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COMPARATIVE BIOCHEMICAL COMPOSITION OF THE SWEET CHERRY FRUITS

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SUMMARY

Comparative studies on the complex biochemical indicators of the fruits of sweet cherry (*Prunus avium* L.) cultivars were conducted as a new focus, to recognize their genotypes. Eight sweet cherry cultivars were procured from the Federal Horticultural Center for Breeding, Agrotechnology, and Nursery (FSBSO ARHCBAN), Moscow, Russia, namely, Moskvoretskaya, Chermashnaya, Italyanka, Iput, Tyutchevka, Fatezh, Sinyavskaya, and Podarok Ryazani, and two cultivars, i.e., Regina and Krasa Kuban from Azerbaijan and the Southern Federal District of Russia (Republic of Crimea), respectively. The studies were conducted through traditional (potentiometry, refractometry, and spectrophotometry) and modern analytical (energy-dispersive spectrometry, gas chromate-mass-spectrometry) methods. Considerable genetic variations were detected among the evaluated cultivars of the sweet cherry for all studied traits. The most harmonized taste from the balanced content of acids and sugars in the fruits is noted with the sweet cherry cultivars, i.e., Sinyavskaya, Fatezh, Krasa Kubani, Podarok Ryazani, and Regina. Cultivars Italyanka, Sinyavskaya, and Podarok Ryazani have 2.3, 3.5, and 4.2 times more, respectively, phenolic compounds than the cultivar Krasa Kubani. The following decreasing order of the accumulation of various macro and micro-elements was observed in the sweet cherry fruits, i.e., K > P > Mo > Mg > Ca > Se > Co > Mn > Fe > Zn. The comparison of sweet cherry fruits' metabolomic profiles revealed the composition of organic and phenolic acids, sugar alcohols, carbohydrates and their derivatives, amino acids, and other compounds. In total, 41 individual compounds were determined. In sweet cherry fruits, carbohydrates are presented by monosaccharides, which are the components of a healthy diet, and their derivatives. Among organic acids, the most significant differences were detected in the presence of arabinoic, fumaric, and erythro-pentonic acids; fatty acids found in sweet cherries are valuable for human nutrition. The biologically active substances, i.e., kojic acid and myo-inositol, were also detected in the sweet cherry cultivars, Moskvoretskaya, Fatezh, Podarok Ryazani, Sinyavskaya, Krasa Kubani, and Regina. The metabolome is an important biochemical indicator of the plant's phenotype and it allows to reveal hidden differences in their genotypes.

Keywords: *Prunus avium* L. fruits, promising varieties, biologically active substances, mineral composition, metabolites

Key findings: Sweet cherry fruit cultivars owned by the Federal Horticultural Research Center for Breeding, Agrotechnology, and Nursery (FHRCBAN), Moscow, Russia surpassed all those cultivars obtained from the trade network in terms of biologically active substances content. These promising sweet cherry fruit genotypes could be used in future breeding programs for further improvement.

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INTRODUCTION

Sweet cherry (*Prunus avium* L.) has been cultivated since ancient times worldwide. According to FAO, the world production of sweet cherries varies between 1.3 and 1.5 million tons (FAOSTAT, 2020). The share of sweet cherry fructiferous plantations in the world is more than 3.1%, which makes about 125,000 ha. The majority of the plantation (42.6%) is concentrated in the Middle East and European countries (Durau *et al*., 2012). The success in sweet cherries cultivation is determined by the climatic conditions, as well as, the adaptivity and pomological characteristics of cultivars that influence the prime costs (labor costs, technologies, and market structure).

In relation to area of cultivation, Europe plays a leading role having 50% of the world's production. Romania, in southeastern Europe, is one of the large producers of sweet cherries (Sansavini and Lugli, 2008; Sîrbu *et al*., 2012). But, a decrease in sweet cherries production was noted in many western European countries, and this is correlated with high production costs. However, in Turkey, Spain, South America, and the USA, the production of sweet cherries increases. Sweet cherry is in great demand on both the domestic level and the world market. A significant part of sweet cherry crop yield is used for fresh consumption, however, in the food manufacturing industry, the sweet cherry is mostly used in preservation, juice production, and as frozen fruits (Dever *et al*., 1996; Klincsek and Szabó, 2002; Sirieix *et al*., 2002).

According to scientifically based standards, the annual consumption of sweet cherry fruit per capita should be at 2 kg (Winkler and Knoche, 2019). Sweet cherry fruits in taste are much superior to other stonecrops and are characterized by balanced biochemical composition. The sweet cherry fruit is among the first to open the season, as a source of easily digestible monosaccharides, and contains a powerful immunostimulatory complex of valuable nutrients, giving the reason for its popularity (Blagov *et al*., 2009). Given its useful properties and composition, sweet cherry is also called 'sweet medicine' as its fruits contain biologically active substances, which have curative action (McCune *et al.*, 2010; Robinson *et al*., 2017). Among these substances are the phenolic compounds, which are also important components of sweet cherry fruits.

The polyphenol synthesis in the human and animal cells is impossible, as they get the same mostly with plant food (Kim *et al*., 2005; Usenik *et al*., 2008; González-Gómez *et al*., 2009; Nemtinov *et al*., 2021). The information about the presence of these phenolic compounds in plants, vegetables, fruits, tea, and other drinks is the basis of proper nutrition (Gao and Mazza, 1995; Esti *et al*., 2002; Zarei, 2017; Motyleva *et al*., 2021a; Pekhova, 2021). Past studies revealed that fresh fruits could be a supplementary source for the daily recommended intake of minerals (Upadysheva *et al*., 2018; Motyleva *et al*., 2021b). Having the presence of Ca in the sweet cherries, their consumption strengthens the vessels. Significantly, brightly colored cultivars got the scientists' and doctors' attention because the use of anthocyanins in recent years showed the prevention and control of cancer (Gogoaşă *et al*., 2014; Mehari *et al*., 2015).

The basic biochemical characteristics of cultivated plants that describe their valuable nutritive, medical, and biological properties are secondary metabolites of plants and basic substances of primary metabolism. For this reason, the usage of plants' genetic resources in support of quality nutrition serves as basis for a healthy diet that is becoming more and more accepted. (Is this what you meant?) Russian southern regions, as well as, Central Russia also started the breeding research of this valuable fruit crop. The breeders of the FSBSO ARHCBAN have achieved significant and tangible results. They have also created unique sweet cherry cultivars, i.e., Moskvoretskaya, Chermashnaya, Fatezh, Sinyavskaya, Podarok Ryazani, as well as, in other institutions of Central Russia, i.e., Italyanka (Federal Research Center named after I.V. Michurin, Michurinsk, Russia), and cultivars viz., Iput and Tyutchevka (All-Russian Williams Research Institute, Lobnya, Russia).

