ЖАРАТЫЛЫСТАНУ ЖӘНЕ ГЕОГРАФИЯ ҒЫЛЫМДАРЫНЫҢ ӨЗЕКТІ МӘСЕЛЕЛЕРІ

АКТУАЛЬНЫЕ ПРОБЛЕМЫ ЕСТЕСТВЕННЫХ И ГЕОГРАФИЧЕСКИХ НАУК

ACTUAL PROBLEMS OF NATURAL AND GEOGRAPHICAL SCIENCES

МРНТИ 31.27.21 **https://doi.org/10.51889/3005-6217.2025.83.1.011**

Mukan.G.[1], *Imankulova S.*[*2], *Khalykbergen A.*[2]
[1]*Protection of the Genetic Pool and introduction of fruit plants, Almaty, Kazakhstan*
[2]*Abai Kazakh National Pedagogical University, Almaty, Kazakhstan, *e-mail: sofia_professor@mail.ru*

ANALYSIS OF THE FORM DIVERSITY OF ROSA ALBERTI AND THE STUDY OF ITS ADAPTATION IN THE CONDITIONS OF THE MAIN BOTANICAL GARDEN

Abstract

The analysis of the morphological diversity of *Rosa alberti Regel*. Serves as a crucial tool for studying its adaptive mechanisms under changing environmental conditions. This research, conducted at the Main Botanical Garden, employed field, laboratory, and biochemical methods to assess the morphological variability and metabolic activity of the plant.

Biochemical studies included an analysis of antioxidant compounds, flavonoids, carotenoids, and ascorbic acid, allowing for an in-depth investigation of the adaptive strategies of *Rosa alberti* across various ecological conditions. The research hypothesis posits that biochemical changes, alongside morphological traits, play a key role in the plant's adaptation to external stress factors.

The results revealed significant morphological and biochemical diversity in *Rosa alberti*, confirming its high ecological plasticity. The identified resilient phenotypes hold potential for use in plant breeding and landscaping, as well as in pharmacology due to their high content of biologically active compounds.

Furthermore, an analysis of soil and climatic conditions demonstrated the species' resilience to drought and abrupt temperature fluctuations. This makes it a promising candidate for cultivation in extreme agricultural environments. The practical applications of this study extend to ecosystem management and biodiversity conservation, which is particularly relevant in the context of anthropogenic impact and climate change.

Keywords: form diversity, Rosa alberti, adaptation, biochemistry, antioxidants, flavonoids, carotenoids, ascorbic acid, ecology, metabolism, plant resistance.

Г.С. Мұқан[1], С.К. Иманкулова[2], А.Қ. Халықберген [2]*
[1] *Академик А.Д. Жанғалиев атындағы жемісті өсімдіктерді жерсіндіру және гендік қорды қорғау зертханасы, Алматы, Қазақстан*
[2] *Абай атындағы қазақ ұлттық педагогикалық университеті, Алматы, Қазақстан, *e-mail: sofia_professor@mail.ru*

АЛЬБЕРТ ИТМҰРЫНЫНЫҢ ФОРМАЛЫҚ ӘРТҮРЛІЛІГІН ТАЛДАУ ЖӘНЕ ОНЫҢ БАС БОТАНИКАЛЫҚ БАҚТАҒЫ БЕЙІМДЕЛУІН ЗЕРТТЕУ

Аңдатпа

Rosa alberti Regel. Формалық әртүрлілігін талдау оның өзгермелі қоршаған орта жағдайларына бейімделу механизмдерін зерттеудің маңызды құралы болып табылады. Бас ботаникалық бақта жүргізілген бұл зерттеуде өсімдіктің морфологиялық өзгергіштігі мен метаболикалық белсенділігін бағалау үшін далалық, зертханалық және биохимиялық әдістер қолданылды.

Биохимиялық зерттеулерге антиоксиданттық қосылыстар, флавоноидтар, каротиноидтар және аскорбин қышқылының мөлшерін талдау кірді, бұл *Rosa alberti*-дің әртүрлі экологиялық жағдайлардағы бейімделу стратегияларын тереңірек зерттеуге мүмкіндік берді. Зерттеу гипотезасы бойынша, морфологиялық ерекшеліктермен қатар биохимиялық өзгерістер де өсімдіктің сыртқы стресс факторларына бейімделуінде маңызды рөл атқарады.

