How to Cite: Mukan, G.S., Sankaibayeva, A.G., Kidarbek, T., Baimaganbetova, M.M., Dostemessova, A.B. (2025). Morphological and biochemical analysis of hawthorn and rosehip of the Ulytau region. *Fundamental And Experimental Biology, 30*, 4(120), 65-75. https://doi.org/10.31489/2025FEB4/65-75

Research Article

https://doi.org/10.31489/2025FEB4/65-75

UDC 574.3 Received: 25.08.2025 | Accepted: 15.10.2025 | Published online: 31 December 2025

G.S. Mukan*, A.G. Sankaibayeva, T. Kidarbek, M.M. Baimaganbetova, A.B. Dostemessova

Institute of Botany and Phytointroduction, Almaty, Kazakhstan
**Correspong author: appleforest_protection@yahoo.com*

Morphological and biochemical analysis of hawthorn and rosehip of the Ulytau region

The study investigates the morphological and biochemical profiles of two forms of *Crataegus chlorocarpa* and five forms of *Rosa* species (*R. laxa*, *R. acicularis*, *R. spinosissima*) from natural populations in the Zhanaarka district, Ulytau region, Kazakhstan. Geographical coordinates, shrub height, age, crown shape, yield, fruit size, color, and taste were assessed. Biochemical analyses quantified vitamin C, anthocyanins, leucoanthocyanidins, catechins, sugars, pectins, and titratable acidity using standardized methods. *Rosa acicularis*-058 showed the highest vitamin C content (576.4 mg/100 g FW), while *Rosa spinosissima*-064 excelled in anthocyanins (1259.3 mg/100 g FW). *Crataegus* forms were notable for their catechin content (up to 242.3 mg/100 g FW). Pearson's correlation revealed strong positive correlations between vitamin C and leucoanthocyanidins (r=0.83, p=0.02), and between titratable acidity and sugars (r=0.86, p=0.01).UPGMA cluster analysis identified three distinct groups based on biochemical traits. These findings highlight the potential of these wild plants for nutraceutical development and breeding, as they surpass some conventional crops in bioactive compounds.

Keywords: Ulytau region, *Crataegus chlorocarpa*, *Rosa* species, morphology, biochemistry, vitamin C, anthocyanins, cluster analysis

Introduction

The vegetation cover of the Ulytau region ranges from steppe to desert, with plants such as *Artemisia*, *Stipa*, and *Salsola* dominating. The climate of the region is dry and continental, characterized by a hydrothermal coefficient of approximately 0.5, an average annual air temperature ranging from 2.8 to 3.6 °C, and a summer temperature peak of 23-24 °C. Significant temperature fluctuations and limited precipitation create difficult conditions for plant life, resulting in vegetation that is typical of northern deserts and that varies from north to south depending on humidity and temperature. The tree and shrub flora of Ulytau is mainly from the *Rosaceae* family and is widely used for landscaping in the industrial regions of Karaganda and Zhezkazgan. Among them, the most common are *Lonicera tatarica* L., *Elaeagnus angustifolia* L., and *Elaeagnus oxycarpa* Schlecht., *Padus avium* Mill., *Viburnum opulus* L., *Rosa laxa*, and *Crataegus chlorocarpa* [1].

The genus *Rosa* comprises approximately 400 species worldwide, with 21 species native to Kazakhstan, four of which are endemic [2–4]. This genus is of growing interest due to its fruits used in the pharmaceutical industry and folk medicine [5]. Rosehips are rich in vitamins, minerals, and phytochemicals, which are confirmed by modern scientific research [6–8]. They are used for the production of drinks, jams, jellies, tea, and wine [9, 10].

The genus *Crataegus* is represented by more than 300 species, seven of which grow in the mountainous and steppe regions of Kazakhstan [2–4]. Hawthorn fruits are valued for their cardiotonic properties and are widely used in official medicine in the treatment of cardiovascular diseases [11]. In addition to medicinal use, they are in demand in the food industry for the preparation of jams, jellies, and jelly. In several countries, such as China, Turkey, and Iran, hawthorn is cultivated as a fruit crop [12–14].

Growing interest in nutraceuticals is driving the selection of forms high in phenols and antioxidants that are superior to traditional crops such as blueberries and sea buckthorn [15–18].

In the Ulytau region, rosehips and hawthorns grow mainly in amateur gardens and are used as border plants, although their commercial cultivation is not yet developed.

This study aimed to determine the morphological characteristics of the fruits, as well as the biochemical indicators of selected forms of hawthorn and rosehip from the Zhanaarka district of the Ulytau region.

Experimental

The study was carried out in the natural populations in the Zhanaarka district of the Ulytau region. Two forms of *Crataegus* (*Crataegus chlorocarpa*: Cr-049, Cr-050) and five forms of rosehips (*Rosa laxa*: *R.laxa*-049, *R.laxa*-051; *R. acicularis*: R.acic-058, R.acic-063; *R. spinosissima*: R.spin-064) were investigated.

The coordinates and altitudes of the growing sites were determined using a Garmin eTrex 10 GPS navigator (Tab. 1). For each bush, the origin (seed or sprout), age (using an increment borer [19]), height, crown shape, and yield (on a 5-point scale) were recorded. The fruits were harvested at the end of August, transported in plastic containers, and stored at -20°Cuntil analysis.

Table 1

Coordinates of the localities of the selected forms of *Crataegus chlorocarpa*and species of the genus *Rosa* (*R. laxa, R. acicularis, R. spinosissima*)

Forms	Forestry	Coordinates		Altitude m
		North	East	
Cr-049	Zhanaarka	48°55′6815″	070°54′9710″	567
Cr-050	Zhanaarka	48°55′6782″	070°55′0079″	518
R.laxa-049	Zhanaarka	48°55′6815″	070°54′9710″	567
R.laxa-051	Zhanaarka	48°55′6754″	070°55′0154″	517
R.acicularis-058	Karazhal	47°59′6157″	070°48′3381″	490
R.acicularis-063	Boltai	47°47′0221″	071°31′8400″	645
R.spinosissima-064	Boltai	47°46′9958″	071°31′8493″	644

Morphological analysis. The size of the fruits was measured with a caliper with an accuracy of 0.1 mm. Length, width, shape, color of the peel and pulp, taste, number of seeds, and ripening time were determined.