The main considered attributes were tree habits and winter hardiness, as well as, the ripening period, the taste, the skin color, the average weight of fruit, and resistance to *Monilia cinerea* and *Coccomyces hiemalis* Higg. However, phytochemical status and nutritional properties are not being evaluated in the breeding programs. Sweet cherries from

Azerbaijan (cv. Regina) and Southern Federal District of Russia (Republic of Crimea) (cv. Krasa Kubani) were also included in the study as these are mostly found widely marketed in Central Russia. The aim of the present research was a comparative evaluation of the cherry nutritional composition, phytochemical content, and antioxidant capacity of sweet cherry fruits belonging to various ecological-geographical origins.

MATERIALS AND METHODS

Experimental conditions

The field research was carried out in 2018–2019 at the experimental plantations of sweet cherry (*P. avium* L.), located at a laboratory plot of the FSBSO ARHCBAN, Moscow, Russia (55° 56′ North latitude, 37° 64′ East longitude). The overall area of the sweet cherry plantation is 0.5 ha. The garden of intensive type was set out in 2000 using the scheme of 5 x 2.5 m. The soil in the row spacing was black fallow (Figure 1). All the laboratory research was conducted in the Biochemistry and Physiology Laboratory of FHRCBAN.

Biological material

The fruits of the best acknowledged sweet cherry (*P. avium* L.) cultivars from the collection of FRC–Horticulture, i.e., Moskvoretskaya, Chermashnaya, Italyanka, Iput, Tyutchevka, Fatezh, Sinyavskaya, and Podarok Ryazani, were analyzed in comparison with the cultivars, i.e., Regina (from Azerbaijan) and Krasa Kubani (from Southern Federal District of Russia (Republic of Crimea), which are widely sold in various markets of Central Russia. The distinguished phenotypic characteristics of collected sweet cherry cultivars are shown in Table 1. There were phenotypic differences in terms of tree habit, winter hardiness, vegetative stage, fruit ripening, fruit taste, fruit skin, fruit weight, and resistance to diseases, i.e., *Monilia cinerea* and *Coccomyces hiemalis* Higg. Table 2 shows the origins and originators of the sweet cherry cultivars under study.

All the sweet cherry (*P. avium* L.) fruits were picked in the mature stage. The average probe of the fruits (not less than 50 berries from each tree and not less than 10 trees of each cultivar) was collected at the stage of harvest maturity. The samples from the sales chain were also represented, and six biochemical parameters were studied.

Chemicals

All the reagents, solvents, and standards used were of analytical quality (minimal purity 99%) and were bought from Sigma Aldrich, USA.

Plant preparation and extraction

Sample preparation

From a representative 500 g sample of fruits, at least 300 g of flesh was prepared. The mass was homogenized using the analytical homogenizer IKAA11 basic (Germany). Then it was extracted by double distilled water (to determine antioxidant activity and phenol compounds sum) and by pure methanol (to study the metabolites composition) and centrifuged at 4000 g (Sigma, Germany) within 10 min. The supernatant was used for measurements purposes. We performed all extractions in triplicate independent samples. The sweet cherry cultivar, Fatezh, was used as control.

Basic chemical analyses

General biochemical parameters. i.e., total soluble solids (TSS) content , were determined via the refractometric method according to GOST ISO 2173 (2013), and the values were expressed in percentage. The total titratable acidity (TTA) was estimated via the potentiometric method by pH meter HI 2211 HANNA (Germany) via titrating with 10 N. NaOH is expressed in the equivalent of apple acid in percentage GOST ISO 750 (2013).

Total polyphenol compounds (TPC)

The total content of polyphenol compounds was determined with Folin–Ciocalteu reagent according to the method described by Velioglu *et al*. (1998). The 0.1 ml of each sample extract was mixed with 0.1 ml of the Folin-Ciocalteu, 1 ml of 20% (w/v) sodium carbonate, and 8.8 ml of distilled water. The final mixture was shaken then incubated for 30 min in the dark at room temperature. The absorbance was measured at 750 nm using a Helios Y UV–V spectrophotometer. Gallic acid (25 – 250 mg/L; R2 = 0.996) was used as the standard, and the results were expressed in mg/g gallic acid equivalents and mg of gallic acid (GAE) calculated on the wet weight of plants.

Moskvoretskaya

Iput

Chermashnaya

Italyanka

Moskvoretskaya

Tyutchevka

Podarok Ryazani

Sinyavskaya

Figure 1. Sweet cherry *(Prunus avium* L.) cultivars used in the study.

Table 1. Tree and fruit characteristics of the sweet cherry *(Prunus avium* L.) cultivars.

Sweet cherry cultivars	Tree habit	Winter hardiness	Time of beginning Of fruit ripening	Fruit taste	Fruit skin Color	Average fruit weight (g)	Resistance to *Monilia cinerea* and *Coccomyces hiemalis* Higg.
Fatezh	Medium	Above average	Early	Sour-sweet and dessert-like	Red-yellow	4-6	Resistant
Chermaschnaya	Medium	Winter-hardy	Very early	Sweet, with slight acidity, dessert	Yellow	4.5	Resistant
Podarok Ryazani	Medium	Winter-hardy	Medium	Sweet	Yellow-red	7	Resistant
Moskvoretskaya	Medium	Winter-hardy	Early	Dessert-like	Red-yellow	4.7	Resistant
Iput	Medium	Winter-hardy	Early	Sweet	Dark-red	5.3	Resistant
Italyanka	Medium	Winter-hardy	Early	Sweet, dessert	Dark-red	6	Resistant
Tyutchevka	Medium	Winter-hardy	Late	Sweet	Red	5.3	Highly and average resistant to the moniliosis & coccomycocis, respectively
Sinyavskaya	Medium	Above average	Medium-early	Sour-sweet, dessert	Dark-red	4.6	Resistant

Table 2. Origins and originators of the sweet cherry (*Prunus avium* L.) cultivars.