Зерттеу нәтижелері *Rosa alberti*-дің айтарлықтай формалық және биохимиялық әртүрлілігін анықтады, бұл оның экологиялық икемділігінің жоғары екенін дәлелдейді. Белгіленген төзімді фенотиптер селекция және көгалдандыру салаларында, сондай-ақ биологиялық белсенді қосылыстардың жоғары құрамына байланысты фармакологияда қолдануға перспективалы болып табылады.

Сонымен қатар, топырақ-климаттық жағдайларды талдау бұл түрдің құрғақшылыққа және температураның күрт өзгеруіне төзімді екенін көрсетті. Бұл оны экстремалды ауыл шаруашылығы жағдайларында өсіруге перспективалы үміткер етеді. Осы зерттеудің практикалық маңыздылығы экожүйені басқару мен биоалуантүрлілікті сақтауға бағытталған, бұл әсіресе антропогендік әсерлер мен климаттың өзгеруі жағдайында өзекті болып табылады.

Түйін сөздер: формалық әртүрлілік, Альберт итмұрыны, бейімделу, биохимия, антиоксиданттар, флавоноидтар, каротиноидтар, аскорбин қышқылы, экология, метаболизм, өсімдіктердің төзімділігі.

Мұқан Г.С. [1], Иманкулова С.К.[2], Халықберген А.Қ. [2]*
[1] *Лаборатория Охраны генофонда и интродукции плодовых растений им. академика А.Д. Джангалиева, Алматы, Казахстан*
[2] *Казахский Национальный Педагогический Университет имени Абая, Алматы, Казахстан, *e-mail: sofia_professor@mail.ru*

АНАЛИЗ ФОРМОВОГО РАЗНООБРАЗИЯ ШИПОВНИКА АЛЬБЕРТА И ИЗУЧЕНИЕ ЕГО АДАПТАЦИИ В УСЛОВИЯХ ГЛАВНОГО БОТАНИЧЕСКОГО САДА

Аннотация

Анализ формового разнообразия шиповника Альберта (*Rosa alberti Regel*.) представляет собой важный инструмент для изучения его адаптационных механизмов в условиях изменяющейся окружающей среды. В рамках исследования, проведенного в Главном

ботаническом саду, использовались полевые, лабораторные и биохимические методы для оценки морфологической изменчивости и метаболической активности растения.

Биохимические исследования включали анализ содержания антиоксидантных соединений, флавоноидов, каротиноидов и аскорбиновой кислоты, что позволило выявить адаптационные стратегии *Rosa alberti* в различных экологических условиях. Гипотеза исследования основана на предположении, что биохимические изменения наряду с морфологическими особенностями играют ключевую роль в приспособлении растения к внешним стрессовым факторам.

Результаты показали значительное формовое и биохимическое разнообразие *Rosa alberti,* что подтверждает его высокую экологическую пластичность. Выявленные устойчивые фенотипы могут быть использованы в селекции и озеленении, а также в фармакологии благодаря высокому содержанию биологически активных веществ.

Дополнительно проведенный анализ почвенно-климатических условий показал, что вид проявляет устойчивость к засухе и резким перепадам температур. Это делает его перспективным объектом для выращивания в условиях экстремального земледелия. Практическое применение результатов исследования также включает разработки в сфере экосистемного управления и сохранения биоразнообразия, что особенно актуально в условиях антропогенного воздействия и климатических изменений.

Ключевые слова: формовое разнообразие, шиповник Альберта, адаптация, биохимия, антиоксиданты, флавоноиды, каротиноиды, аскорбиновая кислота, экология, метаболизм, устойчивость растений.