Biochemical analysis. Vitamin C content was determined by the iodometric method [20]. Leucoanthocyanidins (LAC) were analyzed using the butanol-HCl method [21]. Anthocyanins were extracted with a 1 % HCl solution in 96 % ethanol [22]. Catechins were determined by the vanillin method [23]. Titratable acidity (TA) was measured by titration with 0.1 N NaOH. The content of sugars was determined colorimetrically by the Bertrand method [24], and water-soluble pectin (WSP) and water-insoluble pectin (WIP) were determined by the carbazole method with calibration by galacturonic acid [25]. The results were expressed in mg/100 g of fresh weight (FW).

Statistical analysis. Mean values and standard deviations were calculated in *Microsoft Excel* 2019. P-value and confidence intervals adjusted for comparing a family of 7 estimates (confidence intervals corrected using the Tukey method).

Cluster analysis was performed using the unweighted pair-group method with arithmetic mean (UPGMA) with Euclidean distance using Past Software.

Results and Discussions

Table 1 shows that most of the forms of fruit plants are concentrated in the Zhanaarka forest. The northernmost points are represented by forms from Zhanaark (latitude coordinates 48° and above). Forms Karazhal and Boltay are represented at more southern latitudes (47°). The forestry of Zhanaarka is represented by four forms (Cr-049, Cr-050, *R.laxa*-049, *R.laxa*-051), which are geographically very close to each other. Karazhal is represented by one form (*R.acicularis*-058). Boltai is represented by two forms (*R.acicularis*-063, *R.spinosissima*-064) with similar coordinates.

The minimum altitude is recorded in Karazhal (490 m). The maximum altitude is in Boltay (645 and 644 m). Zhanaark sections are located at altitudes of 517–567 m. Altitude range: 490–645 m. The data are conducive to a comparative analysis of ecological and geographical conditions at different points of growth of fruit plant species in the Ulytau region.

As part of the study of economically valuable traits, the morphological features of shrubs and fruits of the selected forms of fruit plants growing in the Zhanaarka district of the Ulytau region were analyzed (Fig. 1).

Figure 1. A — *Crataegus chlorocarpa*-049; B — *Crataegus chlorocarpa*-050; C — *R.laxa*-049; D — *R.laxa*-051; E — *R.acicularis*-058; F — *R.acicularis*-063; G — *R.spinosissima*-064

Two forms of *Crataegus chlorocarpa*have seed origins, aged 8 years, with a height of 3.5 m (049) and 4.0 m (050). A spreading crown was noted in the *Crataegus chlorocarpa* (Cr-049), and a spherical in the *Crataegus chlorocarpa* (Cr-050) form. The yield of both forms is high — 5 points (Tab. 2).

All selected 5 forms of rosehips have a rootsucker origin. The age of the bushes varies from 6 to 10 years. The height of the bushes ranges from 1.5 m (*R-laxa* 051, *R.spinosissima*-064) to 3.0 m (*R.acicularis*-063). The crown shape is spherical (*R. laxa*-049) and spreading (in other forms). The yield is excellent: 5 points (*R.laxa*-049, *R.laxa*-051, *R.acicularis*-058), 4 points (*R.acicularis*-063, *R.spinosissima*-064) (Tab. 2).

Table 2

Morphological description of the selected forms of fruit plants in the Zhanaarka district of the Ulytau region

Form	Origin	Shrub age	Shrub height, m	Crown form	Productivity, points
Cr-049	Seed	8	3,5	Spreading	5
Cr-050	Seed	8	4,0	Spherical	5
R.laxa-049	Rootsucker	6	2,0	Spherical	5
R.laxa-051	Rootsucker	10	1,5	Spreading	5
R.acicularis-058	Rootsucker	8	2,5	Spreading	5
R.acicularis-063	Rootsucker	10	3,0	Spreading	4
R.spinosissima-064	Rootsucker	8	1,5	Spreading	4

The fruits of the two selected forms of *Crataegus chlorocarpa* are round and orange, with orange pulp. The taste of the fruits is sweet. The ripening period of fruits was observed in the 3rd decade of August (Tab. 3).

Table 3

Main economically valuable traits of selected forms of fruit plants in the Zhanaarka district of the Ulytau region

Form	Fruit length (cm)	Fruit width (cm)	Fruit shape	Peel color	Pulp color	Fruit taste	Quantity of seeds	Ripening period
Cr-049	1.05±0,02	1.05±0,02	Round	Orange	Orange	Sweet	3.6±0,54	3 decade of August
Cr-050	1.1±0,02	1.1±0,02	Round	Orange	Orange	Sweet	4.74±0,5	3 decade of August
R.laxa-049	2.04±0,04	1.14±0,06	Pear-shaped	Red	Orange	Sweetish-sour	45.6±2,4	3 decade of August
R.laxa-051	2.28±0,05	1.16±0,03	Pear-shaped	Red	Orange	Astringent	12.8±0,8	2 decade of Sept.
R.acic-058	1.48±0,04	1.09±0,03	Pear-shaped	Red	Orange	Sweetish-sour	7.8±0,83	1 decade of Sept.
R.acic-063	1.55±0,07	1.28±0,03	Pear-shaped	Dark red	Orange	Sweet	7.8±0,83	1 decade of Sept.
R.spin-064	0.74±0,03	0.98±0,02	Flat-globose	Black	Black	Sweetish-sour	3.4±1,51	2 decade of Sept.

The maximum fruit size is found in *R. laxa*-049 (2.04 cm) and *R. laxa*-051 (2.28 cm), the minimum in *R. spinosissima*-064 (0.74 cm). The shape of the fruits is pear-shaped (*R.laxa*-049, *R.laxa*-051, *R.acicularis*-058, *R.acicularis*-063) and flat-globose (*R.spinosissima*-064). The color of the peel is red in the forms *R. laxa*-049, *R. laxa*-051, *R. acicularis*-058, dark red in the form *R. acicularis*-063, and black in *R. spinosissima*-064. The pulp is mostly orange in all forms of rosehips, except for the *R. spinosissima*-064 form, which is black. Taste: sweetish-sour (*R.laxa*-049, *R.spinosissima*-064), astringent (*R.laxa*-051), sweetish-sour (*R.acicularis*-058), sweet (*R.acicularis*-063). Number of seeds: from 3.4 (*R.spinosissima*-064) to 45.6 (*R.laxa*-049). Ripening period was 3rd decade of August (*R.laxa*-049), 1-2nd decade of September (other forms).

