How to Cite: Korganbayeva Z.S., Pernebekova R.K., Kirgizbayeva A.A., Bekmurzaeva E.K. (2026). Phytochemical and Elemental Characterization of *Rheum tataricum*. *Fundamental and Experimental Biology. 2026, 31, 2(122), 42-51.* https://doi.org/10.31489/2026FEB2/42-51

Research article

https://doi.org/10.31489/2026FEB2/42-51

UDC 581.192 Received: 4.11.2025 | Accepted: 18.02.2026 | Published online: 30 June 2026

Z.S. Korganbayeva[1*], R.K. Pernebekova[1, 2], A.A. Kirgizbayeva[3], E.K. Bekmurzaeva[1]

[1]*South Kazakhstan Medical Academy, Shymkent, Kazakhstan;*
[2]*Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan, Kazakhstan;*
[3]*S.D. Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan*
[*]*Corresponding author: zaurekorganbayeva@gmail.com*

Phytochemical and Elemental Characterization of *Rheum tataricum*

This study presents a phytochemical and elemental characterization of *Rheum tataricum* L. collected in the Almaty region of Kazakhstan, aimed at describing its compositional features as a potential source of plant secondary metabolites. Elemental analysis revealed high levels of calcium, magnesium, phosphorus, sulfur, and zinc in the leaves, whereas the stems contained elevated levels of rubidium and comparable amounts of potassium, sodium, and chlorine. Quantitative phytochemical screening demonstrated a generally stable accumulation of major metabolite groups, including anthraquinones, flavonoids, tannins, triterpenoids, and phenolic acids, across vegetative stages, with noticeable seasonal variation observed primarily for carbohydrates and tannins. The stems were characterized by higher contents of tannins and triterpenoids, whereas the leaves accumulated greater amounts of phenolic acids and micronutrients. These organ-specific and stage-dependent patterns reflect ecological adaptation to semi-desert conditions and suggest complex regulation of secondary metabolism in *R. tataricum*. The results highlight the phytochemical richness of this species; however, its biological and pharmacological activities cannot be inferred from the present data and require confirmation through dedicated bioassays.

Keywords: Rheum tataricum, phytochemical analysis, elemental composition, secondary metabolites, Almaty region.

Introduction

The genus *Rheum* (*Polygonaceae*) comprises several species of high ethnopharmacological and practical importance due to their content of bioactive compounds such as anthraquinones, flavonoids, and tannins [1]. Many representatives of the genus are used in traditional medicine as laxative, choleretic, astringent, and antispasmodic agents [2, 3]. In Kazakhstan, *Rheum tataricum* L., commonly known as Tatar rhubarb (*Tüyezhapyraq* in Kazakh), is one of the most prominent and widespread species of this genus [4, 5].

The current state of knowledge on *Rheum* species in Kazakhstan indicates that at least seven of the nine known rhubarbs possess medicinal properties, while *Rheum altaicum* Losinsk. and *Rheum wittrockii* Lundstr. are listed in the Red Book of Kazakhstan as protected species [6, 7]. Experimental introduction studies have been carried out on four native species, *R. compactum (*syn. *R. altaicum), R. maximovichii, R. tataricum,* and *R. wittrockii*, at the Altai and Main Botanical Gardens [5, 7, 8]. Among them, *R. tataricum* has shown good adaptation under local conditions, although flowering and fruiting occur irregularly, and the species exhibits an introduction success index (ISI) of 4 [9].

Morphologically, *R. tataricum* is a perennial herb (ephemeroid) characteristic of desert and semi-desert zones, forming dense stands on saline and gray-brown soils. The plant has a strong upright rhizome covered with brownish-yellow scales and 2-3 grooved, hollow, branched stems reaching 2-3 m in height. The leaves are large (up to 35×50 cm), rounded, heart-shaped at the base, and supported by three prominent veins; their undersides are slightly pubescent [10, 11]. The inflorescence is paniculate-spherical, consisting of small (approximately 3 mm) cream-colored flowers with brown veins. The fruits are triangular or heart-shaped, dark brown to black, with narrow red-brown wings about 1-1.5 mm wide. The species flowers in April-May and produces fruits in May-June [4, 12].

Geographically, *R. tataricum* is distributed across many regions of Kazakhstan, including the Caspian, Bokeev, Aktobe, Torgay, Kyzyl-Orda, Ulytau, Karatau, and Chu-Ili mountain ranges, extending through the Balkhash-Alakol and Kyzylkum areas [4, 13]. The rhizomes and fruit pericarp are rich in tannins, while the fresh leaves are grazed by sheep and camels, giving the plant both ecological and economic importance [9, 10].

In folk medicine, *R. tataricum* has been used in both Eastern and Western traditions for its anti-tumor, febrifuge, and hemostatic properties [14]. However, scientific validation of these pharmacological effects through systematic phytochemical and elemental analysis remains limited. Despite its long-standing traditional use and successful acclimatization, *R. tataricum* remains insufficiently studied with respect to its detailed phytochemical profile and elemental composition [15]. Therefore, this study aims to conduct a botanical, phytochemical, and elemental characterization of *Rheum tataricum* L. (Polygonaceae Juss.) from the Balkhash region of Almaty Province as a basis for further evaluation of its biological activity in future studies.

