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COMPARATIVE ANALYSIS OF THE ANATOMICAL AND MORPHOLOGICAL FEATURES OF *RHEUM TATARICUM* L. PLANTS FROM DIFFERENT ECOPOPULATIONS

There are about 60 species of the genus *Rheum* L. (Polygonaceae) distributed mainly in temperate and subtropical Asia, with the largest number (38 species, including 19 endemics) recorded in China. All species of the genus are used as medicinal plants. According to modern pharmacology, the most important property of the rhubarb root is regulation of the stomach and intestine function, due to its laxative effect; rhubarb also has antipyretic properties and antioxidant activity. The high content of dietary fibers provides protection against cardiovascular diseases, and vitamin K is valuable for the prevention of osteoporosis. However, the active ingredients and their mechanism of action have not been sufficiently studied.

Rheum tataricum L., known for its high resistance to drought, salinity, and lack of nutrients is the least studied species of wild rhubarb. The whole plant, and especially the leaves, contains several toxic compounds, in particular anthraquinone glycosides and calcium oxalate crystals.

Here we present the results of a comparative analysis of the anatomical and morphological structure of *Rh. tataricum* plants from ecopopulations growing in the Balkhash and Karatal districts of the Almaty region. We identified the differences due to the weather and climatic conditions of the ecopopulations. It is important to note that many idioblasts containing calcium oxalate were found in the rhizomes of *Rh. tataricum*, which prevent animals from eating plants and getting poisoned. The number of idioblasts in the central circle of the *Rh. tataricum* rhizome was smaller in the Balkhash district than in the Karatal district, while the idioblasts were larger in size in the former district. The medicinal and nutritional value of *Rh. tataricum* growing in a semi-desert environment indicates a high potential of the species in plant breeding, medicine, and as a food source.

Key words: *Rheum tataricum*, extract, pharmacology, antioxidant activity, ecopopulation, morphology.

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Әртүрлі экопопуляциялардан жиналған *Rheum tataricum* L. өсімдіктерінің анатомиялық-морфологиялық құрылымының ерекшеліктерін салыстырмалы талдау

Polygonaceae тұқымдасы *Rheum* L. туысының 60 – қа жуық түрі табиғатта негізінен қоңыржай және субтропикалық Азияда, ең көп 38 түрі Қытайда таралған, оның ішінде 19-ы эндемик. Туыстың барлық түрлері дәрілік өсімдік ретінде қолданылады. Қазіргі фармакология рауғаш өсімдігі тамырының ең маңызды қасиеті асқазан-ішек жолдарының ауруларына шипа екенін көрсетті, өйткені рауғаш сығындысы іш жүргізетін әсерге ие, рауғаш сонымен қатар антипиретикалық қасиеттерге және антиоксиданттық белсенділікке ие. Диеталық талшықтың жоғары мөлшері жүрек-қан тамырлары ауруларынан қорғайды, ал К дәрумені остеопороздың ал-

дын алу үшін құнды. Алайда, белсенді компоненттер мен олардың әсер ету механизмі әлі нақты анықталған жоқ.

Rheum tataricum L. құрғақшылыққа, тұздануға және қоректің тапшылығына жоғары төзімділігімен танымал, жабайы рауғаштың ең аз зерттелген түрі. Өсімдікте, әсіресе жапырақ тақталарында бірнеше улы қосылыстар, атап айтқанда антрахинон гликозидтері, сондай-ақ кальций оксалат кристалдары бар. Бұл жұмыста *Rh. tataricum* өсімдіктерінің анатомиялық-морфологиялық құрылымының ерекшеліктеріне салыстырмалы талдау жүргізілді. Алматы облысының Балқаш және Қаратал аудандарында өсетін эконопуляцияларда ауа-райы-климаттық жағдайларына байланысты айырмашылықтар анықталды. Маңыздысы, *Rh. tataricum* тамырсабақтарында құрамында кальций оксалаты бар идиобласттардың көп мөлшері табылды, бұл жануарлардың өсімдікті жеуіне және оларды улы заттарға айналдыруына жол бермейді. Атап өту керек, *Rh. tataricum* тамырының орталық цилиндрінде идиобласттар көлемі Қаратал ауданына қарағанда Балқаш ауданында үлкенірек және саны жағынан аз мөлшерде болды. Дәрілік және қоректік құндылығы *Rh. tataricum* түрін шөлейт ортада өсіру, медицина және тамақтану саласында қолдану перспективасын көрсетеді.