Sweet cherry cultivars	Origin	Authors
The cultivars, obtained at the All-Russian Horticultural Institute of Breeding, Agrotechnics, and Nursery (now the Federal State Budgetary Scientific Organization, Federal Horticultural Center for Breeding, Agrotechnology and Nursery)		
Fatezh	By planting the seeds from free pollination of sweet cherry Leningradskaya Zheltaya	Evstratov A.I.
Sinyavskaya	By planting the seeds from free pollination of sweet cherry Leningradskaya Zheltaya.	Evstratov A.I.
Chermaschnaya	By planting the seeds from free pollination of sweet cherry Leningradskaya Zheltaya	Evstratov A.I., Enikeev H.K.
Podarok Ryazani	By selection of the sweet cherry seedlings of unknown origin	Borisova A.A., Kashin V.I.
Moskvoretskaya	From free pollination of the best cultivars of sweet cherry.	Morozova N.G.
The cultivars obtained at the Federal Research Center named after I.V. Michurin		
Italyanka	By breeding sweet cherry cultivars Slava Zhukova and Bigarro	Zhukov O.S., Nikiforova G.G.
The cultivars obtained at the All-Russian Williams Research Institute		
Iput	From hybridization of 3-36 x 8-14	Kanshina M.V., Astakhov A.I.
Tyutchevka	From hybridization of 3-36 x Krasnaya Plotnaya	Kanshina M.V.

Antioxidant activity of extracts by the DPPH method

The scavenging activity on the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical was determined through spectrophotometric, according to the method described by Brand-Williams *et al*. (1995) and Chen *et al*. (2013). The principle of the analysis was based on the color change of DPPH solution from purple to yellow as the radical was quenched by antioxidants. The homogenized leaves were mixed with distilled water and methanol. The samples were put on the shaker Lab-PU-01 (Russia) for 6 h, and then were filtered and the antioxidant activity was measured 10 min after interaction between the extract and the reagent. The absorbance was recorded at 517 nm to determine the concentration of the remaining DPPH. All measurements were performed in triplicate. The radical-scavenging activity was calculated as a percentage as follows:

$$\text{DPPH radical-scavenging (\%)} = ([AC - AAt] / AC) \times 100,$$

where:

AC – DPPH solution absorption;
AAt – absorption at the antioxidant presence.

The lower absorbance of the reaction mixture indicates a higher level of free radical scavenging activity. The water and ethanol extract spectral profiles of the fruits were accepted at the range of 190 to 550 nm.

EDS - analysis

In sweet cherry (*P. avium* L.) fruits, the chemical composition of the basic ash components (phosphorus - P, potassium - K, manganese - Mn, iron - Fe, magnesium - Mg, calcium - Ca, zinc - Zn, selenium - Se, molybdenum - Mo, and cobalt - Co) was determined by the method of energy dispersive spectrometry (ESD) on the analytical raster electron microscope JEOL JSM 6090 LA (Motyleva *et al*., 2021b). The X-ray microanalysis data are presented in the form of standard protocols which contain the microstructure picture of the samples under study, where the table of the data in weighting and atomic correlation, spectra, and histograms are presented in Figure 2.

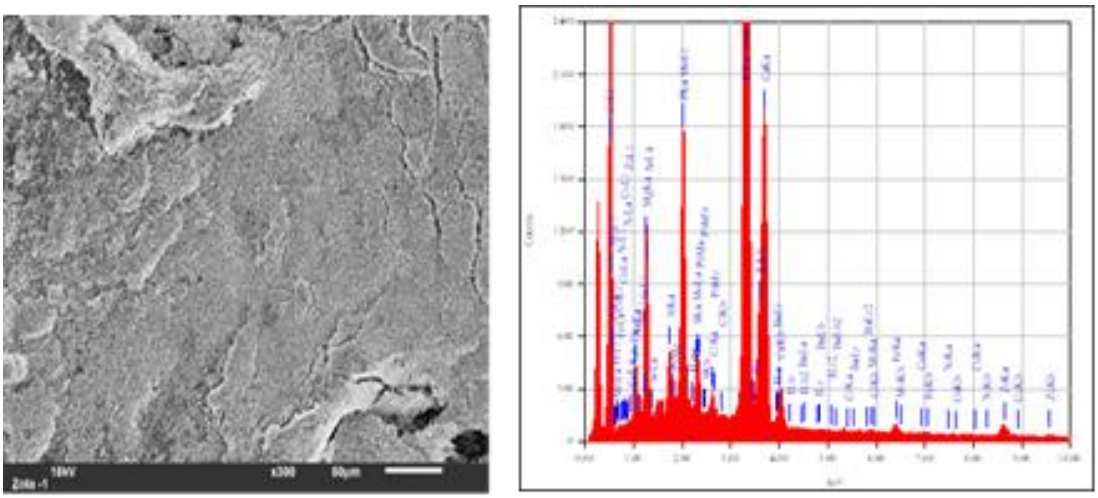

Figure 2. The EDS analysis report, A) Microstructure of the sample under study. B) General view of the X-ray.

Metabolic analysis by gas chromatography-mass spectrometry

The metabolites analysis was fulfilled using the method of gas chromatography-mass spectrometry (GC-MS) via GCMS chromatograph JMS-Q1050GC (JEOL Ltd., Japan). Capillary column DB-5HT (Agilent, USA) (length 30 m, inner diameter - 0.25 mm, the film thickness - 0.52 μ m, and gas-carrier – helium) was used. The temperature gradients during the analysis were within the range of 40 °C to 280 °C, the injector and interface temperature was 250 °C, while the ionic source

was 200 °C. Gas flow in the column was equal to 2.0 mL/min, split-flow injection mode, with the sample injected in volume 1-2 mcl of the evaporated extract. The analysis was held for 45 min. The derivation was held using silylation reagent N, O - Bis (trimethylsilyl) trifluoracetamide - BSTFA following the method described in the past studies (Robbins and Robbins, 2003; Marinova and Batchvarov, 2011; Han *et al*., 2012; Bergman, 2014). Identification of the substances was done according to NIST-5:National Institute of Standards and Technology (USA) retention behavior and mass spectra. The scanning range was 33–900 m/z, while the identification of substances credibility was within 75%–98%.

Statistical analysis

The statistical processing of the data was done using the following programs: Statistica 7, and Excel 7.0 for Windows. All the analyses were performed in triplicate. The results were expressed as mean values (n = 10) with standard error (Sx).