Experimental

2.1. Study Site and Plant Material

Plant material of *Rheum tataricum* L. was collected in April 2023 in the Balkhash district of Almaty region, Kazakhstan, at an altitude of 381 m above sea level (45°35′28.3″ N, 77°19′55.5″ E). The area is characterized by an arid climate with saline gray-brown soils typical of semi-desert ecosystems. Taxonomic identification of the species was performed using the generic and species keys of the family Polygonaceae for the flora of Kazakhstan. A voucher specimen of *Rheum tataricum* L.fil. is deposited in the Herbarium of the Institute of Botany and Phytointroduction, Almaty (Herbarium AA), voucher No. 2197/25-*Rheum tataricum* L.fil., identified by Zh.Zh. Karzhaubekova and R.B. Arysbayeva and confirmed by N.G. Gemejiyeva.

Plant material was collected from a single natural population within one sampling site. A total of 16 individual plants were sampled to represent four vegetative phases (four plants per phase).

2.2. Preparation of Plant Material

Fresh plant material was separated into stems and leaves. The aerial parts were air-dried in the shade at 25–30 °C with periodic turning until constant weight was achieved, corresponding to a residual moisture content of 10–12 %. The dried material was ground to a fine powder using a stainless-steel mill and stored in airtight containers protected from light and moisture until further analysis.

2.3. Determination of Elemental Composition

The mineral composition of the stems and leaves was determined using atomic absorption spectroscopic (AAS) analysis following ashing at 450 °C. Samples (1 g) were digested in a mixture of HNO:HCl (3:1, v/v) and filtered. Elemental concentrations (Na, K, Mg, Fe, Zn and other elements) were quantified using a PerkinElmer AAnalyst 400 spectrophotometer. Calibration was performed using certified standard solutions. All elemental determinations were performed in triplicate for each plant sample (n = 3). Results were expressed as a percentage of dry weight.

2.4. Phytochemical Screening

Qualitative tests for major groups of biologically active substances, alkaloids, flavonoids, anthraquinones, tannins, coumarins, triterpenoids, polysaccharides, phenolic acids, amino acids, catechins, organic acids, and carbohydrates, were conducted using standard phytochemical procedures [16–18]. The following reactions were applied: Dragendorff's test for alkaloids, Bornträger's reaction for anthraquinones, ferric chloride test for phenolic compounds and tannins, Shinoda reaction for flavonoids, and Molisch test for carbohydrates. Results were expressed qualitatively as "present" or "absent."

2.5. Quantitative Determination of Bioactive Compounds

Quantitative analyses of key phytochemical groups were performed spectrophotometrically using reported procedures [19–22]. Flavonoid content was determined by the aluminum chloride colorimetric method (λ=415 nm) and expressed as milligrams of quercetin equivalents per gram of dry weight (mg QE/g DW). Tannin concentration was measured by the Folin-Denis assay (λ = 760 nm, mg GAE/g DW). Anthraquinones were quantified using the modified Bornträger reaction, while total polysaccharides were determined by the phenol-sulfuric acid method. For ease of comparison across compound classes, quantitative results were subsequently converted and presented as percentage of dry weight. Values obtained from calibration curves (mg equivalents per g DW) were recalculated assuming 1 g of dry plant material per extraction, using the relationship: 1 % DW = 10 mg/g DW. All measurements were performed in triplicate (n = 3) using a Shimadzu UV-1800 UV–Vis spectrophotometer.

2.6. Comparative Analysis by Vegetative Phase

To evaluate the dynamic accumulation of bioactive compounds, analyses were conducted across four vegetative stages: (1) bud formation, (2) flowering, (3) fruiting, and (4) dormancy. For each vegetative phase, samples from four independent individual plants were analyzed (n = 4 per phase). Comparative analysis was carried out separately for stems and leaves.

2.7. Statistical Analysis

All data were expressed as mean ± standard deviation (SD) of at least three replicates. Statistical comparisons among vegetative stages were performed using one-way ANOVA followed by Šidák's multiple comparisons test ($p< 0.05$) in GraphPad Prism 10.0. For two-group comparisons, an unpaired t-test was used ($p < 0.05$).

Results

3.1 Elemental Composition of Rheum tataricum

The elemental analysis of *Rheum tataricum* revealed distinct differences between stems and leaves in mineral composition (Table 1). The total mineral content of stems accounted for approximately 3.0 % of dry weight, while leaves showed a higher accumulation of macro- and microelements. Calcium (Ca) and magnesium (Mg) were the most abundant macronutrients, with significantly higher concentrations in leaves (0.83±0.03 % and 0.55±0.02 %, respectively) compared to stems (0.49±0.02 % and 0.46±0.01 %; $p<0.0001$). Similar trends were observed for phosphorus (P) and sulfur (S), which were also significantly elevated in leaves ($p=0.0004$ and $p<0.0001$, respectively). In contrast, rubidium (Rb) content was higher in stems (0.32±0.02 %) than in leaves (0.11±0.01 %; $p<0.0001$). Potassium (K), sodium (Na), and chlorine (Cl) did not differ significantly between organs ($p=0.7889$). Among trace elements, zinc (Zn) was notably enriched in leaves (0.78±0.04 %), whereas iron (Fe) was undetected in stems but present in leaves (0.21±0.01 %; $p<0.0001$). The relatively high Zn concentration observed in leaves should be interpreted with caution, as it may reflect local soil geochemistry and site-specific environmental conditions rather than species-level hyperaccumulation.