The analysis revealed the morphological diversity of the selected forms of fruit plants. Seed forms of *Crataegus chlorocarpa* are characterized by high yields, considerable height, and rounded orange fruits with a sweet taste, which makes them suitable for fresh consumption. Wild rose forms are distinguished by a wide variety of shapes, colours, and taste qualities of fruits, which allows them to be used in breeding for various purposes (food, technical, and processing). These forms can serve as valuable material for creating new varieties with high yields, original fruit characteristics, and adaptation to regional conditions.

Table 4 contains comparative data on the biochemical indicators of the selected forms of *Crataegus chlorocarpa* and species of the genus *Rose*. The content of vitamin C, leucoanthocyanidins, catechins, anthocyanins, titratable acidity, total sugars, water-soluble pectin, and water-insoluble pectin was measured.

Table 4

Biochemical indicators of the selected forms of fruit plants in the Zhanaarka district of the Ulytau region

Form	Vitamin C mg/% FW	LAC mg/% FW	Catechin mg/% FW	Antocyanin mg/% FW	TA % FW	Sugars % FW	WSP % FW	WIP % FW
Cr-049	2.99 ± 0.07^{a}	193.7 ± 0.2^{d}	180.0 ± 0.2^{b}	30.7 ± 0.3^{d}	0.64 ± 0.01^{a}	4.2 ± 0.4^{a}	0.55 ± 0.02^{a}	0.36 ± 0.06^{a}
Cr-050	3.34 ± 0.02^{a}	140.4 ± 0.2^{f}	242.3 ± 0.1^{a}	16.8 ± 0.3^{e}	0.56 ± 0.01^{a}	3.6 ± 0.15^{a}	0.95 ± 0.03^{b}	0.84 ± 0.02^{b}
R.laxa-049	140.4 ± 0.3^{d}	166.3 ± 0.4^{e}	164.4 ± 0.1^{c}	7.92 ± 0.03^{g}	2.4 ± 0.1^{b}	13.8 ± 0.4^{b}	2.08 ± 0.03^{d}	1.49 ± 0.01^{c}
R.laxa-051	82.36 ± 0.2^{b}	70.56 ± 0.3^{g}	89.13 ± 0.1^{d}	42.6 ± 0.2^{c}	1.8 ± 0.1^{b}	19.2 ± 0.15^{c}	2.44 ± 0.05^{e}	2.28 ± 0.01^{e}
R.acic-058	576.4 ± 0.2^{f}	435.6 ± 0.4^{a}	29.52 ± 0.03^{e}	52.5 ± 0.2^{b}	3.9 ± 0.2^{c}	24.6 ± 0.3^{d}	1.41 ± 0.01^{c}	1.73 ± 0.01^{d}
R.acic-063	153.1 ± 0.4^{e}	200.16 ± 0.2^{c}	182.4 ± 0.2^{b}	12.87 ± 0.03^{f}	3.2 ± 0.2^{c}	21.6 ± 0.15^{cd}	1.39 ± 0.03^{c}	5.73 ± 0.02^{d}
R.spin-064	9.50 ± 0.1^{c}	228.2 ± 0.1^{b}	4.03 ± 0.02^{f}	1259.3 ± 0.35^{a}	2.24 ± 0.07^{b}	24.9 ± 0.15^{d}	2.14 ± 0.01^{d}	2.24 ± 0.02^{e}

Note – Different letters in the same column indicate significant differences at $P\leq0.05$; Abbreviations: TA-titratable acidity; WSP-water-soluble pectin; WIP-water-insoluble pectin; LAC — leucoanthocyanidin

The highest content of vitamin C was recorded in *Rosa acicularis*-058 at 576.4 mg/100 g, which is an order of magnitude higher than the rest of the samples. The minimum values for the forms of *Crataegus chlorocarpa* (Cr-049, Cr-050) are less than 4 mg/100 g.

The richest forms of leucoanthocyanidin are *Rosa acicularis*-058 (435.6 mg/100 g) and *Rosa spinossisima*-064 (228.2 mg/100 g). Among hawthorns, the level of leucoanthocyanidins is lower (about 140–194 mg/100 g). The maximum values of catechins were found in *Crataegus chlorocarpa*-050 (242.3 mg/100 g) and *Rosa acicularis*-063 (182.4 mg/100 g).

In terms of anthocyanin content, *Rosa spinosissima*-064 (1259.3 mg/100 g) is the absolute leader; the closest competitor in terms of anthocyanin content is inferior tenfold—for *Rosa acicularis*-058, *the* value is only 52.5 mg/100 g, and the rest of the samples are even lower.

The highest titrable acidity is in *Rosa acicularis*-058 (3.9 g/100 g), followed by *Rosa acicularis*-063 (3.2 g/100 g). The lowest values were observed in two forms of hawthorn–0.56-0.64 %.

Sugars are the most important component of fruits and berries. The content of sugars in fruits is a feature of the species: their high or low levels, inherent in a botanical species, usually remain quite stable over many years, similar in climatic conditions and in different habitats [25]. Hawthorn fruits contain mainly fructose, as well as small amounts of glucose and sucrose [26]. The clear leaders in sugars are various forms of the genus *Rosa* (especially *R. spinosissima* and *R. acicularis* — more than 24 g/100 g), hawthorn has much less sugar (3.6–4.2 g/100 g).

The largest amount of water-soluble pectin was found in *Rosa laxa*-051 (2.44), and water-insoluble pectin in *Rosa acicularis*-063 (5.73).

In all cases, the fruits of the genus *Rosa* are significantly superior to hawthorn in terms of vitamin C, sugars, and acidity. The form *R. spinosissima*-064 stands out for its ultra-high anthocyanin content. *Crataegus chlorocarpa* is promising in terms of catechin content, but its fruits are insignificant in most other parameters. For use in the food industry or medicine, the fruits of *Rosa acicularis*-058 are optimal in terms of vitamin C content.

To obtain anthocyanins in large quantities, *Rosa spinosissima*-064 should be chosen. *Crataegus* fruits are mainly suitable for the production of catechins, but are inferior in other respects. The data allow us to recommend different forms for targeted needs—for example, *Rosa acicularis*-058 for the production of vitamin concentrates, *Rosa spinosissima*-064 for anthocyanin extract, and hawthorn as a source of catechins.

Table 5 shows Pearson's correlation coefficients between nine variables measured in the fruits of various species of rose hips and Altai hawthorn. The data are based on seven samples collected at different altitudes (from 490 to 645 m).

