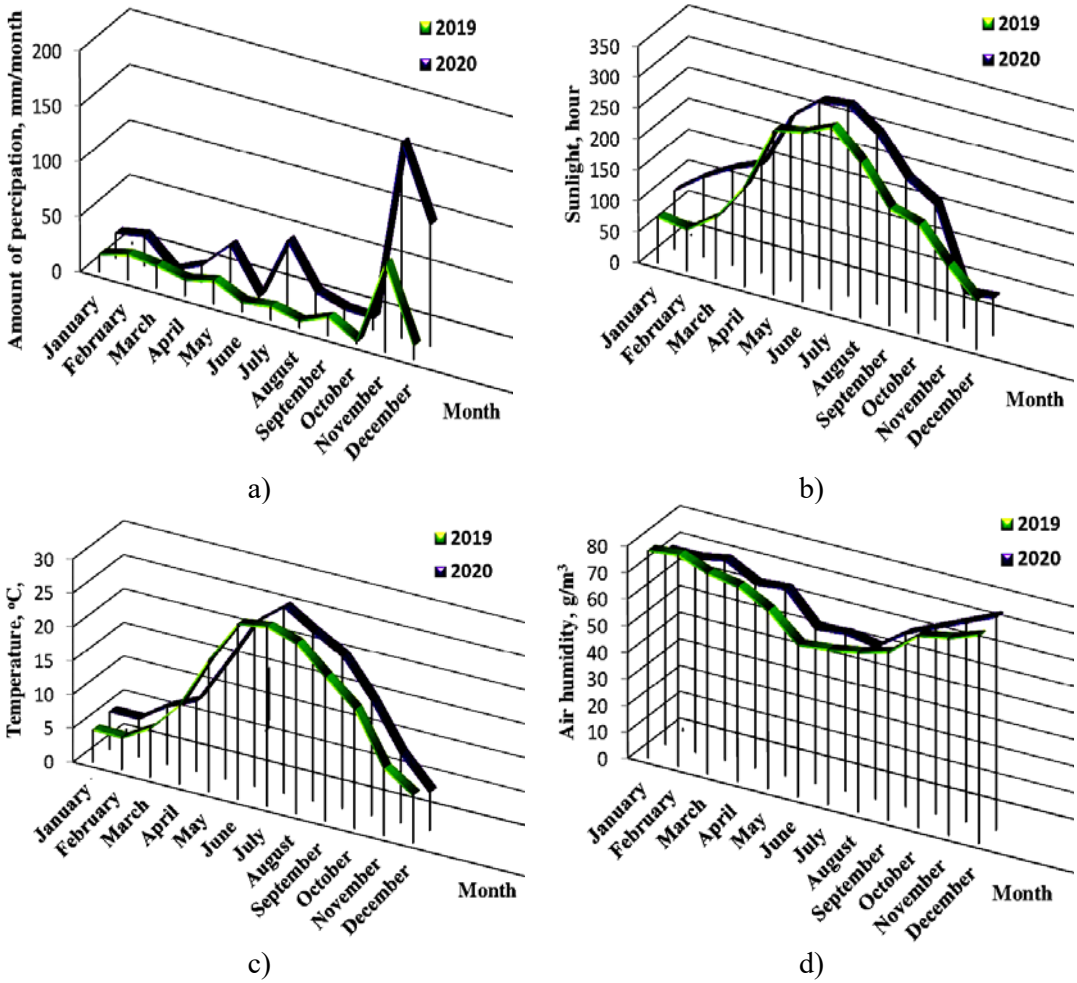

Figure 1. *The total amount of precipitation (a), sunshine (b), temperature (c) and humidity (d) in the vineyards of Mugarta village of Derbent district by month in the 2019-2020 period*

At the same time, an increase in the temperature of the growing season can lead to the thermal stress of grapes, which is often associated with water scarcity in arid climates or pests and diseases in humid climates. This may result in disorderly budding [13].

Figure 1 shows the results of observations of changes in precipitation (Figure 1a), sunshine (Figure 1b), temperature (Figure 1c) and humidity (Figure 1d) of the terroir of the Derbent district (Mugarty village) of the Republic of Dagestan in the 2019 - 2020 period.