Түйін сөздер: *Rheum tataricum*, экстракт, фармакология, антиоксиданттық белсенділік, эконопуляция, морфология.

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Сравнительный анализ особенностей анато-морфологического строения растений *Rheum Tataricum* L. из различных эконопуляций

В природе встречается около 60 видов растений рода *Rheum* L. (Polygonaceae), распространенных преимущественно в умеренной и субтропической Азии, с наибольшим разнообразием в Китае – 38 видов, в том числе 19 эндемиков. Все виды рода используются как лекарственные растения. Современная фармакология показала, что наиболее важным свойством корня ревеня является регуляция работы желудка и кишечника, так как экстракт ревеня оказывает слабительное действие, ремень также обладает жаропонижающими свойствами и антиоксидантной активностью. Высокое содержание пищевых волокон обеспечивает защиту от сердечно-сосудистых заболеваний, а витамин К ценен для профилактики остеопороза и остеопороза. Однако активные ингредиенты и механизм их действия до сих пор четко не определены.

Rheum tataricum L. – самый малоизученный вид дикого ревеня, известный своей высокой устойчивостью к засухе, засолению и недостатку питательных веществ. Растение, особенно листовые пластинки, содержит несколько токсичных соединений, в частности гликозиды антрахинона и кристаллы оксалата кальция.

В настоящей работе проведен сравнительный анализ анато-морфологической структуры растений *Rh. tataricum* из эконопуляций, произрастающих в Балхашском и Каратальском районах областей г. Алматы. Выявлены различия, обусловленные погодными-климатическими условиями произрастания эконопуляций. Важно отметить, что в корневищах *Rh. tataricum* обнаружено большое количество идиобластов, содержащих оксалат кальция, которые не позволяют животным поедать растения и превращать их в токсичные. Следует отметить, что в центральном цилиндре корневища *Rh. tataricum* идиобласты в Балхашском районе крупнее, чем в Каратальском, и имеют небольшое количество. Лекарственная и пищевая ценность *Rh. tataricum* в полупустынном местообитании указывает на перспективность использования *Rh. tataricum* в селекции, медицине и питании.

Ключевые слова: *Rheum tataricum*, экстракт, фармакология, антиоксидантная активность, эконопуляция, морфология.

Introduction

Plants have been used for medicinal purposes since ancient times and, despite the progress achieved in the development of synthetic drugs, herbal remedies still play a significant role in modern medicine. Among promising sources of biologically active substances of natural origin are Kazakh representatives of the Polygonaceae Juss. family, among which there are many medicinal plants.

The family Polygonaceae includes about 50 genera, which are distributed all over the world, contains more than 1000 species. In Kazakhstan there are 141 species in 11 genera. Of these, 42

species have pharmacological properties, 15 are used in official medicine and 34 in folk medicine (Table 1) [1, 2].

Most medicinal species belong to the genera *Rumex* L. (15 species), *Rheum* L. (7), and *Persicaria* Hill (6). The species of the genus *Rheum* L. are rich in tannins, have a substantial natural resource base, and their uses in traditional medicine are well known; therefore, they deserve a further comprehensive study [3].

In this regard, the study, development, and rational use of medicinal species of the genus *Rheum* L. will expand the use of renewable plant sources and assist in preservation of their diversity in nature.