Table 1

Elemental composition of Rheum tataricum stems and leaves (mean±SD, % dry weight)

Element	Stems (%±SD)	Leaves (%±SD)	*p*-value
Calcium (Ca)	0.49±0.02	0.83±0.03	<0.0001
Potassium (K)	0.40±0.01	0.38±0.01	0.7889
Sodium (Na)	0.29±0.01	0.31±0.01	0.7889
Magnesium (Mg)	0.46±0.01	0.55±0.02	<0.0001
Phosphorus (P)	0.17±0.01	0.23±0.01	0.0004
Sulfur (S)	0.24±0.01	0.35±0.01	<0.0001
Chlorine (Cl)	0.40±0.01	0.38±0.01	0.7889
Silicon (Si)	0.18±0.01	0.29±0.02	<0.0001
Rubidium (Rb)	0.32±0.02	0.11±0.01	<0.0001
Iron (Fe)	ND	0.21±0.01	<0.0001
Zinc (Zn)	0.07±0.01	0.78±0.04	<0.0001

Note. Values are expressed as mean±SD (n=3). ND = not detected. Statistical significance was determined using an unpaired t-test.

Overall, leaves exhibited a greater accumulation of essential elements, reflecting their active metabolic role, while stems contained relatively higher levels of Rb and comparable concentrations of K, Na, and Cl.

3.2. Dynamics of Biologically Active Compounds in the Stem of Rheum tataricum during Vegetative Phases

The quantitative composition of the main groups of biologically active substances in stem of *Rheum tataricum* varied slightly across vegetative phases (Table 2). Carbohydrates dominated the extractive fraction throughout all growth stages, accounting for approximately 20–22 % of the dry weight, followed by tannins (2–4 %), triterpenoids (4-5 %), and anthraquinones (3-4 %). Minor constituents included amino acids (1-2 %), flavonoids (2-3 %), polysaccharides (1-2 %), and trace levels of alkaloids, catechins, and organic acids (<1 %).

Table 2

Quantitative composition of the main groups of biologically active substances in stem of Rheum tataricum during different vegetative phases (mean±SD, % of dry weight)

Bioactive compound group	Budding period (mean±SD)	Flowering period (mean±SD)	Fruiting period (mean±SD)	Dormant period (mean±SD)
Alkaloids	0.38±0.03	0.41±0.04	0.42±0.03	0.44±0.02
Amino acids	2.03±0.10	1.88±0.09	1.81±0.09	1.69±0.08
Anthraquinones	3.82±0.19	3.91±0.20	3.97±0.20	4.08±0.21
Tannins	4.26±0.21	3.93±0.20	3.68±0.18	2.11±0.11
Catechins	0.29±0.02	0.28±0.02	0.28±0.02	0.26±0.02
Coumarins	1.14±0.06	0.96±0.05	0.91±0.05	0.83±0.04
Organic acids	0.18±0.01	0.16±0.01	0.15±0.01	0.13±0.01
Polysaccharides	1.72±0.09	1.83±0.09	1.94±0.11	2.11±0.10
Triterpenoids	4.16±0.21	4.39±0.22	4.52±0.23	4.73±0.24
Carbohydrates	20.82±1.14	21.14±1.06	21.30±1.27	21.75±1.09
Phenolic acids	0.32±0.02	0.28±0.02	0.28±0.02	0.26±0.02
Flavonoids	2.49±0.12	2.32±0.12	2.27±0.11	2.20±0.11

Note. Values are presented as mean±SD (n = 4). Statistical significance was evaluated using Šídák's multiple comparisons test.

Statistical analysis using Šídák's multiple comparisons test confirmed significant variation in several compound groups among developmental stages (p<0.05). A decrease in tannin content was observed in dormant period (2.11±0.11 %; p< 0.0001) compared to the budding phase (4.26±0.21 %), while intermediate values were recorded during flowering (3.93±0.20 %) and fruiting (3.68±0.18 %). Similarly, carbohydrates showed a modest but statistically significant decrease from the dormant (21.75±1.09 %) period to the budding (20.82±1.14 %) phase, comparing to the (p = 0.0173).

Other compound classes, including alkaloids, amino acids, anthraquinones, catechins, coumarins, organic acids, polysaccharides, triterpenoids, phenolic acids, and flavonoids, exhibited no statistically significant fluctuations across vegetative phases (p>0.05).

Overall, the phytochemical profile of stem of *R. tataricum* remained relatively stable throughout the growing cycle, with the highest variability observed in the concentrations of tannins and carbohydrates, reflecting potential shifts in metabolic allocation during active and dormant stages.

3.3. Dynamics of Biologically Active Compounds in the Leaves of Rheum tataricum during Vegetative Phases

The quantitative composition of the main groups of biologically active substances in the leaves of *Rheum tataricum* varied minimally across vegetative phases (Table 3). Carbohydrates remained the predominant component throughout all stages, accounting for approximately 17-18 % of dry weight, followed by tannins (3-4 %), triterpenoids (3-4 %), and anthraquinones (3-4 %). Minor components included amino acids (1-2 %), flavonoids (1-2 %), and polysaccharides (1-2 %), whereas alkaloids, catechins, coumarins, organic acids, and phenolic acids were present in trace amounts (<1 %).