It shows that the sum of temperatures above 10 °C has an increase in 2019 in May, June, August and October by an average of 2.3, 1.7, 0.3 and 0.6 °C compared to the next year, while in 2020 it is July, September and November (by 1.1, 1.3 and 0.2 °C respectively). Regarding the sunshine, all data in 2020 were higher from January to

October, marked by the maximum values in July > June > August > May > September > October > April > March > February > January (except November and December) compared to 2019. As for precipitation, the 2020 indicators differed exclusively for all months: November > December > July > May > February > January > August > April > October, except for March, June and September data. Relative humidity in 2020 was higher in the following sequence: December > November > March > February > January > May > April > September > July > June, except for August and October in comparison with 2019.

***Table 1**. Soil and climatic characteristics of the terroir of the Derbent district of the village of Mugarta (Republic of Dagestan)*

Indicator	Soil and climatic characteristics
Characteristics and type of soil	The soils of the area are light chestnut, deep-plowed, carbonate, medium loamy mechanical composition, clay, sandy loam, sand; characterized by a small content of humus in the horizon A (2.5-3.5 %); a higher location in the profile of carbonate white-eye and gypsum secretions, humus reserves in the horizon A+B are 200 t/ha. Increased content of the silty fraction, which causes some compaction of this layer, is detected in the horizon B. The provision of soils with mobile phosphorus is 2.2-0.3 mg/100 g, potassium is 21.0-76.0 mg/100 g of soil.
Geographical coordinates	41°59'50" N, 48°09'42" E
Altitude [m]	448
Landform	Foothills, the coast to the Caspian Sea. Gently rolling plains with slopes from 2 to 6°
Natural landscape	Dry-steppe, deluvial-alluvial and abrasive-accumulative terraced lowland
Climate	Subtropical

Thus, at the time of harvest *in September 2020*, the regularity of the increase in temperature, humidity and sunshine, except for the amount of precipitation, was found.

Physical and chemical indicators

Slightly elevated temperatures during the growing season contributed to a decrease in the overall acidity of grapes and wine, which corresponded to generally accepted indicators [13]. The mass concentration of titrated acids in the test wines was within the limits of GOST (not less than 3.5 $g \cdot dm^{-3}$); the harmonious acidity, the content of which in the berries is due, as is known, to anthropogenic factors, was below 7.0 $g \cdot dm^{-3}$ (Table 2). In the wine samples in the 2019-2020 period, the values of SO_2 (2.2:37.4 %, Control:Test (further as C:T), *p*H (0.6:1.6 %, C:T) and the reduced extract decreased (0.6:0.4 %, C:T) with a simultaneous increase in titrated (11.3:12.0 %, C:T) and volatile (30.0:2.1 %, C:T) acidity. Lower *p*H values of the sample in 2020 compared to 2019 made it possible to conduct lactic acid fermentation more efficiently. The high values of volatile acidity in wines in 2020 indicate the oxidation of wine, which is often associated with the activity of acetic acid bacteria. Volatile acids in concentrations corresponding to GOST practically do not participate in the formation of the flavor of

wine, but they make a significant contribution to the creation of aroma. Together with alcohols, they formed esters with aromas of various berries and fruits, the descriptions of which are shown in Table 1. The values of ethanol vary significantly: in the test wines, an increase of 4.4 % was observed, on the contrary, in control wines, a decrease of 13.1 %, which is associated with the biochemical activity of the strains. As earlier studies have shown, changes in all organoleptic parameters in both wine samples are undoubtedly associated with the aromatic complex, the mass concentration of which varied depending on the Y-4270 and D-19 strains used [14].

Table 2. *Physicochemical indicators of red dry wines of the 2019-2020 harvest*

Indicator	control sample		test sample	
	harvest 2019	**harvest 2020**	**harvest 2019**	**harvest 2020**
Volume fraction of ethyl alcohol [%]	13.00	11.30	11.30	11.80
Titrated acids [g·dm^{-3}]	5.00	5.60	6.20	6.90
Volatile acids [g·dm^{-3}]	0.40	0.84	0.30	0.39
SO_2 [mg·dm^{-3}]	68.00	42.60	122.00	86.13
Reduced sugars [g·dm^{-3}]	<0.60	0.90	<0.60	0.60
Reduced extract [g·dm^{-3}]	27.30	27.20	27.10	26.50
*p*H	3.70	3.64	3.40	3.38

In accordance with the standard requirements, both versions of the wines from the 2019 - 2020 harvest showed good tasting characteristics. However, the test samples prepared using the Y-4270 strain had a slightly lower number of points (Table 3).