Table 5

Pearson's correlation matrix between nine variables of different forms of rosehip species (*R. laxa, R. acicularis, R. spinosissima*) and two forms of C.chlorocarpa

Compound	Vitam C	LAC	Catechin	Anthocyan	TA	Sugar	WSP	WIP	Altitude
Vitamin C	1.00 (0.00)	**0.83 (0.02)**	-0.43 (0.33)	-0.26 (0.57)	**0.80 (0.03)**	0.52 (0.23)	0.03 (0.94)	0.13 (0.79)	-0.44 (0.32)
LAC	**0.83 (0.02)**	1.00 (0.00)	-0.50 (0.25)	0.11 (0.82)	0.66 (0.11)	0.45 (0.32)	-0.23 (0.62)	0.00 (1.00)	-0.15 (0.74)
Catechin	-0.43 (0.33)	-0.50 (0.25)	1.00 (0.00)	-0.64 (0.12)	-0.56 (0.19)	**-0.81 (0.03)**	-0.56 (0.19)	-0.05 (0.91)	-0.04 (0.93)
Anthocyan	-0.26 (0.57)	0.11 (0.82)	-0.64 (0.12)	1.00 (0.00)	0.06 (0.90)	0.45 (0.32)	0.37 (0.41)	0.03 (0.95)	0.55 (0.20)
TA	**0.80 (0.03)**	0.66 (0.11)	-0.56 (0.19)	0.06 (0.90)	1.00 (0.00)	0.86 (0.01)	0.38 (0.40)	0.59 (0.17)	0.11 (0.82)
Sugare	0.52 (0.23)	0.45 (0.32)	**-0.81 (0.03)**	0.45 (0.32)	0.86 (0.01)	1.00 (0.00)	0.65 (0.12)	0.59 (0.16)	0.27 (0.56)
WSP	0.03 (0.94)	-0.23 (0.62)	-0.56 (0.19)	0.37 (0.41)	0.38 (0.40)	0.65 (0.12)	1.00 (0.00)	0.26 (0.57)	0.11 (0.81)
WIP	0.13 (0.79)	0.00 (1.00)	-0.05 (0.91)	0.03 (0.95)	0.59 (0.17)	0.59 (0.16)	0.26 (0.57)	1.00 (0.00)	0.58 (0.17)
Altitude	-0.44 (0.32)	-0.15 (0.74)	-0.04 (0.93)	0.55 (0.20)	0.11 (0.82)	0.27 (0.56)	0.11 (0.81)	0.58 (0.17)	1.00 (0.00)
In brackets: p-values ($p<0.05$)									

A significant and strong correlation was observed between vitamin C and leucoanthocyanidins (LAC) (r=0.83, p=0.02). In rose hips, vitamin C often correlates with other antioxidants, as shown in studies [27], where the content of ascorbic acid varies with genotype and growing conditions.

Titratable acidity (TA) is associated with increased vitamin C content (r=0.80, p=0.03), which is typical for fruit plants: organic acids stabilize vitamin C and promote its accumulation. A correlation was found between titratable acidity and sugars (r=0.86, p=0.01). Acidity and sugars often balance each other in fruits (the sugar/acid ratio affects the taste). In rose hips, sugars (fructose, glucose) correlate with ripeness and acids. A moderate correlation was observed between sugars and water-soluble pectins (WSP) (r=0.65, p=0.12). WSP often increases with sugar content, as both are associated with fruit ripening and cell wall hydrolysis.

Other moderate correlations were also noted: LAC and TA (r=0.66), Sugars and WIP (water-insoluble pectin) (r=0.59), and TA and WIP (r=0.59). These relationships indicate a group of variables related to acidity and carbohydrates (TA, Sugars, pectins), which reflects fruit metabolism. In studies of the flora of Transylvania [28], vitamin C and acids contained in *Rosa canina* correlate positively, as they accumulate in response to stress (cold, altitude).

A significant negative correlation was observed between catechin and sugars (r=-0.81, p=0.03). Catechins (polyphenols) decrease with an increase in sugars, which may indicate different metabolic pathways: catechins are synthesized in the early stages, while sugars are synthesized during ripening. Catechin and anthocyanin (r=-0.64, p=0.12)—moderate negative. Anthocyanins and catechins are both flavonoids, but their synthesis may compete (e.g., under the influence of light or temperature).

A moderate positive correlation was found between altitude and anthocyanin content (r=0.55, p=0.20). Anthocyanins often increase at altitude due to increased UV radiation (stress protection), as in studies of *Rosa canina* [27]. WIP and Altitude (r=0.58, p=0.17), insoluble pectins may increase at altitude for structural adaptation (thicker cell walls). This is consistent with the literature: in rosehips at high altitudes, anthocyanins and pectins increase for protection, while vitamin C varies by genotype [28].

Thus, the correlation matrix reveals key patterns in the biochemistry of rosehips and hawthorn (Fig. 2): strong positive correlations between Vitamin C, LAC, TA, and sugars suggest synergistic metabolism of antioxidants and carbohydrates associated with fruit maturity and quality.

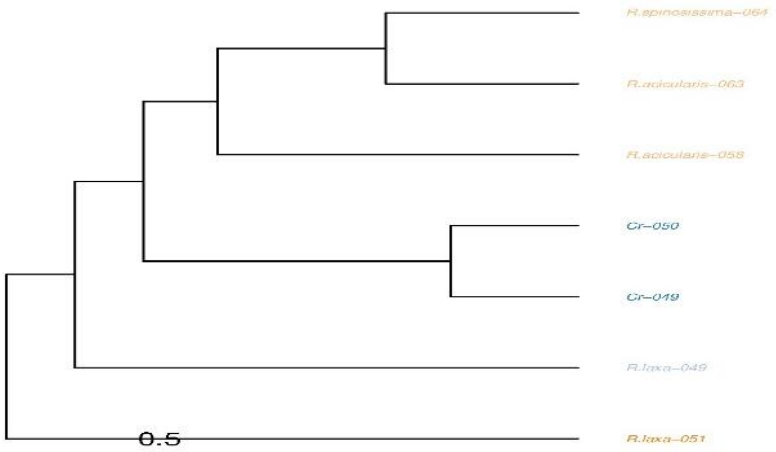

Figure 2. Cluster analysis of selected fruit plants by biochemical characteristics

Negative correlations with Catechin indicate alternative pathways for flavonoid biosynthesis. The altitude at which fruit plants grow in Ulytau has a weak effect, but may stimulate anthocyanins and pectins as an adaptation to stress, as confirmed by studies in Turkey [29], where in *Rosa canina* genotypes, anthocyanin content increases with altitude due to UV.