RESULTS AND DISCUSSION

At present, ensuring high production without compromising fruit quality is a big challenge for growers. It is therefore important to know the intrinsic quality characteristics of each variety. Based on this knowledge, the breeder will be able to develop strategies to develop new varieties that can improve the quality of cherries. The organoleptic and nutritional qualities of cherries depend on the genotypes up to a large extent. The differences among the sweet cherry (*P. avium* L.) genotypes were significant for all the studied traits. Total soluble solids (TSS) content influences the fruit's taste significantly and various sugars, which were found in the cell juice, have an essential share in this characteristic (Girard and Kopp, 1998; Mahmood *et al*., 2012). The highest content of TSS was noted in the sample of sweet cherry fruit cultivar, Krasa Kubani. However, in sweet cherry cultivars, i.e., Podarok Ryazani, Moskvoretskaya, Fatezh, Sinyavskaya, and Regina (the sample from Azerbaijan), the TSS content were 2.8% to 3.0% less in comparison with the cultivar, Krasa Kubani. In the cultivars, Chermashnaya, Italyanka, and Tyutchevka, TSS content were 4.5% to 8.0% less. In these sweet cherry cultivars, the TSS differences were statistically significant at the $P < 0.005$ (Figure 3).

In the sweet cherry samples of different cultivars under study, the range of titratable acidity varies from 0.4% (Fatezh and Sinyavskaya) to 0.7% (Italyanka), (Figure 4). It was also observed that the content of soluble solids in sweet cherry berries depends on the variety, and the same was also confirmed in the research work of Radičević *et al*. (2008). Bernalte *et al*. (2007) also reported acidity ranging 0.50% to 0.58% for the two sweet cherry cultivars. Past studies also authenticated that the acidity was ranging between 0.70% to 1.0%, which was comparable with our results (Esti *et al*., 2002; Karlidag *et al*., 2009).

According to Vursavus *et al*. (2006), generally, a balanced taste of fruits is determined by the contents of sugars and acids. The main indicator of fruit-eating quality is the sugar-acid index. According to the biochemical evaluation, the sugar-acid ratio varied from 22.12 (Italyanka) to 40.18 (Fatezh) among all the sweet cherry cultivars (Figure 5). The most harmonized taste and ratios of sugars and acids were detected in the fruits of sweet cherry cultivars, i.e., Sinyavskaya (41.12), Fatezh (40.05), Krasa Kubani (38.12), and Regina and Podarok Ryazani in the range of 34.86 to 35.00.

The content of total polyphenol compounds (TPC) also determines the fruit's organoleptic properties (taste, aroma, and color) in many ways, because not only the concentration of protons in organic acids, but the nature of the anion of their molecule, as well, influences the perception of acid taste. This peculiarity also determines the combined gustatory sensation in the fruits (Gonçalves *et al*., 2004). The content of TPC sum in the sweet cherry fruits varied from 22 to 42 mg GAE/100gr in the consequence given in Figure 6. It should be noted that the content of TPC in the sweet cherry cultivars, Sinyavskaya, Fatezh, and Krasa Kubani, were 1.6 to 2.2 times higher than in the cultivars. Tyutchevka, Iput, and Italyanka.

The content of TPC in sweet cherries, Regina, Moskvoretskaya, and Podarok Ryazani was about the same. It has previously been reported that the total phenol content of sweet cherries range from 23 to 264 mg GAE/100 g ww, indicating that plant genotype strongly influences the total phenol content in sweet cherries (Vangdal and Slimestad, 2006). Results further revealed that a high negative correlation (r – 0.838) was observed between titratable acids and TPC sum. It is also a well-known fact that phenolic compounds contribute

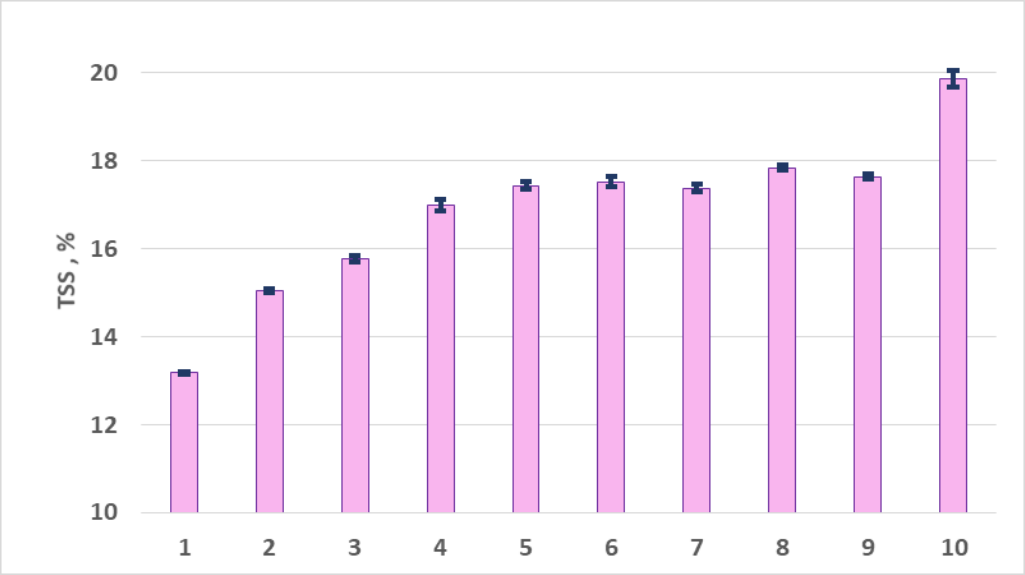

Figure 3. Average values of TSS in the sweet cherry cultivar fruits (%). 1-Tyutchevka, 2 – Iput, 3 – Italyanka, 4 – Chermashnaya, 5 – Sinyavskaya, 6 – Regina, 7 – Fatezh, 8 – Moskvoretskaya, 9 - Podarok Ryazani, 10 – Krasa Kubani.