Table 3. *Tasting characteristics of the "Kara-Koisu" dry red wines*

Indicator	control sample		test sample	
	harvest 2019	**harvest 2020**	**harvest 2019**	**harvest 2020**
Color	dark ruby color with a garnet tint	dark red	dark ruby color with a purple tint	ruby with a garnet tint
Aroma	berry with tones of blackthorn, plum	berry, with hints of nightshade, ripe fruit	bright, complex, berry with tones of juniper and dried fruits	bright, berry, with hints of nightshade, violets and ripe fruits
Flavor	full-bodied, very fresh with an astringent aftertaste	clean, moderately fresh, full-bodied, with a berry aftertaste	full-bodied, very fresh with a smooth aftertaste	clean, fresh, with a berry aftertaste
Points	8.1	8.0	8.5	8.2

Temperature difference during the growing season by 0.3 - 1.7 °C changes the physiology of vines, causing certain shifts in the primary (organic acids) and secondary (phenolic substances) metabolism of berries and the composition of the wine. In accordance with this, there is a tendency of changing the color of red wines [15]. The

deep dark ruby color of the wines of the 2019 harvest was observed in conditions of water shortage during the growth and maturation of the grapes. The comparative characteristics of the organoleptic indicators of the wines of two years showed a certain lightening of the color, the appearance of the aroma of berry tones with hints of nightshade and ripe fruits; berry aftertaste (Table 3).

Organic acids

Organic acids can partially come from grapes or be formed during the fermentation of wine as intermediates of yeast metabolism. Their accumulation in wine depends on the grape variety, climatic conditions and production technology, including the strains used. As a result of the conducted studies, 6 aliphatic oxy-acids were identified in the wine samples (Table 4), the component composition of which can serve as a criterion for falsification, a marker of the flavor and aromatic properties of the authenticity of wines, to prevent bacterial diseases. The susceptibility of all organic acids to natural conditions was found. It is noteworthy that there is a significant variation in the values of one of the indicators of the authenticity of wines - the ratio of *tartaric/malic acids,* which can be due to both the climatic characteristics of the region and the aging of the wines.
Mass concentrations of tartaric, malic and lactic acids prevailed over other acids. A warmer spring of 2020 could contribute to the development of unbalanced growth of vines with an active vegetative period, and the subsequent rainy and warm summer allowed increasing the maturity of grapes, affecting the microclimate of the vegetation cover.

Table 4. *Mass concentration of organic acids in "Kara-Koisu" red dry wines*

Indicator [g·dm^{-3}]	**control sample**		**test sample**	
	2019	2020	2019	2020
Tartaric	1.6060	2.8240	2.0010	3.7330
Malic	0.0210	0.0652	1.2120	2.4520
Succinic	0.8593	0.8392	0.5510	1.1890
Citric	0.1292	trace amounts	0.3434	0.2543
Acetic	0.3193	0.8523	0.4707	0.1650
Lactic	2.2930	1.3090	0.5506	0.1948
Tartaric/citric	12.4303	2.8240/trace amounts	5.8270	14.6795
Total content	***5.2278***	***5.8897***	***5.1287***	***7.9881***

Absorption increased radiation by grapes bunches (Figure 1b) could lead to a decrease in acidity during maturation and a higher accumulation of tartaric, malic and lactic acids, which is confirmed by our and literary data [2].
It was found that the change in climatic conditions in 2019-2020 resulted in the greatest accumulation of tartaric, malic and succinic acids in the test wines when using the *S. cerevisiae* strain Y-4270. Thus, the content of tartaric (1.76:1.87 times, C:T), malic (3.11:2.2 times, C:T), *succinic (except the control sample)* naturally increased in red

wines in 2020; on the contrary, citric (trace amount: 1.35 times, C:T), *acetic* (*except the control sample)* and lactic (1.75: 2.83 times, C:T) acids significantly decreased. The content of succinic and acetic acids, apparently, depended on the biochemical properties of the strains and the conditions of the technological process.

Succinic acid is a powerful antioxidant, which is 1.4 times higher in the test sample in 2020 than in the control. The usual content of citric acid, which gives the wine the best taste sensations, is in trace amounts, but in the test wines it is much more. The content of malic acid, which contributes to an increase in the by-products of oxidation and astringency of wine, is usually very rapidly reduced due to participation in various biochemical processes [16]. Lactic acid gives wine smoothness; its amount is significantly less in the test wines obtained using the Y-4270 strain. The value of acetic acid less than 3g is not a wine fault; the absence of a pattern of its accumulation in 2019 (test) and 2020 (control) is shown.