Based on the structure and the association distances, the following key points are distinguished: Cluster 1: *R.spinosissima*-064, *R.acicularis*-063, *R.acicularis*-058—these elements are combined at a short distance, which indicates their high similarity. Cluster 2: Cr-050, Cr-049—also close elements, but different from Cluster 1. Cluster 3: *R.laxa*-049, *R.laxa*-051–coalesced at a distance close to 0.5 and more distant from other clusters. Distances and similarities: Mergers within each cluster occur at a distance of less than 0.5, suggesting a close relationship within the groups. Clusters 1 and 2 join each other at a distance greater than 0.5,

showing moderate similarity, while Cluster 3 joins them at an even greater distance, indicating a significant difference. The distance threshold of 0.5 separates the three main clusters. Color coding: Orange markings: *R.spinosissima*-064, *R.acicularis*-063, *R.acicularis*-058, *R.laxa*-051**—**belong to the genus *Rosa*. Blue markings: Cr-050, Cr-049**—**indicate the genus *Crataegus*. Light blue mark: *R.laxa*-049**—**also belongs to the genus *Rosa*, but highlighted separately, possibly due to the characteristics of the species.

Thus, the dendrogram distinguishes three main clusters: Cluster 1 (*R.spinosissima*-064, *R.acicularis*-063, *R.acicularis*-058), Cluster 2 (Cr-050, Cr-049), Cluster 3 (*R.laxa*-049, *R.laxa*-051). Clusters 1 and 2 are more similar to each other than to Cluster 3, as indicated by the union distances. A threshold of 0.5 effectively separates these groups. Color coding (orange for the genus *Rosa*, blue for *Crataegus*) suggests taxonomic differences between clusters.

Conclusions

In conclusion, this comprehensive analysis of two *Crataegus chlorocarpa* forms and five Rosa species from the Ulytau region reveals substantial morphological diversity and biochemical richness, adapted to the arid continental climate. Key highlights include the superior vitamin C in *Rosa acicularis*-058, exceptional anthocyanins in *Rosa spinosissima*-064, and high catechins in Crataegus forms, with Rosa species generally outperforming hawthorn in vitamins, sugars, and acidity. Correlation and cluster analyses underscore synergistic metabolic pathways and taxonomic groupings, influenced minimally by altitude. These results position Ulytau's wild fruits as valuable resources for nutraceuticals, pharmaceuticals, and food products, potentially exceeding traditional antioxidants like blueberries. The data inform targeted breeding for resilient varieties, supporting sustainable use under Kazakhstan's Flora Law. Future studies should incorporate genetic sequencing, multi-year environmental monitoring, and expanded sampling to validate and extend these findings for commercial applications.

Funding

The research was carried out within the framework of program BR23591088 "Creation of the Plant Cadastre of the Ulytau Region" as the Implementation of the Tasks of the Law of the Republic of Kazakhstan "On Flora" for the Sustainable Use of the Botanical Resources of the Region.

Conflict of Interest

Authors declare no conflict of interest.

Author contribution

The manuscript was prepared with the contributions of all authors, who have given their approval to the final version. **Mukan G.S.** — conceptualization, project administration, writing, review and editing; **Sankaibayeva A.G. —** investigation, data curation, and plant material collection; **Kidarbek T.** — methodology, formal analysis, and visualization; **Baimaganbetova M.M. and Dostemessova A.B.** — data curation, statistical analysis.

References

1 Максутбекова Г.Т. Дикорастущие древесно-кустарниковые растения Жезказганского региона и их применение в озеленении / Г.Т. Максутбекова, М.К. Ахматов // Международный научно-исследовательский журнал. — 2017. — № 11(65). — С. 25–32. https://doi.org/10.23670/IRJ.2017.65.

2 Джангалиев А.Д. Дикие плодовые растения Казахстана / А.Д. Джангалиева, Т.Н. Салова, Р.М. Туречанова. — Алматы, 2001. — 135 с.

3 Imanbayeva A. A. Study of the Floristic, Morphological, and Genetic (atpF–atpH, Internal Transcribed Spacer (ITS), mat K, psbK-psbI, rbcL, and trnH-psbA) Differences in *Crataegus ambigua* Populations in Mangistau (Kazakhstan) / A. Imanbayeva, N. Duisenova, A. Orazov, M. Sagyndykova, I. Belozerov, A. Tuyakova // Plants. — 2024. — Vol. 13. — Article ID 1591. https://doi.org/10.3390/plants13121591.

4 Ишмуратова М.Ю. Флора гор Улытау (Центральный Казахстан) / М.Ю. Ишмуратова, Г.Ж. Мырзалы, В.И. Ивлев, А.Н. Матвеев. — Караганда: РИО Болашак-Баспа, 2016. — 127 с.

5 Jiménez-López J. *Rosa rubiginosa* and *Fraxinus oxycarpa* herbal teas: characterization of phytochemical profiles by liquid chromatography-mass spectrometry, and evaluation of the antioxidantactivity / J. Jiménez-López, A.Ruiz-Medina, P. Ortega-Barrales, E.J. Llorent-Martínez // New J. Chem. — 2017. — Vol. 41. — P. 7681–7688.

6 Smanalieva J. Investigation of nutritional characteristics and free radicalscavenging activity of wild apple, pear, rosehip, and barberry from the walnut-fruit forests of Kyrgyzstan / J. Smanalieva, J. Iskakova, Z. Oskonbaeva, F. Wichern, D. Darr // Eur. Food Res. Technol. — 2020. — Vol. 246. — P. 1095–1104.

7 Peña F. Bioactive Compounds andAntioxidant Activity in the Fruit of Rosehip (*Rosa canina* L. and *Rosa rubiginosa* L.) / F. Peña, S. Valencia, G. Tereucán, J. Nahuelcura, F. Jiménez-Aspee, P. Cornejo, A. Ruiz // Molecules, 28. — 2023. — Vol. 3544. https://doi.org/10.3390/molecules28083544.

8 Sagbas H.I. Investigation of Fruit Quality and Biochemical Traitsof Rosehip (*R. canina*) Ecotypes in the Aegean Region of Türkiye / H.I. Sagbas // Horticulturae. — 2023. — Vol., 9. — Article ID 1292. https://doi.org/10.3390/horticulturae9121292.