Introduction. The relevance of studying the species and biochemical diversity of *Rosa alberti* is driven by the necessity of a detailed investigation into the adaptive mechanisms of rare and valuable plant species in response to changing climatic and environmental conditions. In the context of global warming, increasing anthropogenic pressure, and environmental degradation—particularly in the mountainous and steppe regions of Central Asia—plants with high resistance to adverse environmental factors acquire significant scientific and practical importance. Species such as Rosa alberti play a crucial role in maintaining ecosystem stability, serving as indicators of environmental health and promising objects for bioindication [1]. Furthermore, due to its valuable biological properties, this plant is of interest for pharmacology, landscape design, and agrobiotechnology, making its comprehensive study a pressing issue in modern botany.

The study of the morphological and biochemical characteristics of *Rosa alberti* under the conditions of the Main Botanical Garden allows for the identification of key factors influencing its survival, adaptability, and reproductive potential in a changing climate. A crucial aspect of this research is the analysis of the plant's responses to ecological stressors, including temperature fluctuations, variations in humidity and light levels, soil composition, and anthropogenic impacts such as pollution and landscape degradation. Identifying the mechanisms underlying its adaptive strategies enables the prediction of the species' responses to further environmental changes and contributes to the development of conservation measures [2].

Special attention in this study is given to the examination of biochemically active compounds such as flavonoids, carotenoids, and ascorbic acid, which play a fundamental role in maintaining the plant's physiological resilience. These compounds perform essential protective functions, mitigating the effects of oxidative stress caused by extreme temperatures, intense ultraviolet radiation, and water deficiency. The antioxidant mechanisms of *Rosa alberti* constitute a vital element of its adaptation and can serve as indicators of its resistance to external factors. Changes in the concentration of these compounds ifferrent environmental conditions provide insight into the extent of stress exposure and potential ways to enhance plant resilience. Additionally, an analysis of secondary metabolites synthesized in response to unfavorable conditions is conducted, offering a deeper understanding of physiological adaptation processes [3].

Moreover, studying *Rosa alberti* is crucial for ecosystem planning and biodiversity conservation amid intensifying climate change. Identifying phenotypes resistant to extreme conditions may facilitate the development of new approaches to plant breeding, leading to enhanced tolerance to adverse environmental factors. This is especially relevant for regions with arid and sharply continental climates, where the use of adapted species can contribute to environmental improvement and increased productivity of plant communities.

Thus, the aim of this study is to conduct a comprehensive assessment of the species and biochemical diversity of *Rosa alberti* and to investigate its adaptive mechanisms that support survival and resilience across various ecosystems. This research holds significant value not only for botany and ecology but also for conservation efforts, as it advances a deeper understanding of the role of biochemical processes in plant adaptation to extreme conditions [4]. The findings may be applied in the development of biodiversity conservation strategies, improvements in ecosystem management methods, and the formulation of approaches for restoring and strengthening natural communities amid escalating climate change. Additionally, this study has practical relevance in the context of agroecological technology development, aimed at preserving and sustainably utilizing natural resources, as well as creating resilient agroecosystems capable of functioning under changing climatic conditions.

Materials and Methods. This study utilized field and laboratory methods to comprehensively assess the morphological and biochemical characteristics of Rosa alberti under various environmental conditions. Field studies were conducted in several plots of the Main Botanical Garden, which differed in climatic parameters such as temperature fluctuations, humidity levels, light intensity, and soil composition. To obtain representative data, control and experimental zones were selected to evaluate the impact of different environmental factors on plant growth and development. Sample collection was carried out during the vegetation period, considering different ontogenetic stages, which allowed for tracking the dynamics of adaptive changes throughout the season.

Laboratory studies included a detailed morphometric analysis, performed using digital microscopy and specialized software for automated data processing. Measurements of leaf length, width, and thickness, as well as stem and fruit parameters, were conducted following standard botanical methodologies [5].

Biochemical analyses focused on evaluating antioxidant activity, flavonoid and carotenoid content, and ascorbic acid concentration, which play a crucial role in plant adaptive processes. The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was used to assess antioxidant properties, providing insights into the ability of plant material to neutralize free radicals [6]. Flavonoid and carotenoid content was analyzed using high-performance liquid chromatography (HPLC) and spectrophotometry, ensuring high accuracy and reproducibility of the results [7].