In addition to the fundamental contribution to the acidity of wine, organic acids, being metal chelators, affect all redox reactions responsible for the aging of wine products. The concentration of acids in wine and their connection with cations of alkaline and alkaline earth metals determine the taste qualities and stability of products to turbidity.

The elemental composition of wine

The elemental composition of the wine projects similar results of the mineral composition of the water and soil of the terroir as an identification indicator of naturalness and authenticity, important for the geographical classification of wine products. The accumulation of metals is caused by various factors: the grape variety, winemaking methods, yeast, contact with technological machinery at various stages of the oenological process, including aging, storage and transportation. In addition, the content of macronutrients and their ratio in wine are significantly influenced by the *natural and climatic conditions of the grape growing place* [17, 18].

Analyzing the data in Table 5, the terroir wines contain elements whose number decreases in the following order: K > Mg > Ca > Na > NH_4.

Table 5. *The content of cations in the "Kara-Koisu" red dry wines*

Indicator [mg·dm^{-3}]	**control sample**		**test sample**	
	Harvest 2019	Harvest 2020	Harvest 2019	Harvest 2020
Ammonium	3.09	8.40	3.16	0.10
Potassium	805.00	1060.00	690.00	887.00
Sodium	11.40	65.20	49.30	47.20
Magnesium	108.00	117.00	130.00	102.00
Calcium	54.00	82.00	92.50	90.90
Total content	***981.49***	***1332.6***	***964.96***	***1127.2***
Sodium/potassium	0.0142	0.0615	0.0714	0.0532

The common high levels of potassium, magnesium and calcium, which provide the bactericidal properties of wines, are found in soils of carbonate rocks containing loams, clay, sandy loam, sand, which is confirmed by our data (Table 1). The dominant content of these elements in experimental wines is due to the regional specifics of chestnut soils

and the proximity of vineyards to the coast of the Caspian Sea. According to the results obtained, the metal content corresponds to the generally accepted quality standards of red table wines and, accordingly, ensures the resistance of wines against the appearance of casse.

According to the International Organization of Vine and Wine (OIV), for natural wines, the ratio of "sodium/potassium" should be no more than 0.56. It is noteworthy that the concentration of these cations is significantly influenced by the natural and climatic conditions of the place where the grapes grow. Thus, it can be assumed that for the wines of the terroir of the Derbent district, the ratio "sodium/potassium" will be significantly lower than the values indicated in the literature, since the amount of potassium is considerable. Moreover, it is known that the prevailing potassium content may be associated with a longer contact of the pomace with the juice during the production of red wines. For Russian-made wines, this ratio is 0.04 - 0.06.

More precipitation in May, June, August (Figure 1a) in 2020 certainly resulted in the washing of some elements from the soil, water absorption and potassium sequestration in the grape plant. Part of the sequestered potassium is re-mobilized during maturation, increasing its level in berries, which can positively affect the *p*H of berries [19, 20] and, accordingly, wine. It should be taken into account that the mass concentration of mineral substances can increase when processing must and wines with bentonite, during gypsum, chalking and sulfitation.

In addition, some mineral elements are partially utilized by yeast cells and their decrease continues during the processing and aging of wine, as is the case with calcium and sodium (Table 5).

In 2019, a higher content of mineral elements was observed in the test sample of wine (exception - K^+), on the contrary, in 2020, the control sample was distinguished (exception - Ca^{++}). Changes in climatic conditions in 2019-2020 revealed a pattern of increasing the amount of metals in the control sample of wine and reducing them in the test wine (exception - K^+).

We can conclude that the content of mineral elements in wine is ambiguous and depends on both soil and climate and the conditions of the technological process, including the biochemical potential of wine strains. The results of the research revealed that the wines of this region, regardless of climatic conditions, are characterized by increased concentrations of potassium, magnesium and calcium.

Vitamin-like substances

Vitamin-like substances have radioprotective, antiviral, bactericidal and antioxidant properties that protect wine from pathogenic microorganisms; they are involved in the composition of the taste of wine products**.** The total content of phenolic substances that affect the organoleptic parameters of wine is the highest in the control 2019 and test samples in 2020, due to which the intensity of color shifted to a more "burgundy" hue. Thus, the wine acquired classic garnet tones (Table 3).

As follows from Table 6, the total amount of phenolic acids is higher in 2019 (control) due to syringic and in 2020 (test) - nicotinic acids, which could indicate the biochemical characteristics of the strains used.