9 Tomar O. Determination of some quality properties and antimicrobial activities of kombucha tea prepared with different berries / O. Tomar // Turk. J. Agric. For. — 2023. — Vol. 47. — P. 252–262.

10 Murathan Z.T. Determination of fatty acids and volatile compounds in fruits of rosehip (*Rosa* L.) species by HS-SPME/GC-MS and Im-SPME/GC-MS techniques / Z.T. Murathan, M. Zarifikhosroshahi, N.E. Kafkas // Turk. J. Agric. For. — 2016. — Vol. 40. — P. 269–279.

11 Грудзинская Л.М. Аннотированный список лекарстенных растений Казахстана / Л.М. Грудзинская, Н.Г. Гемеджиева, Н.В. Нелина, Ж.Ж. Каржаубекова. — Алматы, 2014. — 230 с.

12 Balta M.F. Somefruit traits of hawthorn (*Crataegus* spp.) genetic resources from Malatya, Turkey / M.F. Balta, F. Çelik, N. Türkoğlu, K. Özrenk, F. Özgokçe // Res J Agric Biol Sci. — 2006. — Vol. 2. — P. 531–536.

13 Guo T.J. Hawthorn (*Crataegus*) Resources in China / T.J. Guo // Hort Sci. — 1995. — Vol. 30. — P. 1132–1134.

14 Khadivi A. Morphological variabilities of Crataegus monogyna and C. pentagyna in northeastern areas of Iran / A. Khadivi, P. Heidari, M. Rezaei, A. Safari-Khuzani, M. Sahebi // Industrial Crops and Products. — 2019. — Vol. 139. — Article ID 111531. https://doi.org/10.1016/j.indcrop.2019.111531.

15 Prior R.L. Antioxidant capacity is influenced by total phenolic andanthocyanin content, maturity, and variety of *Vaccinium* species / R.L. Prior, G. Cao, A. Martin, E.Sofic, J. McEwen, C. O'Brien et al. // J Agric Food Chem. — 1998. — Vol. 46. — P. 2686–2693.

16 Cavallos-Casals B.A. Selecting new peach and plum genotypes rich in phenoliccompounds and enhanced functional properties / B.A. Cavallos-Casals, D. Byrne, W.R. Okie, L. Cisneros-Zevallos // Food Chem. — 2006. — Vol. 96. — P. 273–280.

17 Ercişli S. The genotypic effectson the chemical composition and antioxidant activity of seabuckthorn (*Hippophae rhamnoides* L.) berries grown in Turkey / S. Ercişli, E. Orhan, O. Özdemir, M. Şengül // Sci Hortic. — 2007. — Vol. 15. — P. 27–33.

18 Mukan G. Survey, selection, and study of promising forms of sea buckthorn (*Hippophae rhamnoides* L.) in Burabay National Park / G. Mukan, L. Shadmanova, A. Sankaybayeva, L. Ugit, M. Razhanov, A. Yeszhanova // Pak. J. Bot. — 2025. — Vol. 57(6). http://dx.doi.org/10.30848/PJB2025-6(13).

19 Бейдеман И.Н. Методика изучения фенологии растений и растительных сообществ / И.Н. Бейдеман. — Новосибирск: Наука, 2004. — 155 с.

20 Сапожникова Е.В. Определение содержания аскорбиновой кислоты в окрашенных растительных экстрактах йодометрическим методом / Е.В. Сапожникова, Л.С. Дорофеева // Консервация и овощесушильная промышленность. — 1966. — № 5. — С. 29—31.

21 Hagerman A. Tannin Chemistry / A. Hagerman. — 2002. — [Electronic resource]. — Access mode: http://www.users.muohio.edu/hagermae/tannin.

22 Скорикова Ю.Г. Методика определения антоцианов в плодах и ягодах / Ю.Г. Скорикова, Е.А. Шафран // Труды III Всероссийского семинара по биологически активным (лечебным) веществам плодов и ягод. — Свердловск, 1968. — С. 451.

23 Hagerman A. Quantification of tannins in tree foliage laboratory manual. FAO/IAEA / A. Hagerman, I. Harvey-Mueller, H.P.S. Makkar. — Vienna, 2000. — P. 4–7.

24 Ермаков А.И. Методы биохимического анализа растений / А.И. Ермаков. — Л., 1987. — 430 с.

25 Zhang L.F. Effects of calcium and pectin methylesterase on quality attributes and pectin morphology of jujube fruit under vacuum impregnation during storage / L.F. Zhang, P. Wang, F.S. Chen, S.J. Lai, H.G. Yu, H.S. Yang // Food Chemistry. — 2019. — Vol. 289. — P. 40–48. https://doi.org/10.1016/j.foodchem.2019.03.008.

26 Павилионов А.А. Новые плодовые ягодные культуры / А.А. Павилионов, И. Рожков. — М.: Россельхозиздат, 1986. — 88 с.

27 Bakhtiar Z. Quantification of fatty acids in seed oil and important bioactive compounds in Iranian *Rosa canina* L. ecotypes for potential cosmetic and medicinal uses / Z. Bakhtiar, G. Eghlima, M. Hatami, M.H. Mirjalili // Sci. Rep. — 2023. — Vol. 13(1). — P. 22721. https://doi.org/10.1038/s41598-023-50135-y.

28 Roman I. Bioactive compounds and antioxidant activity of Rosa canina L. biotypes from spontaneous flora of Transylvania / I. Roman, A. Stănilă, S. Stănilă // Chem. Cent. J. — 2013. — Vol. 7(1). — P. 73. https://doi.org/10.1186/1752-153X-7-73.