Table 3

Quantitative composition of the main groups of biologically active substances in leaves of Rheum tataricum during different vegetative phases (mean±SD, % of dry weight)

Bioactive compound group	Budding period (mean±SD)	Flowering period (mean±SD)	Fruiting period (mean±SD)	Dormant period (mean±SD)
Alkaloids	0.43±0.03	0.41±0.03	0.39±0.02	0.34±0.02
Amino acids	1.70±0.09	1.63±0.08	1.55±0.08	1.42±0.07
Anthraquinones	3.23±0.16	3.35±0.17	3.46±0.18	3.62±0.18
Tannins	3.82±0.19	3.74±0.18	3.55±0.17	3.38±0.16
Catechins	0.98±0.05	0.93±0.05	0.87±0.04	0.75±0.04
Coumarins	1.08±0.05	1.03±0.05	0.99±0.05	0.94±0.05
Organic acids	0.24±0.02	0.22±0.02	0.21±0.02	0.19±0.02
Polysaccharides	1.39±0.07	1.45±0.07	1.58±0.08	1.74±0.08
Triterpenoids	3.25±0.16	3.42±0.17	3.57±0.18	3.69±0.18
Carbohydrates	17.11±0.85	17.32±0.87	17.68±0.88	18.02±0.90
Phenolic acids	0.42±0.03	0.45±0.03	0.46±0.03	0.49±0.03
Flavonoids	2.01±0.10	1.88±0.09	1.76±0.09	1.63±0.08

Note. Values are presented as mean±SD (n = 4). Statistical significance was evaluated using Šídák's multiple comparisons test.

Statistical analysis using Šídák's multiple comparisons test confirmed that carbohydrate content exhibited significant variation among the vegetative phases (p=0.0004 and p=0.0265). Specifically, a notable decrease was observed from the dormant to the budding stage (from 18.02 ± 0.90 % to 17.11 ± 0.85 %). However, differences between intermediate stages (flowering and fruiting) were not statistically significant (p>0.05).

All other compound classes, including alkaloids, amino acids, anthraquinones, tannins, catechins, coumarins, organic acids, polysaccharides, triterpenoids, phenolic acids, and flavonoids, showed no statistically significant differences ($p > 0.05$) across vegetative phases, indicating overall biochemical stability in leaf composition.

Overall, the phytochemical profile of the leaves of *R. tataricum* remained relatively stable throughout the growing cycle, with minor fluctuations primarily observed in carbohydrate content. This stability suggests that the leaf metabolic composition is largely conserved across vegetative phases, with only slight adjustments in primary metabolite levels during seasonal transitions.

3.4 Comparative Analysis of Stems and Leaves

To better illustrate organ-specific accumulation patterns, the content of the main classes of biologically active substances in the stems and leaves of *Rheum tataricum* was compared across all vegetative stages (Fig. 1). Both organs exhibited a similar qualitative composition dominated by carbohydrates, tannins, triterpenoids, and anthraquinones, yet their quantitative ratios differed significantly.

At all growth phases, stems accumulated higher levels of tannins and triterpenoids (p< 0.05), confirming their role as major storage tissues for secondary metabolites. Conversely, leaves contained significantly higher levels of phenolic acids during each developmental period (p < 0.0001), likely reflecting their active participation in photosynthesis-associated oxidative processes and stress responses. Minor but consistent differences were also detected for catechins and carbohydrates in some phases (p = 0.015–0.0363).