According to the results of studies in 2019, orotic and protocatechic acids were absent in the wines. At the same time, the experimental wine (strain Y-4270) showed an

increase in resveratrol, ascorbic acid and caffeic acid by 19.2, 1.4, 17.7 times respectively compared to the control wine. On the contrary, a sample of wine prepared using the D-19 strain was distinguished by an increase in chlorogenic, nicotinic, gallic and lilac acids by 2.1, 0.1, 2.6, 10.0 times respectively (Table 6).

Table 6. *Biologically active substances in the "Kara-Koisu" red dry wines*

Indicator [g·dm^{-3}]	**control sample**		**test sample**	
	harvest 2019	harvest 2020	harvest 2019	harvest 2020
Chlorogenic acid	7.8420	0.9837	3.8290	14.0000
Nicotinic acid	0.1292	0.9002	*ND	43.5000
Orotic acid	*ND	7.3220	*ND	8.1710
Caffeic acid	1.5620	20.6300	27.6500	9.8710
Gallic acid	2.6300	3.9220	*ND	4.8850
Syringic acid	115.000	*ND	11.5400	*ND
Protocatechic acid	*ND	*ND	*ND	33.64
Gallic/syringic	0.0229	3.9220/ND	ND/11.5400	4.8850/ND
Total content phenolic acids	***127.1632***	***33.7579***	***43.0190***	***114.067***
Trans-Resveratrol	0.1461	2.5430	2.7990	4.0030
Ascorbic acid	8.8240	5.2200	12.5500	9.6270

*ND - Not Detected

The wine of the 2020 harvest was characterized by increased content of almost all the studied compounds in the experimental wine: resveratrol - 1.6, ascorbic - 1.8, chlorogenic - 14.2, nicotinic - 48.3, orotic - 1.1, gallic - 1.3, protocatechin - 33.6 times. Syringic acid was not detected.

Representatives of the groups of oxybenzoic *(gallic, syringic)* and oxycoric (*caffeic)* acids were contained in wine in minor concentrations, but their influence on the development of wine cannot be overstated. In addition, depending on the region, the value of the ratio of gallic/syringic acids varies greatly or even is absent in some years. As the results showed, the lowest ratio of these acids is characteristic for this region in wines from the Cabernet-Sauvignon variety. At the same time, for wines produced in 2020, a high value of gallic acid and, significantly, in 2019, syringic acid was recorded.

In the process of alcoholic fermentation, the amount of nicotinic acid is significantly reduced due to its high adsorption by yeast. Nevertheless, the amount of acid in the 2020 wine sample is quite high, which may be caused by the increased tryptophan decomposition due to high values of sunlight (Figure 1b).

The amount of trans-resveratrol, a natural phytoalexin synthesized by the grape plant in response to biotic or abiotic stress, is lower in wine than other polyphenols, which corresponds to the literary data. Its content can be influenced by the grape variety, meteorological conditions, terroir conditions, soil type and viticulture methods [21, 22]. In general, a positive correlation was found between a high content of trans-resveratrol and increased values of sunshine (all months except September) and precipitation (May, July, August, September) in 2020 (Figures 1a, b).

It was also found that the amount of ascorbic acid, which is a powerful antioxidant that normalizes redox processes in a living organism in almost all diseases, is significantly

lower in the wine of the 2020 harvest, which is most likely due to the influence of climatic conditions of this period.
Thus, an increase in solar radiation and more precipitation in 2020 led to an increase in the amount of resveratrol, nicotinic, orotic and gallic acid in wines, and, conversely, to a decrease in ascorbic and lilac acid, leading to product oxidation. There is no regularity in the accumulation of chlorogenic, caffeic and protocatechinic acids, which may be caused by the individual biochemical activity of wine strains.
The data obtained allow us to conclude that the quantitative ratios of phenolic acids have a significant effect on the organoleptic characteristics of wine. Clearly, the amount of the latter in wine is caused by the complex influence of climatic conditions on the chemical composition of the grape plant and the biochemical potential of yeast. The discovered biologically active compounds are especially valued in medicine in the pathophysiology of many diseases, including cardiovascular diseases and cancer.