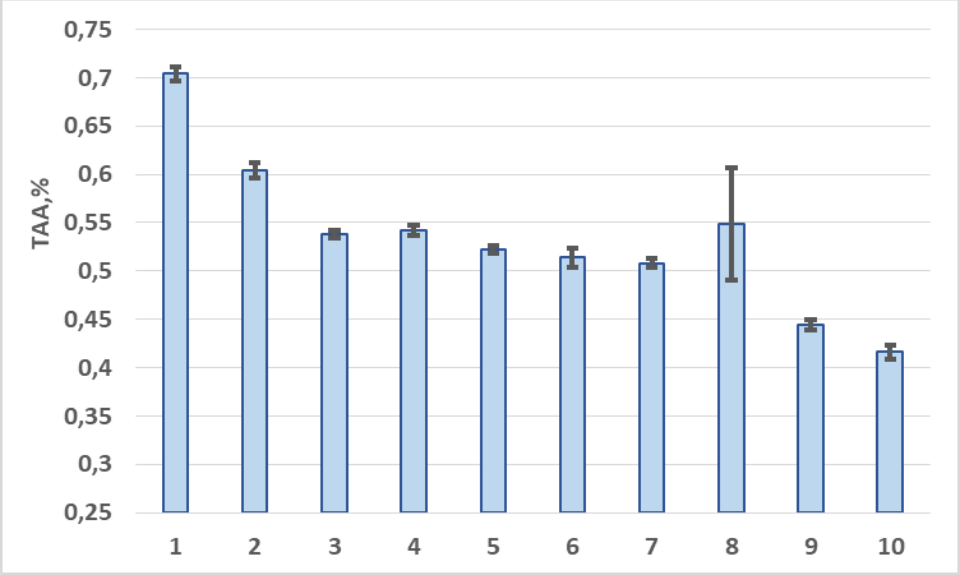

Figure 4. The content of TTA in the sweet cherry cultivar fruits (%). 1 – Italyanka, 2 – Iput, 3 – Chermashnaya, 4 - Tyutchevka, 5 - Podarok Ryazani, 6 – Krasa Kubani, 7 – Regina, 8 – Moskvoretskaya, 9 – Fatezh, 10 – Sinyavskaya

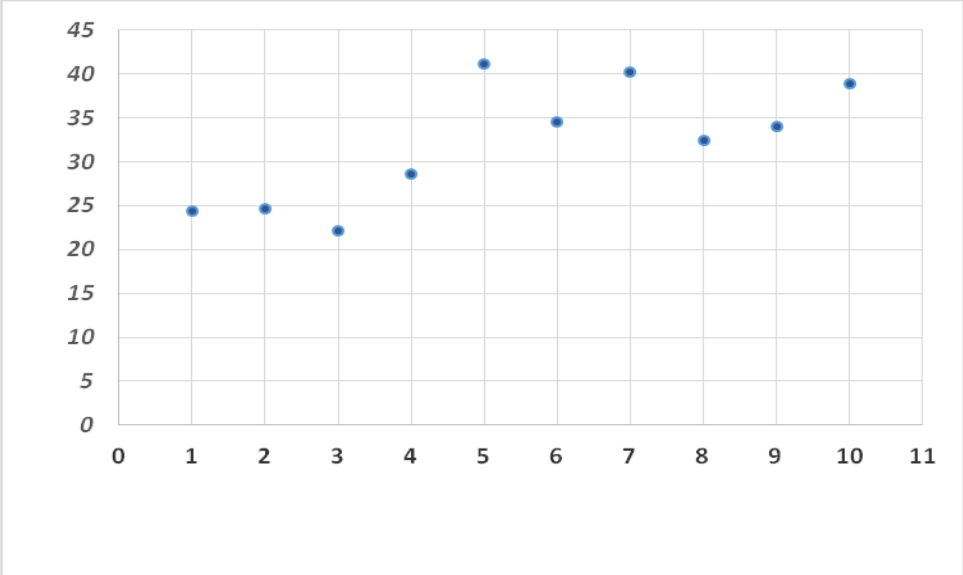

Figure 5. The ratio of sugar and acid in the sweet cherry cultivar fruits. 1 - Tyutchevka, 2 - Iput, 3 – Italyanka, 4 - Chermashnaya, 5 – Sinyavskaya, 6 – Regina, 7 - Fatezh, 8 - Moskvoretskaya, 9 – Podarok Ryazani, 10 – Krasa Kubani.

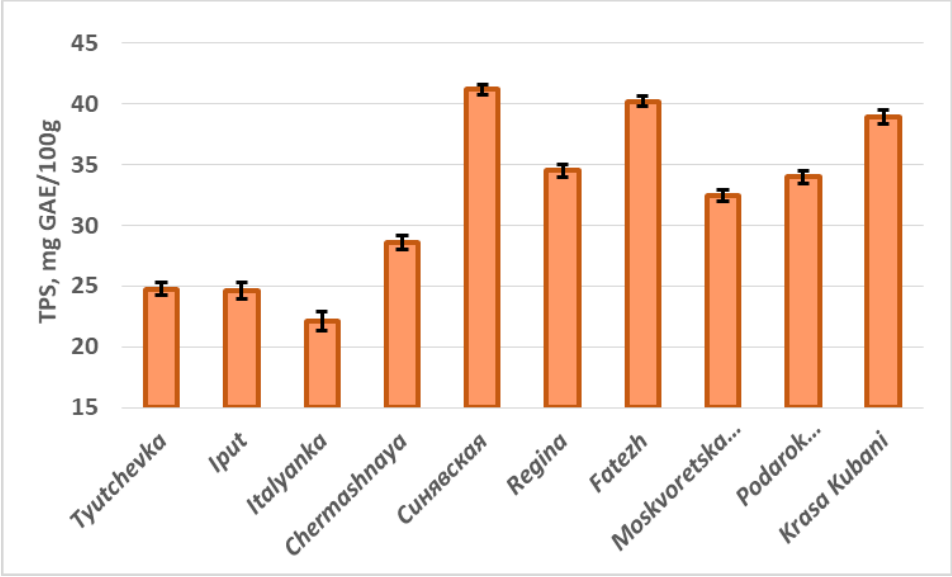

Figure 6. Total polyphenol compounds (TPC) in the sweet cherry cultivar fruits (mg GAE/100 g of the fresh fruits).

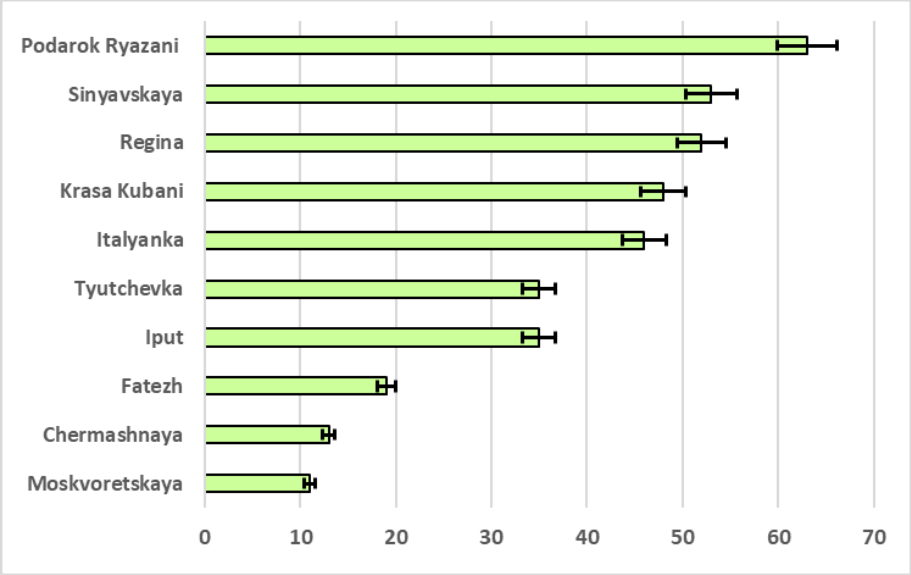

Figure 7. Antioxidant activity of the extracts of the sweet cherry cultivar fruits ethanol extracts (%).

to fruit quality and nutritional value and also provide health-beneficial effects (Tomas-Barberan and Espin, 2001).