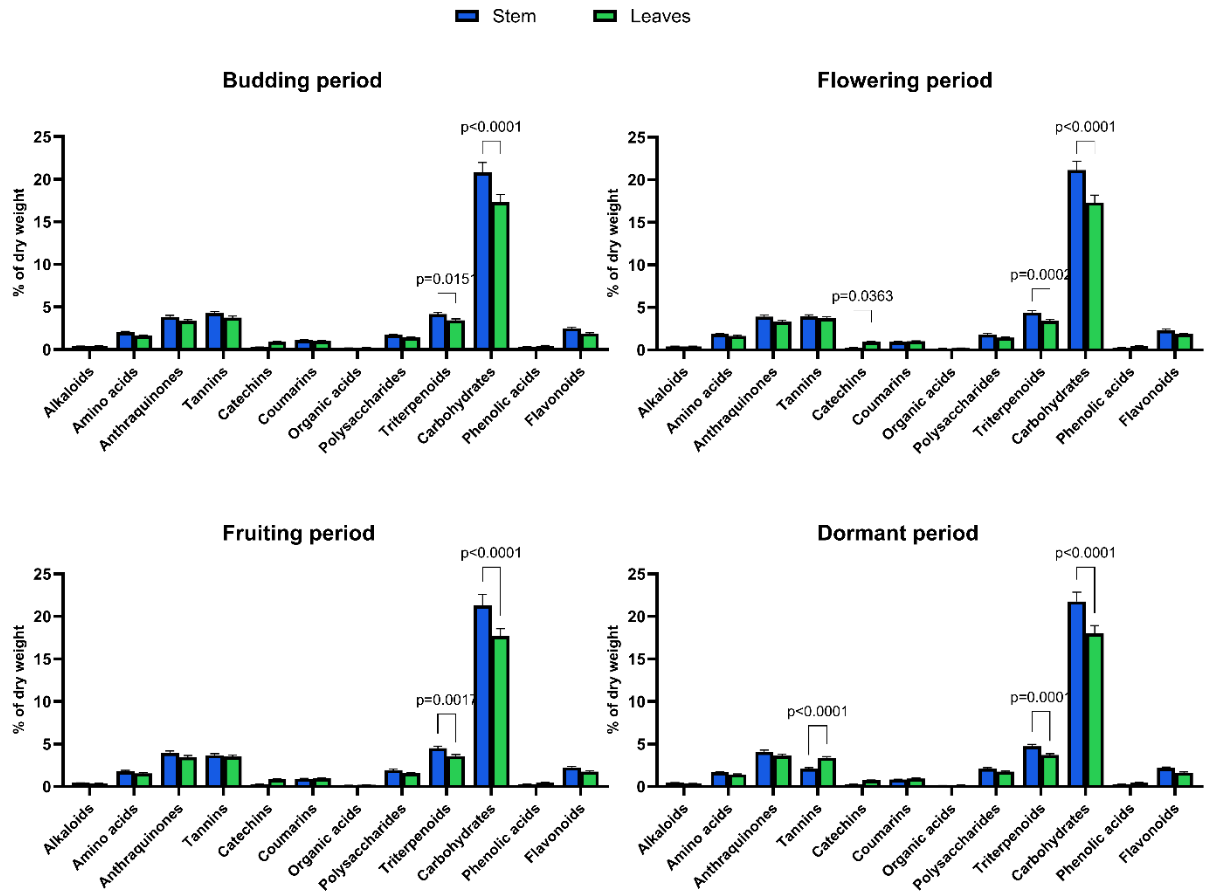

Figure 1. Comparative content of major groups of biologically active compounds in stems and leaves of Rheum tataricum during the budding, flowering, fruiting, and dormant periods

Data represent mean ± SD (n=4). Significant differences between plant organs within each phase were determined using Šídák's multiple comparisons test ($p< 0.05$).

Overall, while the qualitative composition remained stable, the quantitative distribution of metabolites demonstrated clear tissue-specific specialization. Stems primarily served as reservoirs of condensed phenolic compounds, whereas leaves maintained higher proportions of readily oxidized phenolics and primary metabolites.

Discussion

This study delivers an organ- and stage-resolved profile of *Rheum tataricum* under semi-desert conditions, showing leaves enriched in Ca, Mg, P, S and Zn relative to stems, while stems retain more Rb and similar K/Na/Cl, and most phytochemical classes remain stable across the season except for tannins and carbohydrates. These patterns align with prior ecological work showing *Rheum tataricum* efficient mineral translocation and stress adaptation in arid habitats, including high foliar accumulation of several macro-/microelements and evidence of element hyperaccumulation under semi-desert soils [10]. Together, these findings suggest functional differentiation between organs, with leaves acting as metabolically active tissues and stems serving as storage compartments for condensed phenolic compounds.

Our leaf-dominant Ca/Mg/Zn profile concurs with Golubkina et al. (2022), who reported higher Mn/Fe/Co/B and other trace elements in wild *Rheum tataricum* and discussed soil-to-plant transfer influencing antioxidant status [10]. Moreover, similar mineral enrichment in leaves has been observed in *R. officinale* [23] and in rhubarb stalks/leaves more broadly [24], supporting the idea that leaf tissues of the *Rheum* genus preferentially accumulate these macro- and micro-elements as part of their adaptive and antioxidant metabolism. Environmental control over *Rheum* secondary metabolism is also emphasized in a review on the rhubarb value chain, noting climate/soil/altitude effects on anthraquinones, coumarins and stilbenes, consistent with our site-specific findings [25]. This study assessed only macro- and microelements

(Ca, K, Na, Mg, P, S, Cl, Si, Rb, Fe and Zn). Although elevated Zn levels were detected in leaf tissues, the present study does not aim to classify *R. tataricum* as a Zn hyperaccumulator. Such interpretation would require targeted soil–plant transfer analyses, larger population sampling, and controlled comparisons, which were beyond the scope of this work. Toxic heavy metals (Pb, Cd, As and Hg) were not determined and should be addressed in future studies prior to pharmaceutical application.

Across stages, carbohydrates and tannins showed the clearest shifts, while anthraquinones, flavonoids, amino acids and most minor classes were largely constant. This metabolic stability mirrors reports that *Rheum* maintains a robust phenolic/anthraquinone baseline across environments, with quantitative differences driven more by extraction and processing than by growth stage alone. Recent LC–MS/MS work on *Rheum tataricum* roots quantified 53 phytochemicals and demonstrated that supercritical CO_2, subcritical ethanol and ultrasound extractions markedly shift yields and bioactivity profiles, an important methodological caveat when comparing studies [9].

Our stem-greater tannins/triterpenoids and leaf-greater phenolic acids suggest tissue specialization: stems as reservoirs of astringent/antimicrobial phenolics and leaves as sites of redox-active phenolic acids. Such distributions are relevant from a phytochemical perspective, as the Rheum genus is known to contain anthraquinones (e.g., emodin, chrysophanol, rhein) and polyphenolic compounds that have been associated with various biological activities in previous studies. Current reviews summarize a broad range of biological activities that have been reported for anthraquinones and related compounds isolated from various *Rheum* species, including discussions of underlying molecular pathways and metabolism-related effects [26, 27]. In parallel, compound-level data for *R. tataricum* continue to expand. For example, a study from Kazakhstan reported the isolation of several metabolites from *R. tataricum* (e.g., stilbenes, phenylbutanoids, gallotannin) and evaluated their cytotoxic effects using in vitro cell line models [12]. Another review provides a comprehensive overview of anthraquinones, stilbenes, and related compound classes across the Rheum genus, highlighting their structural diversity and biological relevance in systems biology studies [28]. However, it should be emphasized that such findings originate from independent investigations employing targeted bioassays and purified compounds and cannot be directly extrapolated to the compositional data presented in the present study.