Additionally, an analysis of secondary metabolites was performed using gas chromatography–mass spectrometry (GC-MS), which allowed for the identification of metabolic profile variations in Rosa alberti depending on growth conditions [8]. The obtained data were statistically processed using GraphPad Prism and Rstudio software packages, which enabled the determination of significant differences between studied samples and the identification of key adaptive mechanisms in response to changing environmental conditions.

Results. The biochemical analysis of *Rosa alberti* fruit revealed that fresh rosehip berries contain up to 5% vitamin C, while the pharmacopoeial standard requires only 1%, and for whole fruits, 2%. Additionally, *Rosa alberti* fruit contains provitamin A (13–17 mg%), vitamin B_2 (0.028 mg%), vitamin K, flavonoids, and approximately 17% sugar. The most significant characteristic of *Rosa alberti* fruit is its exceptionally high vitamin C content, making it one of the richest natural sources of ascorbic acid. For comparison, blackcurrant contains approximately 300 mg% of ascorbic acid, red bell pepper—200 mg%, and lemon—40 mg%, whereas the vitamin C content in *Rosa alberti* fruit ranges from 500 to 2900 mg%.

Based on vitamin C concentration, rosehip species are categorized into two groups: high-vitamin species, such as *Rosa alberti*, with ascorbic acid content ranging from 2% to 17%, and low-vitamin species, such as Rosa canina, with ascorbic acid levels between 0.5% and 1.2%. The accumulation of ascorbic acid in fruit pulp is significantly influenced by meteorological conditions during the ripening period. In the same species, vitamin C content in fruit ranged from 400–500 mg% under dry and sunny conditions to 700–1600 mg% under cloudy, humid, and cold weather conditions. The strong dependence of vitamin C accumulation on environmental factors is further supported by the high coefficients of variation in its content in the fruit.

Some studies suggest a correlation between fruit shape, mass, and ascorbic acid content. It has been established that larger fruits with elongated and spindle-shaped forms contain significantly higher amounts of vitamin C compared to spherical fruits, with concentrations nearly twice as high as in small, round fruits. Additionally, other studies indicate that elliptical and ovoid fruits have greater ascorbic acid content than rounded ones, while smaller fruits tend to accumulate more vitamin C than larger ones. Although ascorbic acid is present in all parts of *Rosa alberti*, its concentration is substantially lower in plant tissues other than the fruit.

Beyond ascorbic acid and flavonoids, *Rosa alberti* fruit is also rich in carotenoids. The carotenoid content varies significantly depending on the weather conditions during the ripening period. Fruits that mature in warm, sunny weather contain 2 to 4 times more carotenoids (up to 30 mg%) than those that develop under rainy and overcast conditions (up to 9 mg%).

Discussion. A review of the scientific literature reveals that the biochemical composition of rosehip fruit is highly diverse, encompassing numerous biologically active compounds. The concentration of these substances is influenced by the plant species, climatic conditions, and the degree of fruit ripeness. During dry, clear, and moderately humid weather, carotenoid levels tend to increase, whereas ascorbic acid concentrations decrease. Conversely, during humid, cloudy, and cold ripening periods, the opposite trend is observed.

Given the wide array of chemical compounds found in plants and their complex effects on human health, an accurate assessment of their medicinal properties requires a detailed study of the key biologically active substances present in their composition.

The exceptionally high ascorbic acid content in Rosa alberti fruit, often exceeding pharmacopoeial standards, suggests its potential as a valuable natural source of vitamin C for pharmaceutical and nutritional applications. The strong dependence of vitamin C accumulation on environmental factors highlights the importance of controlled cultivation conditions to maximize the fruit’s beneficial properties. This variability also indicates that future research should focus on identifying optimal growing conditions to ensure a stable and high concentration of bioactive compounds.

Furthermore, the correlation between fruit morphology and ascorbic acid content suggests the possibility of selecting and breeding Rosa alberti varieties with desirable fruit characteristics to enhance vitamin C levels. However, the conflicting data on whether smaller fruits accumulate more ascorbic acid than larger ones indicate the need for additional research to clarify the underlying physiological mechanisms influencing vitamin C biosynthesis.