Table 1 – Medicinal plants of the Polygonaceae Juss. family in the flora of Kazakhstan

Genus	Number of medicinal species	Number of species used in medicine			Availability of information about natural resources
		official	folk	experimental	
<i>Aconogonon (Meissn.)Reichenb</i>	2	-	2	1	+
<i>Atraphaxis</i> L.	1	-	1	-	-
<i>Bistorta</i> Hill	2	-	2	-	-
<i>Calligonum</i> L.	2	-	-	2	-
<i>Fagopyrum</i> P. Miller	1	-	-	1	-
<i>Fallopia</i> Adanson	2	-	2	-	-
<i>Oxyria</i> Hill	1	-	1	-	-
<i>Persicaria</i> Hill	6	5	6	1	+
<i>Polygonum</i> L.	3	2	1	-	+
<i>Rheum</i> L.	7	2	6	-	+
<i>Rumex</i> L.	15	6	13	3	+
Total	42	15	34	8	-

The genus *Rheum* has about fifty species, most of which are distributed in Asia. According to M.S.Baitenov [1], nine species grow in Kazakhstan, one of which, *Rheum compactum* L., is listed in the “Red Book of Kazakhstan” [4] as *Rheum wittrockii* Lundstr. *Rheum tataricum* L. is economically valuable; it is the most common species of the genus *Rheum* in Kazakhstan. Reserves of *Rh. tataricum* have been found in areas of the Kyzylorda region, in Central [5] and in Western Kazakhstan. This species has a high content of tannins (from 2.0 to 25.74%) in all parts of the plant, has hemostatic, laxative,

astringent, hemostatic, antipyretic and antitumor effects and can be used as a source of vitamins. The underground parts of *Rh. tataricum*, all parts of which are rich in tannins, are used for medicinal purposes, preparations with antioxidant, P-vitamin and antitumor activity can be obtained from it.

So far, no regulatory documentation and phytopreparations exist for *Rheum tataricum* which is included in the State Register of Medicinal Products of Kazakhstan [6]. The exceptions are two patents for a method for obtaining polyphytic oil extract “Shukur-may” from freshly harvested roots

of *Rheum tataricum*, licorice roots and nettle leaves, and a method for obtaining an oil extract from *Tatar rhubarb* root [7]. Analysis of the available information on the phytochemical properties of the main groups of bioactive compounds in *Rheum tataricum* showed that phytochemical studies of plants of the genus *Rheum* L. had been carried out in 1960s at the Al-Farabi KazNU under the supervision of Professor, Doctor of Chemical Sciences T.K. Chumbalov. In the roots of *Rheum tataricum*, high content of tannins was found, which were isolated and identified [8]. In the available literature, no more recent data on the phytochemical and pharmacognostic properties and resource availability of *Rheum tataricum* could be found.

It is especially important to understand that the current distribution of plants is a result of both the environmental conditions and the ecophysiological potential of the species, combined with the species-specific features of the migration potential [9]. In the modern scientific literature, there is evidence that plants growing in severe climatic conditions tend to have higher concentrations of valuable biologically active substances than plants of the same species cultivated in the optimal for growth conditions [10]. This results in significant variability in the content of active compounds, which also depends on the place of collection, phenological phase of plant development, time of collection, and the organs collected [11-13]. Thus, for the target species, it is important not only to identify the main biologically active substances, but also consider the environmental conditions under which they were formed and accumulated. Therefore, at the initial stage of such studies, it is extremely informative to study morphophysiological and anatomical features of plants in vivo. It is likely that they will differ not only between species, but also between populations growing in different conditions [14-16].

Therefore, the purpose of the present study was a comparative analysis of anatomical and morphological structure of *Rheum tataricum* L. plants from ecopopulations growing in the Balkhash and Karatal districts of the Almaty region characterized by different climatic conditions.

Materials and methods

Rheum tataricum L. is an herbaceous perennial plant growing from a thick, woody rhizome. It forms a

basal tubercle with 20-35 cm long and 27-50 cm wide leaves on short petioles, and blooms in late spring forming peduncles about 35-50 cm high. Samples of *Rheum tataricum* L. were taken from ecopopulations growing in the Balkhash district (26.04.23., 381 m a.s.l., N 45°35'28.3", E 77°19'55.5") and in the Karatal district (23.04.23., 396 m above sea level, N 44°45'03.4", E 75°58'50.6") of the Almaty region.

Taxonomic identification was carried out according to floristic reports [17-22] and Internet resources [22, 23].