Strengths include standardized qualitative/quantitative assays and phase-matched organ comparisons. Limitations include single-region sampling and spectrophotometric class-level quantification rather than targeted LC–MS per class in all organs/stages. Future work should: (i) couple our design with targeted metabolomics (anthraquinones, triterpenoids, tannins) and bioassays; (ii) benchmark extraction-method effects explicitly (supercritical vs. hydroalcoholic) given their strong impact on yields and antibacterial/antioxidant readouts; and (iii) integrate safety/toxicity profiling, since dose-dependent adverse effects are reported for crude *Rheum* extracts and for rhein at higher exposures despite favorable therapeutic signals. Moreover, future studies should include parallel soil elemental analysis and expanded sampling to clarify the mechanisms underlying elevated Zn accumulation and to exclude site-specific effects.

Collectively, the results of this study characterize *Rheum tataricum* as a species with a diverse and stable phytochemical composition. The consistent presence of anthraquinones, triterpenoids, tannins, and phenolic acids across vegetative stages reflects a sustained capacity for secondary metabolite biosynthesis, while organ-specific accumulation patterns highlight pronounced chemical differentiation between stems and leaves. The enrichment of essential elements such as Ca, Mg, and Zn further contributes to understanding the metabolic and ecological features of this species under semi-desert conditions. Taken together, these compositional characteristics, along with the ecological adaptability and availability of *R. tataricum* in Kazakhstan, provide a descriptive basis for future investigations integrating targeted metabolomics, bioassays, and safety assessment to evaluate potential applied uses.

Conclusion

Rheum tataricum demonstrates stable biosynthesis of key secondary metabolites and a pronounced accumulation of essential elements, reflecting its adaptation to semi-desert environments. The consistent presence of anthraquinones, tannins, triterpenoids, and phenolic acids indicates that this species is characterized by a rich and diverse phytochemical composition. However, the present study is limited to elemental and phytochemical characterization, and no conclusions regarding biological or pharmacological activity can be drawn. Evaluation of antioxidant, anti-inflammatory, anticancer, or other bioactivities requires dedicated bioassays and should be addressed in future studies.

Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript. CRediT: **Korganbayeva Z.S.** — conceptualization, methodology, investigation, data curation, writing — original draft; **Pernebekova R.K.** — formal analysis, validation, investigation, writing — original draft, writing — review & editing; **Kirgizbayeva A.A.** — investigation, resources, visualization, data curation, writing — review & editing; **Bekmurzaeva E.K.** — supervision, project administration, writing — review & editing. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

References

1 Yang, X., Li, Y., Zhang, L., Wang, J., & Chen, H. (2024). The phytochemistry and pharmacology of three *Rheum* species: A comprehensive review with future perspectives. *Phytomedicine, 131*, 155772. doi:10.1016/j.phymed.2024.155772

2 Kolodziejczyk-Czepas, J., & Liudvytska, O. (2021). *Rheum rhaponticum* and *Rheum rhabarbarum*: A review of phytochemistry, biological activities and therapeutic potential. *Phytochemistry Reviews, 20*(3), 589–607. doi:10.1007/s11101-020-09715-3

3 Tabin, S., Gupta, R., Kamili, A., & Parray, J. (2022). Medical and medicinal importance of *Rheum* spp. collected from different altitudes of the Kashmir Himalayan range. *Cellular and Molecular Biomedical Reports, 2*(3), 187–201. doi:10.55705/cmbr.2022.349901.1050

4 Salmukhanbetova, Z., & Dimeyeva, L. (2025). Phytocenotic and resource characteristics of *Rheum tataricum L*. f. in the Northern Aral region. *Fundamental and Experimental Biology, 11830*(2), 34–43. doi:10.31489/2025feb2/34-43

5 Aitzhan, M., Aimenova, Z., & Sumbembayev, A. (2024). Studying the species distribution of rhubarbs (*Rheum* L.) in Kazakhstan. *BIO Web of Conferences, 100*, 04034. doi:10.1051/bioconf/202410004034

6 Sumbembayev, A. A., Lagus, O. A., & Nowak, S. (2023). Seed morphometry of *Rheum* L. (Polygonaceae) species from Kazakhstan and its implications in taxonomy and species identification. *Biodiversitas: Journal of Biological Diversity, 24*(9). doi:10.13057/biodiv/d240908

7 Dagarova, S. (2025). Research the seed surface of *Rheum wittrockii* Lundstr. from the flora of Kazakhstan. *Discover Plants, 2*(1), 299. doi:10.1007/s44372-025-00383-1

8 Sitpayeva, G. T., Otradnykh, I. G., & Syedina, I. A. (2021). Collection of rare plant species of Kazakhstan in the conditions of the botanical garden of Almaty. *Problems of Botany of Southern Siberia and Mongolia, 20*(1), 404–408. doi:10.14258/pbssm.2021081