Consequently, sweet cherries may be a good source of natural antioxidants. The antioxidant activity of sweet cherry fruits is shown in Figure 7. The highest antioxidant activity was detected in the fruits of sweet cherry cultivars, i.e., Podarok Ryazani (65%), Sinyavskaya (53%), and Regina (51%). Inversely, the lowest antioxidant activity was recorded in the sweet cherry cultivars, Moskvoretskaya (11%) and Chermashnaya (13%). The results were compared with those of Vangdal and Slimestad (2006), Halvorsen *et al*. (2002), Serrano *et al*. (2005), and Legua *et al*. (2017), who pointed out the influence of the sweet cherry genotype on the antioxidant activity. Antioxidants are known to retard or inhibit oxidation that can be induced by reactive radicals in the biological system (Netzel *et al*., 2007; Elisia and Kitts, 2008).

The high nutrition value of sweet cherry fruits is not only determined by organic bioactive substances such as K, Na, Ca, and Mg, but also in playing an important role (Wills *et al*., 1983; Souzaa *et al*., 2014; Motyleva *et al*., 2017). In the study, the 10 elements were analyzed in the ash of the fruits of various sweet cherry cultivars, i.e., K, P, Mg, Ca, Mo, Co, Mn, Fe, Zn, and Se (Table 3). The most abundant element was K, where the decreasing order of the different elements detected in the ash of the sweet cherry fruits was as follows, i.e., K > P > Mo > Mg > Ca > Se > Co > Mn > Fe > Zn. The K accumulation was ranging from 20.15 (Podarok Ryazani) to 29.51 (Tyutchevka) mass %, P - from 2.64 (Moskvoretskaya) to 5.87 (Tyutchevka) mass %, Mo - from 2.67 (Sinyavskaya) to 7.74 (Fatezh) mass %, while the content of Mg varies insignificantly depending on the cultivar, and the content of Ca varies from 1.04 (Regina) to 3.29 (Podarok Ryazani) mass %, relatively. The accumulation of the rest of the elements was not more than 1% mass. The highest sum of the elements was detected in the ash of the sweet cherry cultivars Tyutchevka (47.2), followed by Fatezh (46.0), Regina (45.0), Iput (44.0) mass%. Mineral compositions are of interest due to their pro-oxidant activity and health benefits (Kalyoncu *et al*., 2009).

As a result of the present experiments, the following data about the composition of metabolites were received in sweet cherry fruits, i.e., the composition of organic and phenolic acids; sugar alcohols; carbohydrates and their derivatives; and amino acids. In total 41 individual compounds were determined (Table 4). Chromatographic profiles of the ethanol extracts were alike, however, the differences were observed in the quantitative content of some substances, especially in the composition of the carbohydrate complex. For example, the content of furonic acid (Rt, min = 13:45), which takes part in the formation of the aroma of the fruits, in the samples of sweet cherry cultivar, Regina (Azerbaijan), was minimal in comparison with the cultivar.

Table 3. Mineral (ash) composition of the sweet cherry cultivar fruits (mass %).

Studied elements	Samples								
	Krasa Kubani	Regina	Iput	Tyutchevka	Chermashnaya	Fatezh	Moskvoretskaya	Sinyavskaya	Podarok Ryazani
Mg	2.19 ± 0.84	2.18 ±0.77	2.23 ±1.01	2.48 ±1.14	2.14 ±1.01	2.36 ±0.87	1.86 ±0.91	1.87 ±0.87	1.81 ±0.83
P	5.67 ±1.12	4.56 ±1.21	5.81 ±1.44	5.87 ±1.33	4.21 ±0.98	4.77 ±2.01	2.64 ±0.74	4.87 ±3.42	3.78 ± 1.11
K	29.02 ± 2.44	28.75 ±2.33	28.97 ±2.25	29.51 ±2.32	24.69 ±3.42	28.30 ±3.11	26.35 ±2.34	27.44 ±3.11	20.15 ±1.24
Ca	1.67 ±0.21	1.04 ±0.45	1.51 ±0.54	2.28 ±0.87	1.67 ±0.37	1.53 ±0.48	1.83 ±0.87	1.79 ±0.86	3.29 ±1.05
Mn	0.12 ±0.06	0.18 ±0.06	0.35 ±0.14	0.15 ±0.05	0.05 ±0.03	0.13 ±0.04	0.24 ±0.09	0.14 ±0.05	0.17 ±0.08
Fe	0.16 ±0.07	0.09 ±0.03	0.08 ±0.06	0.17 ±0.07	0.29 ±0.11	0.22 ±0.08	0.28 ±0.07	0.19 ±0.08	0.13 ±0.06
Co	0.21 ±0.11	0.41 ±0.11	0.31 ±0.33	0.33 ±0.12	0.18 ±0.08	0.14 ±0.05	0.14 ±0.07	0.18 ±0.09	0.07 ±0.03
Zn	n/d	0.01 ±0.03	0.29 ±0.13	0.25 ±0.10	0.17 ±0.12	0.3 ±0.11	0.21 ±0.09	0.27 ±0.11	0.04 ±0.03
Se	0.21 ±0.07	0.34 ±	0.33 ±0.11	0.43 ±0.11	0.18 ±0.09	0.46 ±0.11	0.23 ±0.08	0.32 ±0.11	0.31 ±0.08
Mo	3.58 ±1.11	7.45 ±2.1	4.13 ±1.35	5.69 ±2.21	5.59 ±2.11	7.74 ±1.21	3.21 ±1.14	2.67 ±1.08	2.72 ±1.03
Σ	42.8	45.0	44.0	47.2	39.2	46.0	37.0	38.7	32.9

Note: n/d – the element was not detected.