Microscopic studies were conducted using plant material which was fixed in a mixture of alcohol, glycerin, and water in a 1: 1: 1 ratio.

The anatomical preparations were made following the methods accepted in plant anatomy [24-26, 27, 28]. The slices were obtained using the HS3345 automatic microtome. Microphotographs of anatomical sections were taken on Escope trinocular microscope (Euromix, the Netherlands), High-speed Camera CMEX-5 Pro 5.1 Megapixels.

Results and discussion

Rheum tataricum L. is a perennial ephemeroïd, the leaves are large, rounded, bumpy, with a heart-shaped base and three prominent veins. The flowers are creamy and small. The fruits are three-sided, heart-shaped, finely wrinkled, dark brown nuts with dark red-brown narrow wings. It blooms in April-May and bears fruit in May and early June. It is found in the following floristic areas: 6. Pre-Caspian, 6a. Bukeevsky, 7. Aktyubinsky, 7a. Mugodzharsky, 8. Embensky, 9. Torgayskoye, 10. West Hillock, 10a. Ulytau, 11. East small hillock, 11a. Buzachi, 13b. Mangystaus, 14. Priaralsky, 15. Kyzylorda, 16. Betpak-Dalinsky, 18. Balkhash-Alakol, 20. Kyzylkumsky, 21. Turkestan, 26. Chu-Ili Mountains, and 28. Karatau [29]. The terrain is flat. The climate of the study area is continental. The Karatal district is in a semi-desert climatic zone. Astana has a pronounced continental climate. There is a variety of landscapes in the area. The terrain is mostly flat, the soils are light chestnut, salty, sandy loamy.

The meteorological conditions of the Balkhash and Karatal districts during the rhubarb growing season are presented in Table 2. As follows from the data presented in Table 2, the climate of the Balkhash district is hotter and drier than that of the Karatal district.

Table 2 – Basic meteorological parameters of the Balkhash and Karatal districts of the Almaty region over the growing season of *Rheum tataricum* L.

Month	Average maximum temperature, °C		Maximum temperature for the whole period, °C		Minimum temperature for the whole period, °C		Average precipitation, mm	
	Balkhash	Karatal	Balkhash	Karatal	Balkhash	Karatal	Balkhash	Karatal
April	20.3	14.7	37.0	34.2	–	-9.3	17.7	19.1
May	26.8	22.9	39.3	34.8	0.9	3.8	17.5	21.8
June	31.9	29.0	41.8	39.0	5.4	–	14.5	18.4
July	33.6	30.3	43.4	41.6	10.3	16.2	10.2	17.0
August	32.2	29.2	42.0	41.6	8.1	16.1	7.5	9.1
September	26.1	22.7	39.4	37.8	1.3	7.2	5.6	8.3

When viewing the transverse sections of the rhizomes of *Rheum tataricum* L. plants growing in the Balkhash and Karatal districts at 100 x magnification, peridermal layers (dark brown cells) were visible, forming rows of peripheral cells. The periderm consisted of three layers: phellem, phellogen, and phelloderm. Further along the periphery, parenchymal cells of the primary cortex were in a continuous layer consisting of several circles with numerous inclusions of idioblasts. The cells were rounded and small with slightly thickened walls, intercellular spaces were absent. The secondary phloem was represented by a continuous concentric cell layer next to the cambial layer. The secondary phloem consisted mainly of the axial and radial parenchyma; there were relatively few sieve-shaped tubes in it. The cambial layer was clearly visible and represented by tightly closed cells. The cambium bordered on the central cylinder. The secondary xylem was represented by radial chains of narrow- and wide-lumen small and medium-sized vessels converging to the center of the central cylinder. The area of xylem vessels averaged $0.251 \times 10^{-3} \text{ mm}^2$. The core parenchyma cells were in the center. In all samples, throughout the layer of the rhizome parenchyma there were numerous inclusions with anthracene derivatives. In addition, numerous idioblasts were visible closer to the central cylinder. In some cases, the vessels of the secondary xylem were arranged

in groups of three both in the Balkhash and Karatal rhizome samples.