29 Sevindik E. Characterization of bioactive compounds in rosehip species from the East Anatolia region of Turkey / K. Sevindik // Italian Journal of Food Science. — 2016. — Vol. 28(2). — P. 314–325. https://doi.org/10.14674/1120-1770/ijfs.v198

Г.С. Мұқан, А.Г. Санкайбаева, Т. Кидарбек, М.М. Баймаганбетова, А.Б. Достемесова

Ұлытау облысындағы долана мен итмұрының морфологиялық және биохимиялық талдауы

Зерттеу Қазақстанның Ұлытау облысы Жаңаарқа ауданында өсетін Алтай доланасының (*Crataegus chlorocarpa*) екі түрі мен итмұрынның (*Rosa laxa, R. acicularis, R. spinosissima*) бес түрінің морфологиялық және биохимиялық сипаттамаларын анықтауға арналған. Зерттеу барысында өсімдіктердің географиялық координаттары, өсу биіктігі, жасы, бөрікбасының пішіні, өнімділігі, сондай-ақ жемістерінің мөлшері, түсі мен дәмі тіркелді. Биохимиялық талдау құрамында С дәрумені, антоцианиндер, лейкоантоцианидиндер, катехиндер, қанттар, пектиндер және титрленетін қышқылдық көрсеткіштері анықталды. *Rosa acicularis*–058 С дәруменінің жоғары мөлшерімен (576,4 мг/100 г) ерекшеленсе, *R. spinosissima*–064 антоцианиндердің көп мөлшерімен (1259,3 мг/100 г) көзге түсті. Долананың зерттелген формалары катехиндер көзі ретінде перспективалы екені анықталды. Кластерлік талдау нәтижесінде әртүрлі биохимиялық профилі бар үш топқа жататын өсімдіктер айқындалды. Алынған мәліметтер жаңа сорттарды іріктеу және функционалдық тағам өнімдерін әзірлеу үшін пайдалануға болады.

Кілт сөздер: Ұлытау облысы, *Crataegus chlorocarpa*, Rosa түрлері, морфология, биохимия, С витамині, антоцианиндер, кластерлік талдау

Г.С. Мұқан, А.Г. Санкайбаева, Т. Кидарбек, М.М. Баймаганбетова, А.Б. Достемесова

Морфологический и биохимический анализ боярышника и шиповника Улытауской области

Исследование посвящено изучению морфологических и биохимических характеристик двух форм боярышника алтайского (*Crataegus chlorocarpa*) и пяти форм шиповника (*Rosa laxa, R. acicularis, R. spinosissima*), произрастающих в Жанааркинском районе Улытауской области Казахстана. Определены географические координаты, высота произрастания, возраст, форма кроны, урожайность, а также размеры, окраска и вкус плодов. Биохимический анализ включал определение содержания витамина С, антоцианов, лейкоантоцианидинов, катехинов, сахаров, пектинов и титруемой кислотности. Выявлено, что *Rosa acicularis-058* отличается высоким содержанием витамина С (576,4 мг/100 г), а *Rosa spinosissima-064* – повышенным содержанием антоцианов (1259,3 мг/100 г). Формы боярышника перспективны как источник катехинов. Результаты кластерного анализа показали три группы растений с различными биохимическими профилями. Полученные данные могут быть использованы для селекции новых сортов и разработки функциональных продуктов.

Ключевые слова: Улытауская область, *Crataegus chlorocarpa*, виды *Rosa*, морфология, биохимия, витамин С, антоцианы, кластерный анализ

References

1 Maksutbekova, G.T., & Akhmatov, M.K. (2017). Dikorastushchie drevesno-kustarnikovye rasteniia Zhezkazganskogo regiona i ikh primenenie v ozelenenii [Wild woody and shrubby plants of the Zhezkazgan region and their using in green building]. *Mezhdunarodnyi nauchno-issledovatelskii zhurnal — International scientific and research journal,* 11 (65), 25–32. https://doi.org/10.23670/IRJ.2017.65.146 [in Russian].

2 Dzhangaliev, A.D., Salova, T.N., & Turechanova, R.M. (2001). *Dikie plodovye rasteniia Kazakhstana* [Wild fruit plants of Kazakhstan]. Almaty [in Russian].

3 Imanbayeva, A., Duisenova, N., Orazov, A., Sagyndykova, M., Belozerov, I., & Tuyakova, A. (2024). Study of the Floristic, Morphological, and Genetic (atpF–atpH, Internal Transcribed Spacer (ITS), mat K, psbK-psbI, rbcL, and trnH-psbA) Differences in *Crataegus ambigua* Populations in Mangistau (Kazakhstan). *Plants*, *13*, 1591. https://doi.org/10.3390/plants13121591.

4 Ishmuratova, M.Yu., Myrzaly, G.Zh., Iblev, V.I., & Matveev, A.N. (2016). *Flora gor Ulytau (Tsentralnyi Kazakhstan)* [Flora of the Ulytau Mountains (Central Kazakhstan)]. Karaganda: RIO Bolashak-Baspa [in Russian].

5 Jiménez-López, J., Ruiz-Medina, A., Ortega-Barrales, P., & Llorent-Martínez, E.J. (2017). *Rosa rubiginosa* and *Fraxinus oxycarpa* herbal teas: characterization of phytochemical profiles by liquid chromatography-mass spectrometry, and evaluation of the antioxidantactivity. *New J. Chem.*, *41,* 7681–7688.

6 Smanalieva, J., Iskakova, J., Oskonbaeva, Z., Wichern, F., & Darr, D. (2020). Investigation of nutritional characteristics and free radicalscavenging activity of wild apple, pear, rosehip, and barberry from the walnut-fruit forests of Kyrgyzstan. *Eur. Food Res. Technol.*, *246,* 1095–1104.

7 Peña, F., Valencia, S., Tereucán, G., Nahuelcura, J., Jiménez-Aspee, F., Cornejo, P., & Ruiz, A. (2023). Bioactive Compounds and Antioxidant Activity in the Fruit of Rosehip (*Rosa canina* L. and *Rosa rubiginosa* L.). *Molecules*, *28*, 3544. https://doi.org/10.3390/molecules28083544.

8 Sagbas, H.I. (2023). Investigation of Fruit Quality and Biochemical Traitsof Rosehip (*R. canina*) Ecotypes in the Aegean Region of Türkiye. *Horticulturae*, *9*, 1292. https://doi.org/10.3390/horticulturae9121292.

9 Tomar, O. (2023). Determination of some quality properties and antimicrobial activities of kombucha tea prepared with different berries. *Turk. J. Agric. For*, *47*, 252–262.

10 Murathan, Z.T., Zarifikhosroshahi, M., & Kafkas, N.E. (2016). Determination of fatty acids and volatile compounds in fruits of rosehip (*Rosa* L.) species by HS-SPME/GC-MS and Im-SPME/GC-MS techniques. *Turk. J. Agric. For.*, *40*, 269–279.

11 Grudzinskaya, L.M., Gemedzhieva, N.G., Nelina, N.V., & Karzhaubekova, Zh.Zh. (2014). *Annotirovannyi spisok lekarsvennykh rastenii Kazakhstana* [Annotated list of medicinal plants of Kazakhstan]. Almaty [in Russian].