9 Amangeldinova, M., et al. (2024). Simultaneous quantitative screening of 53 phytochemicals from *Rheum tataricum* L. roots: A comparative study of supercritical CO_2, subcritical ethanol, and ultrasound-assisted extraction for enhanced antioxidant and antibacterial activities, and molecular docking study. *Frontiers in Plant Science, 15*, 1513875. doi:10.3389/fpls.2024.1513875

10 Golubkina, N., et al. (2022). Biochemical characteristics and elemental composition peculiarities of *Rheum tataricum* L. in semi-desert conditions and of European garden rhubarb. *International Journal of Plant Biology, 13*(3), 368–380. doi:10.3390/ijpb13030031

11 Terletskaya, N., et al. (2024). Comparative analysis of the anatomical and morphological features of *Rheum tataricum* L. plants from different ecopopulations. *Eurasian Journal of Ecology, 79*(2), 127–134. doi:10.26577/EJE.2024.v79.i2-012

12 Turgunbayeva, A. A., et al. (2025). Isolation and identification of secondary metabolites in *Rheum tataricum* L.fil. growing in Kazakhstan and surveying of its anticancer potential. *Molecules, 30*(14), 2978. doi:10.3390/molecules30142978

13 Sagyndykova, M. S., Imanbayeva, A. A., Lukmanov, A. B., & Gassanova, G. G. (2021). Resources of Rheum tataricum on the territory of Atyrau region. *Bulletin of Karaganda University. Biology, Medicine and Geography Series, 103*(3), 119–124. doi:10.31489/2021bmg3/119-124

14 Khaja, U. M., Chopra, C., Sehgal, A., Singh, R., & Ganie, S. A. (2025). Unveiling the cancer-fighting potential of Rheum species (rhubarb): Phytochemistry, ethnopharmacology, and mechanistic insights into the anticancer effects of key anthraquinones. *Phytomedicine Plus, 5*(3), 100831. doi:10.1016/j.phyplu.2025.100831

15 Minkayeva, A. A., et al. (2025). Comparative investigation of Rheum tataricum and Rheum palmatum. *International Journal of Biology and Chemistry, 18*(1). doi:10.26577/IJBCh202518113

16 Singh, P. K., Singh, J., Medhi, T., & Kumar, A. (2022). Phytochemical screening, quantification, FT-IR analysis, and in silico characterization of potential bio-active compounds identified in HR-LC/MS analysis of the polyherbal formulation from Northeast India. ACS *Omega, 7*(37), 33067–33078. doi:10.1021/acsomega.2c03117

17 Nortjie, E., Basitere, M., Moyo, D., & Nyamukamba, P. (2022). Extraction methods, quantitative and qualitative phytochemical screening of medicinal plants for antimicrobial textiles: A review. *Plants, 11*(15), 2011. doi:10.3390/plants11152011

18 Youl, O., et al. (2023). Phytochemical screening, polyphenol and flavonoid contents, and antioxidant and antimicrobial activities of Opilia amentacea Roxb. (Opiliaceae) extracts. *Applied Biosciences, 2*(3), 493–512. doi:10.3390/applbiosci2030031

19 Das, B., Saha, P., & Maity, N. (2023). Quantitative estimation of quercetin of some selected edible plants of West Bengal by high-performance thin-layer chromatography densitometry method. *Asian Journal of Pharmaceutical Research and Health Care, 15*(3), 254–261. doi:10.4103/ajprhc.ajprhc_70_23

20 Sarr, A., et al. (2022). Role of condensed tannins in the antioxidant activity of seeds of Cola nitida (Vent.) Schott & Endl. (Malvaceae). *European Journal of Medicinal Plants*, 26–33. doi:10.9734/ejmp/2022/v33i121111

21 Yue, F., Zhang, J., Xu, J., Niu, T., Lü, X., & Liu, M. (2022). Effects of monosaccharide composition on quantitative analysis of total sugar content by phenol-sulfuric acid method. *Frontiers in Nutrition, 9*, 963318. doi:10.3389/fnut.2022.963318

22 Godlewska, K., Pacyga, P., Najda, A., & Michalak, I. (2023). Investigation of chemical constituents and antioxidant activity of biologically active plant-derived natural products. *Molecules, 28*(14), 5572. doi:10.3390/molecules28145572

23 Dai, L., et al. (2024). Changes in the nutrients, phytochemical profile and antioxidant activity of Rheum officinale Baill. leaf blades during different growth periods. *Frontiers in Nutrition, 11*, 1387947. doi:10.3389/fnut.2024.1387947

24 Korus, A., & Korus, J. (2024). Enhancing nutritional value of rhubarb (Rheum rhaponticum L.) products: The role of fruit and vegetable pomace. *Agriculture, 14*(10), 1784. doi:10.3390/agriculture14101784

25 Zou, J., Wu, W., Wang, F., & Hou, K. (2024). The foundation of the rhubarb industry economy: Investigating metabolite disparities of rhubarb between varieties and growing environments on the Tibetan Plateau. *Frontiers in Pharmacology, 15*, 1461523. doi:10.3389/fphar.2024.1461523

26 Deng, T., et al. (2023). Rhein for treating diabetes mellitus: A pharmacological and mechanistic overview. *Frontiers in Pharmacology, 13*, 1106260. doi:10.3389/fphar.2022.1106260

27 Zhao, L., & Zheng, L. (2023). A review on bioactive anthraquinone and derivatives as the regulators for ROS. *Molecules, 28*(24), 8139. doi:10.3390/molecules28248139