A comparative analysis of *Rheum tataricum* L. samples from different ecopopulations revealed a looser structure of all rhizome tissues in samples from the Karatal district. Greater presence of intercellular spaces in the structure of the primary cortex and central cylinder was noted. Large intercellular spaces were randomly located in the parenchymal tissue (Figure 1). The samples from the Balkhash district had a more xeromorphic structure.

The morphometric data presented in Table 3 showed a thinner periderm layer in plants from the Balkhash district ($0.280 \mu\text{m}$) compared with plants from the Karatal district ($0.362 \mu\text{m}$).

The thickness of the primary cortex in plants of the Balkhash district was half that of plants from the Karatal district ($7.960 \mu\text{m}$ and $14.025 \mu\text{m}$, respectively). The total area of xylem vessels in the rhizomes of plants collected in the Balkhash district ($0.251 \times 10^{-3} \text{ mm}^2$) was also smaller than that of plants from the Karatal district ($0.376 \times 10^{-3} \text{ mm}^2$). The opposite pattern was noted in the diameter of the central cylinder: in plants from the Balkhash district, the diameter of the central cylinder was larger than that in plants from the Karatal district ($64.391 \mu\text{m}$ and $59.467 \mu\text{m}$, respectively). These differences appear to be associated with the ecological, geographical, and climatic conditions of *Rheum tataricum* L. populations.