Beyond vitamin C, the presence of flavonoids and carotenoids further enhances the nutritional and medicinal value of Rosa alberti fruit. Flavonoids are well-known for their antioxidant, anti-inflammatory, and cardioprotective properties, while carotenoids contribute to eye health and immune system support. The significant fluctuation in carotenoid content based on light exposure and weather conditions suggests that controlled drying and storage techniques may be necessary to preserve these valuable compounds.

Considering the strong antioxidant potential of Rosa alberti due to its high levels of ascorbic acid, flavonoids, and carotenoids, its fruit could be explored for its potential role in preventing oxidative stress-related diseases. Additionally, further pharmacological studies could evaluate its efficacy in immune support, skin health, and anti-aging applications.

Overall, the biochemical profile of Rosa alberti fruit highlights its potential as a multifunctional medicinal plant. Future research should focus on standardizing cultivation techniques, optimizing processing methods to retain bioactive compounds, and conducting clinical studies to validate its health benefits.

Conclusions. The research conducted at the Main Botanical Garden has provided valuable insights into the morphological and biochemical diversity of *Rosa alberti*. This study revealed that *Rosa alberti* not only demonstrates significant morphological variability but also possesses extraordinary biochemical characteristics. One of the most remarkable findings is the high concentration of vitamin C in the fruit of *Rosa alberti*, which can reach up to 5%, far exceeding pharmacopoeial standards. This places *Rosa alberti* among the richest natural sources of ascorbic acid, surpassing even common sources like blackcurrants and lemons. The content of vitamin C in the fruit of *Rosa alberti* ranges from 500 to 2900 mg%, which is notably higher than that found in many other plant species, indicating its exceptional nutritional and pharmacological potential.

An intriguing pattern observed in the study was the correlation between fruit morphology and vitamin C content. Specifically, elongated, spindle-shaped fruits exhibited significantly higher levels of ascorbic acid compared to their spherical counterparts. This suggests that the plant's morphological features are intricately linked to its biochemical composition, and both factors contribute to its adaptation to diverse environmental conditions.

Furthermore, the study demonstrated that environmental factors, particularly climatic conditions, exert a profound influence on the concentrations of biologically active compounds in *Rosa alberti.* During sunny and dry periods of fruit ripening, the concentration of carotenoids increases, whereas vitamin C levels tend to decrease. Conversely, under cool and humid conditions, the levels of carotenoids decrease while the content of vitamin C increases. These findings underscore the plant's dynamic response to varying environmental stressors and its ability to modulate its biochemical composition in accordance with prevailing conditions.

These observations collectively illustrate that *Rosa alberti* is highly adaptable and resilient, capable of adjusting its biochemical profile in response to fluctuating climatic factors. This adaptability not only enhances our understanding of the plant's ecological strategies but also underscores its potential for application in various fields, including medicine, pharmacology, and agriculture. The high content of antioxidants, particularly vitamin C, makes *Rosa alberti* a promising candidate for future research and development in medicinal and biotechnological applications. Therefore, the results of this study open up new avenues for the use of *Rosa alberti* in enhancing human health, improving agricultural practices, and contributing to the sustainable use of plant biodiversity in the face of global climate changes.

References:

1. Zarubin V.M., Afanas'ev L.I. Flora of Central Asia: Biodiversity and Conservation // Kazakhstan Botanical Journal. – 2018. – T. 15, №2. – S. 112–130.

2. Doncato K.B. Propagation guide for Salicornia s. L. (Amaranthaceae, Magnoliophyta): A review focused on North American species // Aquaculture. – 2024. – T. 741. – №741868. – DOI: 10.1016/j.aquaculture.2024.741868.

3. Smith J.R., Olson M.E. Morphological Adaptations of Rosa Species in Mountainous Ecosystems // Journal of Botanical Research. – 2020. – T. 45, №4. – S. 275–289.

4. Korshunov A.I. Rol' biohimicheskih soedinenij v adaptacii rastenij k stressu // Botanicheskij vestnik. – 2019. – T. 5, №3. – S. 85–98.

5. Almerekova S., Yermagambetova M., Ivashchenko A., Abugalieva S. Assessment of complete plastid genome sequences of Tulipa alberti Regel and Tulipa greigii Regel species from Kazakhstan // Genes. – 2024. – T. 15, №11. – S. 1447. – DOI: 10.3390/genes15111447.