28 Miao, H., Wang, K. -E., Li, P., & Zhao, Y. -Y. (2025). Rhubarb: Traditional uses, phytochemistry, multiomics-based novel pharmacological and toxicological mechanisms. *Drug Design, Development and Therapy, 19*, 9457–9480. doi:10.2147/DDDT.S557114

З.С. Қорғанбаева, Р.К. Пернебекова, А.А. Киргизбаева, Э.К. Бекмурзаева

***Rheum tataricum* фитохимиялық және элементтік сипаттамасы**

Мақалада Қазақстанның Алматы облысында жиналған *Rheum tataricum L.* фитохимиялық және элементтік, сонымен қатар оның құрамдас құрамын қайталама метаболиттердің әлеуетті көзі ретінде сипаттау мақсатында зерттеу ұсынылған. Элементтік талдау жапырақтарда кальций, магний, фосфор, күкірт және мырыштың жоғары деңгейде жинақталуын анықтады, ал сабақтарда рубидий мөлшерінің жоғарырақ болуы және калий, натрий мен хлордың салыстырмалы деңгейлері байқалды. Сандық фитохимиялық скрининг вегетациялық кезеңдерде антрахинондар, флавоноидтар, таниндер, тритерпеноидтар және фенол қышқылдарын қоса алғанда, метаболиттердің негізгі топтарының жалпы тұрақты жинақталуын көрсетті, негізінен көмірсулар мен таниндер үшін маусымдық өзгергіштік байқалды. Сабақтар таниндер мен тритерпеноидтардың жоғары мөлшерімен сипатталса, жапырақтарда фенол қышқылдары мен микроэлементтердің жинақталуы басым болды. Анықталған органға тән және кезеңге тәуелді заңдылықтар жартылай шөлейт экожүйелер жағдайына экологиялық бейімделуді көрсетеді және *R. tataricum* өсімдігіндегі екіншілік метаболизмнің күрделі реттелуін айқындайды. Алынған нәтижелер бұл түрдің фитохимиялық байлығын көрсеткенімен, оның биологиялық және фармакологиялық белсенділігін осы деректер негізінде бағалау мүмкін емес және оны растау үшін арнайы биологиялық сынақтар жүргізу қажет.

Кілт сөздер: Rheum tataricum, фитохимиялық талдау, элементтік құрам, екіншілік метаболиттер, Алматы облысы.

З.С. Қорғанбаева, Р.К. Пернебекова, А.А. Киргизбаева, Э.К. Бекмурзаева

Фитохимическая и элементная характеристика *Rheum tataricum*

В настоящем исследовании представлена фитохимическая и элементная характеристика *Rheum tataricum* L., собранного в Алматинской области Казахстана, с целью описания его компонентного состава как потенциального источника вторичных метаболитов. Элементный анализ выявил высокое содержание кальция, магния, фосфора, серы и цинка в листьях, тогда как стебли характеризовались более высоким содержанием рубидия и сопоставимыми уровнями калия, натрия и хлора. Количественный фитохимический скрининг показал в целом стабильное накопление основных групп метаболитов, включая антрахиноны, флавоноиды, танины, тритерпеноиды и фенольные кислоты, на протяжении вегетационных стадий, при этом заметная сезонная вариабельность наблюдалась преимущественно для углеводов и танинов. Стебли отличались более высоким содержанием танинов и тритерпеноидов, тогда как листья накапливали повышенные уровни фенольных кислот и микроэлементов. Выявленные органоспецифические и фазозависимые закономерности отражают экологическую адаптацию к условиям полупустынных экосистем и указывают на сложную регуляцию вторичного метаболизма у *R. tataricum*. Полученные результаты свидетельствуют о фитохимическом богатстве данного вида; однако его биологическая и фармакологическая активность не может быть оценена на основании представленных данных и требует подтверждения в специализированных биологических тестах.

Ключевые слова: Rheum tataricum, фитохимический анализ, элементный состав, вторичные метаболиты, Алматинская область.

Information about the authors

Korganbayeva Zaure Sarybaevna — Acting Associate Professor, Department of Pharmacology, Pharmacotherapy and Clinical Pharmacology, South Kazakhstan Medical Academy, Shymkent, Kazakhstan; e-mail: zaurekorganbayeva@gmail.com; ORCID: 0009-0000-0160-4461

Pernebekova Rakhat Karimbekovna — Candidate of Biological Sciences, Associate Professor, Department of Pharmacology, Pharmacotherapy and Clinical Pharmacology, South Kazakhstan Medical Academy, Shymkent, Kazakhstan; Department of General Medical Practice Department, Faculty of Medical Postgraduate Education, Khoja Akhmet Yassawi International Kazakh-Turkish University, Turkestan, Kazakhstan; e-mail: rakhat_71@mail.ru; ORCID: 0000-0002-9652-1729

Kirgizbayeva Aray Askanbayevna — Candidate of Biological Sciences, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan; e-mail: kirgizbaeva.a@kaznmu.kz; ORCID: 0009-0003-5034-4442

Bekmurzaeva Elmira Kuanyshovna — Doctor of Medical Sciences, Professor, Head of the Department of Propaedeutics of Internal Diseases, South Kazakhstan Medical Academy, Shymkent, Kazakhstan; e-mail: Elmira-bek@mail.ru; ORCID: 0009-0001-2539-3862