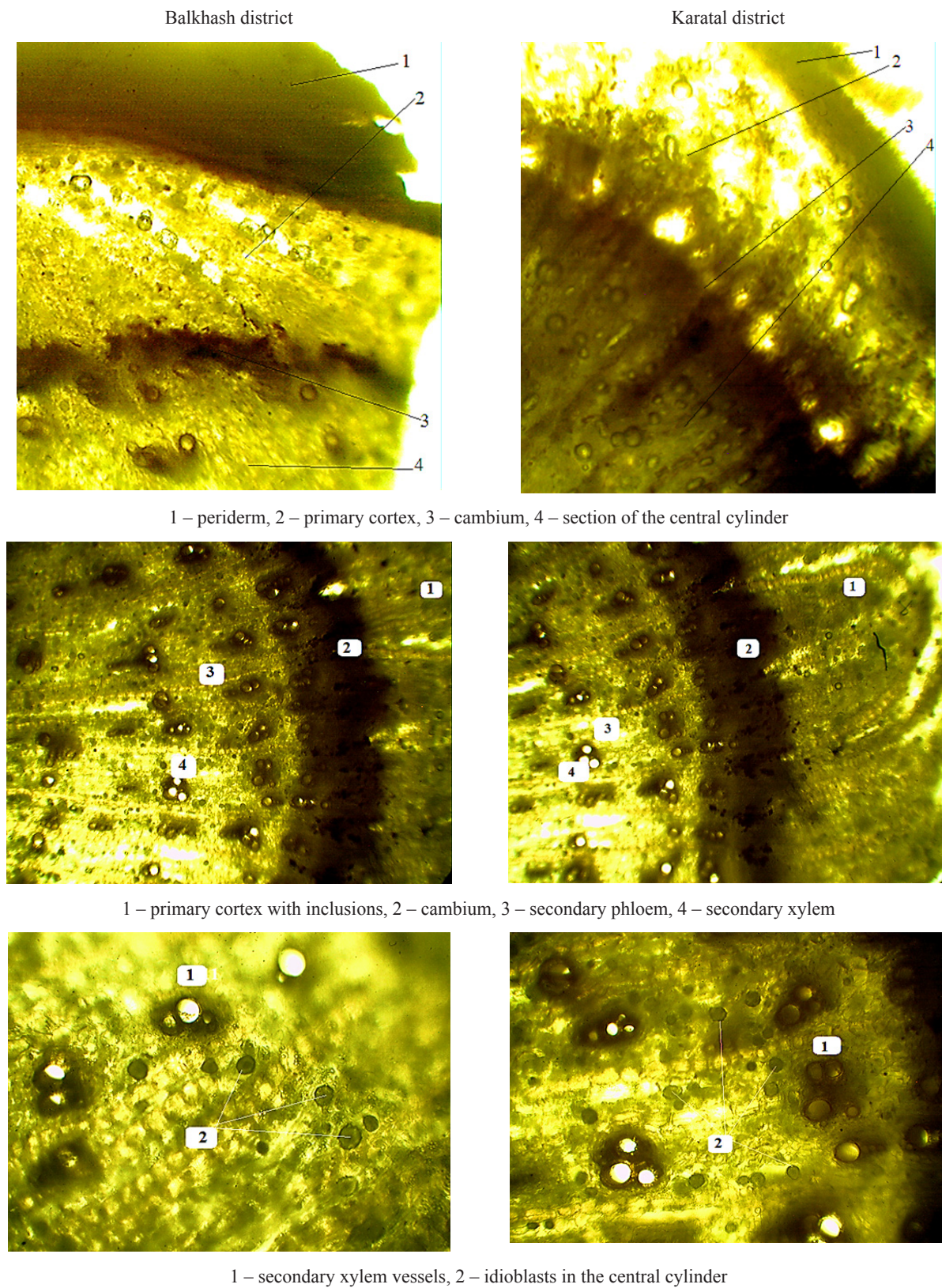


Figure 1 – Anatomical structure of rhizomes of *Rheum tataricum* L. plants from different ecopopulations sampled in the Almaty region (x70)

Table 3 – Morphometric indicators of the anatomical structure of the rhizome of *Rheum tataricum* L. plants from different ecopopulations of the Almaty region.

Study area	Periderm thickness, μm	Primary cortex thickness, μm	Diameter of the central cylinder, μm	Area of xylem vessels, $\times 10^{-3} \text{mm}^2$
Balkhash	0.221	10.368	64.391	0.149
	0.227	6.501		0.118
	0.387	5.661		0.426
	0.331	9.078		0.332
	0.236	8.185		0.229
Average value	0.280	7.960		0.251
Karatal'sky	0.292	14.436	59.467	0.417
	0.300	15.017		0.407
	0.457	14.628		0.226
	0.398	12.123		0.515
	0.361	13.923		0.313
Average value	0.362	14.025		0.376

Conclusions

A comparative analysis of the features of anatomical and morphological structure of *Rheum tataricum* L. plants growing in the Balkhash and Karatal districts of the Almaty region was carried out, and differences due to the weather and climatic conditions of ecopopulations were revealed. Samples from the more arid Balkhash district had a more xeromorphic structure: the peridermal layer and primary cortex were thinner, a total area of xylem vessels was smaller, and the central cylinder was larger in diameter. Thus, the climatic factors of the region affect the morphophysiological characteristics of plants from different ecopopulations.

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Conflicts of interest

All authors have read and are familiar with the content of the article and do not have a conflict of interest.