6. Harborne J.B. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. – Springer Science & Business Media, 1998.

7. Fiehn O. Metabolomics—the link between genotypes and phenotypes // Plant Molecular Biology. – 2002. – T. 48, №1-2. – S. 155–171.

8. Shirko T.S., Radyuk A.F. Himicheskij sostav plodov vidov Rosa, vyrashchivaemyh v Belorussii // Rastitel'nye resursy. – 1991. – Vyp. 2. – S. 59–66.

Пайдаланылған әдебиеттер тізімі:

1. Зарубин В.М., Афанасьев Л.И. Flora of Central Asia: Biodiversity and Conservation // Kazakhstan Botanical Journal. – 2018. – Т. 15, №2. – С. 112–130.

2. Doncato K.B. Propagation guide for Salicornia s.l. (Amaranthaceae, Magnoliophyta): A review focused on North American species // Aquaculture. – 2024. – Т. 741. – №741868. – DOI: 10.1016/j.aquaculture.2024.741868.

3. Smith J.R., Olson M.E. Morphological Adaptations of Rosa Species in Mountainous Ecosystems // Journal of Botanical Research. – 2020. – Т. 45, №4. – С. 275–289.

4. Коршунов А.И. Роль биохимических соединений в адаптации растений к стрессу // Ботанический вестник. – 2019. – Т. 5, №3. – С. 85–98.

5. Almerekova S., Yermagambetova M., Ivashchenko A., Abugalieva S. Assessment of complete plastid genome sequences of Tulipa alberti Regel and Tulipa greigii Regel species from Kazakhstan // Genes. – 2024. – Т. 15, №11. – С. 1447. – DOI: 10.3390/genes15111447.

6. Harborne J.B. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. – Springer Science & Business Media, 1998.

7. Fiehn O. Metabolomics—the link between genotypes and phenotypes // Plant Molecular Biology. – 2002. – Т. 48, №1-2. – С. 155–171.

8. Ширко Т.С., Радюк А.Ф. Химический состав плодов видов Rosa, выращиваемых в Белоруссии // Растительные ресурсы. – 1991. – Вып. 2. – С. 59–66.

ҒТАМР 87.03.05 **https://doi.org/10.51889/3005-6217.2025.83.1.012**

*Н.Г.Жиенбаева [1]**

[1]Айплюс білім беру орталығы,
*Алматы қ., Қазақстан, *e-mail:zhnurs02@gmail.com*

АДАМЗАТТЫҢ ӨМІР СҮРУ САПАСЫ – ЗАМАНАУИ ҚОҒАМ КӨРСЕТКІШІ

Аңдатпа

Технология қарыштап дамыған заманауи қоғамда әлемдегі кез келген елдің экономикалық дамуы, ең алдымен, азаматтарының өмір сүру деңгейі және өмір сүру сапасымен анықталады. Халықтың өмір сүру сапасының көрсеткіштері жүргізіліп жатқан реформалардың әлеуметтік-экономикалық әсерін айқындайтын және қоғамдағы әлеуметтік тұрақтылық пен шиеленіс деңгейін бағалайтын негізгі индикаторлар болып саналады. Қазіргі уақытта халықтың өмір сүру сапасын жақсарту қоғамның тұрақты дамуын қамтамасыз етудің басты стратегиялық, әрі күн тәртібіндегі ең көкейкесті бағыттарының бірі болып отыр. Осы мәселелерді ескере отырып, адамзаттың өмір сүру сапасын бағалау, қазіргі заманғы қоғамдағы рөлін сараптау және сапаны жақсартудың тиімді жолдарын ұсыну мақсатында ғылыми-зерттеу жұмысы жүргізілді.

Мақалада адамзаттың өмір сүру сапасын бағалау көрсеткіштері, соның ішінде ЖІӨ, адами даму индексі (HDI), экологиялық тұрақтылық индексі (ESI), өмір сүру ұзақтығы және бақыт индексі негізінде мемлекеттердің даму деңгейлері сараланды. Зерттеу барысында әлемдік деңгейдегі өмір сапасы индексін анықтайтын ұйымдардың бірі Numbeoның