Phenolic substances

Phenolic compounds are extremely important due to their contribution to the color, taste, aroma, texture, astringency and antioxidant properties of wine [1]. In wines, phenolic substances are formed during the ripening of grapes, alcoholic fermentation and the aging process. The last two stages can be changed with the help of wine-making technologies, but in the context of global warming, their content in grapes is directly dependent on climatic factors. Phenolic compounds are strong antioxidants and their accumulation in the grape plant is stimulated under various stressful conditions, including extreme temperatures, UV radiation, fungal and bacterial infections. These compounds give the grape berry and wine a lot of red, blue or purple colors that are sensitive to changes in *p*H, temperature, light, metal cations.
It is known that each grape variety can synthesize individual phenolic compounds; on the other hand, the environment, especially the geographical location, climate, amount of light, duration of daylight and soil composition affect the content of each class of phenols and their polymers. When using Cabernet-Sauvignon grapes, water stress accelerates the accumulation of anthocyanins and has a positive effect on the expression of key genes involved in their biosynthesis pathways.
The climatic conditions of 2020 were more favorable for obtaining a rich harvest, high-quality wines due to more UV light and precipitation compared to 2019. The research results showed that in 2019, almost all phenolic compounds were in an increased amount in the test sample of wine: phenolic - 1.7 times, monomeric - 2.5 times, anthocyanins - 1.2 times compared to the control sample, except for polymer compounds (Table 7).
The experimental wine of 2020 was also distinguished by high indicators of all phenolic compounds: phenolic - 1.1, monomeric - 10.4, polymer - 1.1, anthocyanins - 2.9 times.
As a rule, variations in the content of polyphenols in red wines are interrelated.
with the *amount of solar radiation* (Fig. 1b), to which the grapes were exposed during cultivation. Solar radiation, as well as elevated temperatures, are a decisive factor in viticulture, contributing to an increase in the induction of the synthesis of polyphenols, monoterpenes and anthocyanins during the ripening of grapes [3]. The fluctuation of their content in grapes can be significant due to the fact that the polyphenol profile significantly depends on the genotype of grapes and interaction with the environment.

Thus, a correlation was found between an increase in the content of phenolic and polymer compounds with an increased level of precipitation, soil moisture capacity and solar radiation.

***Table* 7**. *The content of phenolic substances in the "Kara-Koisu" red dry wines*

Indicator [mg·dm^{-3}]	**control sample**		**test sample**	
	2019	2020	2019	2020
Phenolic	972	1989	1678	2100
Monomeric	482	861	1220	890
Polymer	490	1128	458	1210
Anthocyanins	115	195	139	274
Total content	***2059***	***4173***	***3495***	***4474***

Precipitation data in 2020 significantly exceed 2019 by 2.2 (control sample) and 9.0 (test sample) times. It seems that the moderate availability of water at the beginning of the growing season (Figure 1a) and the subsequent development of grape berries with an increased amount of precipitation is useful since it contributes to the adequate growth of the plant in the late stages of development.

The number of monomeric compounds and anthocyanins for the period 2019 - 2020 is ambiguous and, of course, also depended on the properties of the strains used in the technological process of wine production. As is known, water deficiency worsens photosynthesis, shoot growth, reduces the size of berries, increases the content of tannins and anthocyanins in grapes [2, 13], the amount of which in the test wine doubled, and in the control wine decreased by 1.2 times. Moreover, it is assumed that elevated temperatures during the ripening of grapes lead to higher concentrations of some specific phenols and a tart taste of wine [1].

In turn, the dynamics of yeast growth, as precursors of biologically active substances during alcoholic fermentation, is the basis for the formation of organoleptic and sensory characteristics of the finished wine (Tables 1, 2). The microbial population and various maceration techniques can affect the extraction process and the subsequent level of anthocyanins and tannins, which will further affect the overall bitterness, astringency and color intensity of red wines [23 – 25].

CONCLUSIONS

- The results of soil and climatic studies of the terroir of the Derbent district (Mugarty village) of the Republic of Dagestan and the biochemical composition of wines in 2019 - 2020 provide information about the specifics of the territory, where soil fertility in combination with agroclimatic factors are an important component of the final product of agriculture.
- The correlation of such climatic factors as soil composition, elevated temperature, precipitation and sunlight during the growing season of grapes with improved physical and chemical properties, tasting characteristics, and the content of mineral, vitamin-like and phenolic substances in wine was found. These indicators differed while maintaining the typicality of the brand, the individuality of flavor and aroma. Our study showed that

the selective local strain *of S. cerevisiae* Y-4270 significantly better preserved the specificity of regional wines of the Derbent region compared to the control strain of *S. cerevisiae* D-19.

- The results obtained confirm well-known concepts but require further study due to changing climatic conditions. The reasonable use of various methods of viticulture and active yeast cultures in the conditions of climate change can be beneficial for the strategy of producing high-quality terroir wines.

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