References

- Baitenov M. S. Flora of Kazakhstan // Almaty: Nauka. – 2001. – C. 64-67.
- Abdulina S.A. List of vascular plants of Kazakhstan. – M.: Almaty, 1999. – C. 38-39.
- Grudzinskaya L.M., Gemedzhieva N.G., Nelina N.V., Karzhaubekova Zh.Zh. Annotated list of medicinal plants of Kazakhstan: Reference publication / – Almaty, 2014, – P. 111-115.
- Red Book of Kazakhstan. – 2nd edition revised and supplemented. Volume 2: Plants (number of authors). – Astana, Art Print XXI LLP, – 2014. – P. 80-81.
- Kashkarova N.F. Tatar rhubarb in the Aral Sea region // Materials for the flora and vegetation of Kazakhstan. – Alma-Ata. – 1963. – P. 119-162.
- State Register of Medicinal Products of the Republic of Kazakhstan. – 2013 (List of medicinal products registered and approved for use and production by the Ministry of Health of the Republic of Kazakhstan). [Electronic resource]: adilet.zan.kz (IPS “Adilet”). [Last accessed]: adilet.zan.kz/docs/U950002655.
- Sakhanova S.K., Kuzdenbaeva R.S., Imambaev D.S., Ospanuly A. Method for obtaining oil extract of Tatar rhubarb root. The provisional patent number is 13308. IPC: A61K 35/78.
- Chumbalov T.K., Nurgalieva G.M. Carbohydrates *Rheum tataricum* L. // *Chemistry of natural compounds*, no 1 (1966): 284-285.
- Goncharova, S. B. Molecular phylogeny and taxonomy of flowering plants of the family *Crassulaceae* DC. *Molecular Biology* 43, no 5 (2009): 856-865.
- Sarker U., Oba S. Drought stress enhances nutritional and bioactive compounds, phenolic acids and antioxidant capacity of Amaranthus leafy vegetable, *BMC Plant Biology*, no 18(2018).
- Toderich K. N. et al. Differential impact of salinity stress on seeds minerals, storage proteins, fatty acids, and squalene composition of new quinoa genotype, grown in hyper-arid desert environments, *Frontiers in Plant Science*, no 11 (2020): 607102.
- Selmar D., Kleinwächter M. Stress enhances the synthesis of secondary plant products: the impact of stress-related over-reduction on the accumulation of natural products, *Plant and Cell Physiology* 6, no 54 (2013): 817-826.
- Chrysargyris A., Papakyriakou E., Petropoulos S.A., Tzortzakis N. The combined and single effect of salinity and copper stress on growth and quality of *Mentha spicata* plants. *J. Hazard. Mater*, no 368 (2019): 584-593.

14. Terletsкая N.V., Korbozova N.K., Kudrina N.O., Kobylina T.N., Kurmanbayeva M.S., Meduntseva N.D., Tolstikova T.G. The Influence of Abiotic Stress Factors on the Morphophysiological and Phytochemical Aspects of the Acclimation of the Plant *Rhodiola semenowii* Boriss, *Plants*, no 10 (2021): 1196.
15. Hoffmann, M. H. To the roots of *Carex*: Unexpected anatomical and functional diversity, *Syst. Bot*, no 44 (2019): 26-31.
16. Hoffmann, M.H., Gebauer, S., Lühmann, R. Root anatomy predicts ecological optima in *Carex* (Cyperaceae) in terms of Ellenberg indicator values, *Ecological Indicators*, no 129 (2021): 107979.
17. Flora of Kazakhstan / Ed. by N.V. Pavlova. – Alma-Ata: Publishing House of the Academy of Sciences of the Kazakh SSR. – 1956–1966. – Vol. 1–9.
18. Illustrated field guide to plants of Kazakhstan. – Alma-Ata: Nauka, 1969. – Vol. 1. – P. 644; – 1972. – Vol. 2. – P. 572.
19. Field guide to plants of Central Asia. – Vol. 1–10. – Tashkent. 1968–1993.
20. Cherepanov S.K. Vascular plants of Russia and neighboring states. – 1995. – P.990.
21. Baitenov M.S. Flora of Kazakhstan: Illustrated field guide of families and genera. Almaty, 1999. Vol. 1. – P. 400.
22. Plantarium: an open online atlas and field guide of plants and lichens of Russia and neighboring countries. 2007—2020. [Electronic resource]. URL: <http://www.plantarium.ru/>
23. Plants of the World Online (POWO). [Electronic resource]. URL: <http://powo.science.kew.org>
24. Permyakov A.I. Microtechnics. - M.: Moscow State University, 1988. – P. 11–29.
25. Prozina M.N. Botanical microtechnics. – Moscow: Moscow State University, 1960. – P. 260.
26. Barykina R.P., Veselova T.D., Devyatov A.G. Handbook of Botanical Microtechnics. – Moscow: Moscow State University, 2004. – P. 313.
27. Methods for determining the volumes of medicinal plant resources. – Moscow. – 1986. – P. 50.
28. Korchagin A.A. Species (floristic) composition of plant communities and methods of its study // Field geobotany. – Vol.3. – M.-L., 1964. – P. 39–60.
29. Flora of Kazakhstan. Vol.3. – Alma-Ata. – 1960. – P. 103-110.

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