Moskvoretskaya (Figure 8, on the left side). The content of oxalic acid (Rt, min = 15:50), which forms a sour taste, was significantly higher in the extract of the sweet cherry cultivar. Moskvoretskaya than in the extract of the cultivar, Fatezh (Figure 8, on the right). The organic acid is an important factor in determining fruit acidity (Valero and Serrano, 2010).

Basic differences were not only qualitative but also quantitative as are determined in the composition of carbohydrates and their derivatives. In the sweet cherry cultivar, Krasa Kubani, the content of such substances of carbohydrate nature are as follows: Allofuranose (Rt, min = 20:43), Mannopyranose (Rt, min = 21:21), Mannitol (Rt, min = 22:00), and Galactopyranose (Rt, min = 22:12). On average, these are eight to 12 times higher than in the sweet cherry cultivar, Moskvoretskaya (Figure 9). In sweet cherry fruits, carbohydrates are presented by monosaccharides and their derivatives, which contribute for a healthy diet.

Among organic acids, the most significant differences were detected in the presence of arabinoic, fumaric and erythro-pentonic acids; fatty acids, which were found in the sweet cherry fruits, are also valuable for human nutrition (Karagiannis *et al*., 2021). Kojic acid and myo-inositol were found in the sweet cherry cultivars, Moskvoretskaya, Fatezh, Podarok Ryazani, Sinyavskaya, and in the samples of cultivars, Regina and Krasa Kubani, which increase the fruit's biological activity. Results showed large variations of differences in the physicochemical properties of the sweet cherries. The results also imply that the sweet cherries may supply substantial antioxidants, which, in turn, may provide health-promoting effects to consumers. Sweet cherry is also a good source of macro and micronutrients. The present studies showed that the metabolome is an important biochemical characteristic of the plant's phenotype and allows to reveal the hidden differences in the sweet cherry genotypes.

Table 4. Qualitative analysis of the extractive substances of the sweet cherry cultivar fruits ethanol extracts (by methanol).

No.	Rt (min)	Compounds
		Organic acids
1	20:21	Arabino-hexonic acid
2	18:15	Arabinoic acid
3	19:31	Pentanedioic acid
4	19:53	2-Butenedioic, Fumaric acid
5	10:18	Lactic acid
6	10:28	Glycolic acid
7	10:43	Pyruvic acid
8	11:23	b-Hidropyruvic acid
9	13:45	3-Methyl-2-Furonic acid
10	13:58	DL-Malic (Butanedioic) acid
11	14:16	Erythro-Pentonic acid
12	14:17	Oxalic acid
		Phenolic acids
13	16:56	Catochol
14	18:34	Benzoic acid
15	19:15	Quinic acid
		Fatty acids
16	10:35	α- Ketoisovaleric acid
17	16:34	Pentonic acid
18	19:46	Hexonic acid
19	21:15	Hexadecanoic acid
		Sugar alcohols
20	15:29	Glycerol
21	20:59	Glucitol
22	15:57	3-Hidro-2.3-Dihydromaltol
23	17:22	Ribitol
24	21:40	Galactitol
25	22:01	D-Mannitol
		Carbohydrates and derivants
26	20:00	Levoglucosan
27	20:11	D-(-)Tagatofuranose
28	20:15	L-(-) Sorbose
29	20:21	Methyl-a-D-Glucofuranoside
30	20:36	D-(-)-Fructofuranose
31	20:43	Allofuranose
32	20:55	D-(+)-Talofuranose
33	21:26	D – Fructose
34	22:11	Galactopyranose
35	20:18	Glucofuranoside
36	21:21	D-Mannopyranose
37	38:31	Maltose
Amino acids and other compounds		
38	16:40	Alanin
39	16:41	L-Proline
40	22:32	Kojic acid
41	23:28	Myo-inositol