12 Balta, M.F., Çelik, F., Türkoğlu, N., Özrenk, K., & Özgokçe, F. (2006). Some fruit traits of hawthorn (*Crataegus* spp.) genetic resources from Malatya, Turkey. *Res. J. Agric. Biol. Sci., 2*, 531–536.

13 Guo, T.J. (1995). Hawthorn (*Crataegus*) Resources in China. *Hort Sci., 30*, 1132–1134.

14 Khadivi, A., Heidari, P., Rezaei, M., Safari-Khuzani, A., & Sahebi, M. (2019). Morphological variabilities of Crataegus monogyna and C. pentagyna in northeastern areas of Iran. *Industrial Crops and Products*, *139*, 111531. https://doi.org/10.1016/j.indcrop.2019.111531.

15 Prior, R.L., Cao, G., Martin, A., Sofic, E., McEwen J., O'Brien, C. et al. (1998). Antioxidant capacity is influenced by total phenolic andanthocyanin content, maturity, and variety of *Vaccinium* species. *J Agric Food Chem*, *46*, 2686–2693.

16 Cevallos-Casals, B.A., Byrne, D., Okie, W.R., & Cisneros-Zevallos, L. (2006). Selecting new peach and plum genotypes rich in phenoliccompounds and enhanced functional properties. *Food Chem., 96*, 273–280.

17 Ercişli, S, Orhan, E, Özdemir, O., & Şengül M. (2007). The genotypic effects on the chemical composition and antioxidant activity of sea buckthorn (*Hippophae rhamnoides* L.) berries grown in Turkey. *Sci. Hortic., 15*, 27–33.

18 Mukan, G., Shadmanova, L., Sankaybayeva, A., Ugit, L., Razhanov, M., & Yeszhanova, A. (2025). Survey, selection, and study of promising forms of sea buckthorn (*Hippophae rhamnoides* L.) in Burabay National Park. *Pak. J. Bot., 57*(6). http://dx.doi.org/10.30848/PJB2025-6(13).

19 Beydeman, I.N. (2004). *Metodika izucheniia fenologii rastenii i rastitelnykh soobschestv* [Methodology for studying the phenology of plants and plant communities]. Novosibirsk. Nauka [in Russian].

20 Sapozhnikova, E.V., & Dorofeeva, L.S. (1966). Opredelenie soderzhaniia askorbinovoi kisloty v okrashennykh rastitelnykh ekstraktakh iodometricheskim metodom [Determination of ascorbic acid content in coloured plant extracts using the iodometric method]. *Konservatsiia i ovoshchesushilnaia promyshlennost — Preservating and vegetable drying industry*, 5, 29–31 [in Russian].

21 Hagerman, A. (2002). Tannin Chemistry. Retrieved from http://www.users.muohio.edu/hagermae/tannin.

22 Skorikova, Yu.G., & Shaftan, E.A. (1968). Metodika opredeleniia antotsiantov v plodakh i yagodakh [Methodology for determining anthocyanins in fruits and berries]. *Trudv III Vserossiiskogo seminara po biologicheski aktivnim (lechebnym) veshchestvam plodov i yagod — The collection of works of the Third All-Union Seminar on Biologically Active (Medicinal) Substances in Fruits and Berries*, 451. Sverdlovsk, 451 [in Russian].

23 Hagerman, A., Harvey-Mueller, I., & Makkar, H.P.S. (2000). *Quantification of tannins in tree foliage laboratory manual*. FAO/IAEA. Vienna.

24 Ermakov, A.I. (1987). *Metody biokhimicheskogo analiza rastenii* [Methodology for biochemical analysis of plants]. Leningrad [in Russian].

25 Zhang, L.F., Wang, P., Chen, F.S., Lai, S.J., Yu, H.G., & Yang, H.S. (2019). Effects of calcium and pectin methylesterase on quality attributes and pectin morphology of jujube fruit under vacuum impregnation during storage. *Food Chemistry*, *289*, 40–48. https://doi.org/10.1016/j.foodchem.2019.03.008.

26 Pavilionov, A.A., & Rozhkov, I. (1986). *Novye plodovye yagodnye kultury* [New fruit and berry crops]. Moscow: Rosselkhozizdat [in Russian].

27 Bakhtiar, Z., Eghlima, G., Hatami, M., & Mirjalili, M.H. (2023). Quantification of fatty acids in seed oil and important bioactive compounds in Iranian *Rosa canina* L. ecotypes for potential cosmetic and medicinal uses. *Sci. Rep., 13*(1); 22721. https://doi.org/10.1038/s41598-023-50135-y.

28 Roman, I, Stănilă, A., & Stănilă, S. (2013). Bioactive compounds and antioxidant activity of *Rosa canina* L. biotypes from spontaneous flora of Transylvania. *Chem. Cent. J., 7*(1), 73. https://doi.org/10.1186/1752-153X-7-73.

29 Sevindik, E. (2016). Characterization of bioactive compounds in rosehip species from the East Anatolia region of Turkey. *Italian Journal of Food Science*, *28*(2), 314–325. https://doi.org/10.14674/1120-1770/ijfs.v198.

Information about the authors

Mukan Gauhar Seisenbekkizi — Candidate of Biological Sciences, Head of Laboratory Protection of the Genetic Pool and Introduction of fruit plants named after A.D. Jangaliev, Institute of Botany

and Phytointroduction, Almaty, Kazakhstan; e-mail: appleforest_protection@yahoo.com; ORCID: 0000-0002-4721-882X

Sankaibayeva Anar Gabdisalimovna — Scientific Researcher, Institute of Botany and Phytointroduction, Almaty, Kazakhstan; e-mail: anar_52@mail.ru; ORCID: 0009-0008-5321-6979

Kidarbek Tannur — Junior Scientific Researcher, Institute of Botany and Phytointroduction, Almaty, Kazakhstan; e-mail: tannur84@mail.ru; ORCID: 0000-0002-0988-7870

Baimaganbetova Marzhan Maratovna — Junior Scientific Researcher, Institute of Botany and Phytointroduction, Almaty, Kazakhstan; e-mail: marzhan.baymaganbetova@mail.ru

Dostemessova Anar Berikovna — Junior Scientific Researcher, Institute of Botany and Phytointroduction, Almaty, Kazakhstan; e-mail: anardostemesova@gmail.com; ORCID: 0000-0003-4526-7115