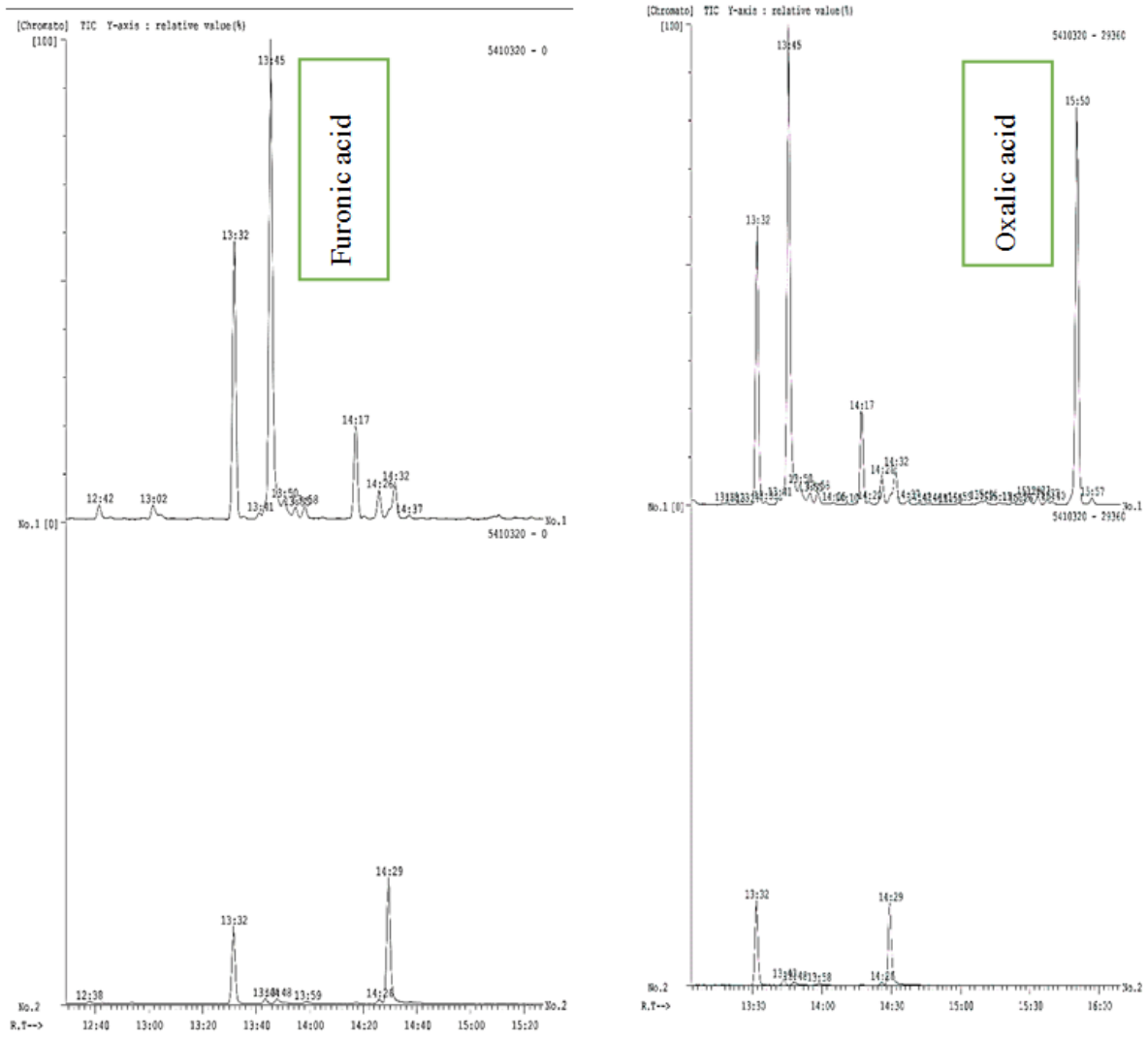

Figure 8. Comparison of the chromatographs sites with the yield time of Furonic acid (in the left, top – the extract of the sweet cherry cultivar Moskvoretskaya, bottom – the extract of the sweet cherry cultivar Regina (from Azerbaijan) and Oxalic acid (in the right, top – the extract of the sweet cherry cultivar Moskvoretskaya, bottom – the extract of the cultivar Fatezh).

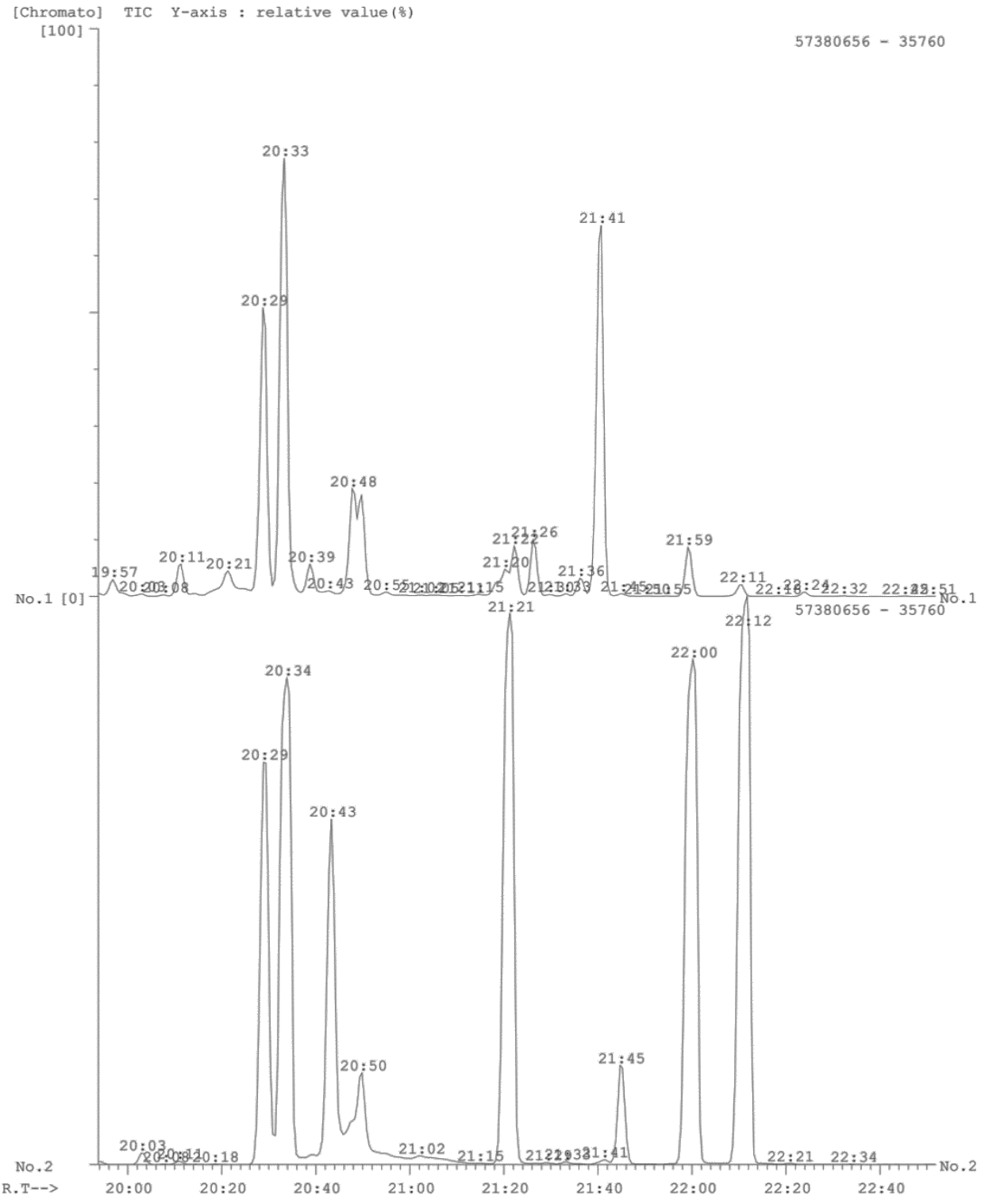

Figure 9. Comparison of the chromatographs sites of the ethanol extracts of the sweet cherry cultivars Moskvoretskaya (top) and the cherry cultivar Regina (from Azerbaijan) Crimea (bottom).

CONCLUSIONS

In the study, special attention was devoted to the basic biochemical indicators, which are characteristic of the nutritional and dietary values of sweet cherry fruits. The study also focused on the physicochemical characteristics. i.e., soluble solids, titratable acidity, the ratio of sugar and acid, the total content of polyphenol compounds, the antioxidant activity, nutritional (carbohydrates, organic acids, minerals, secondary metabolites), and bioactive and health-promoting compounds. Results revealed that the sweet cherry cultivars. i.e., Sinyavskaya, Fatezh, Moskvoretskaya, and Podarok Ryazani were identified as positive for most of the indicators. The sweet cherry cultivar, Podarok Ryazani surpassed the control cultivar (Fatezh) for all the indicators and successfully competed with the cultivars obtained from the sales chain (Regina and Krasa Kubani) based on the density, fruits size, and color. The present finding authenticated that sweet cherry cultivars of the FHRCBAN of Horticulture possess a higher antioxidant capacity, which allows us to recommend their usage in future breeding programs for the development of superior sweet cherry genotypes.

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