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ECOLOGICAL AND PHYTOCHEMICAL COMPOSITION OF *GNAPHALIUM KASACHSTANICUM* KIRP. & KUPRIAN

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SUMMARY

This study focuses on the medicinal plant *Gnaphalium kasachstanicum* and investigation of its ecology and habitat, phytochemical composition, and medicinal values. *G. kasachstanicum* was prevalent in the Tarbagatai Mountains, characterized by a diverse flora and a continental climate. The plant's anatomical features include woolly leaves and small flowers and roots, with distinct epidermal and mesophyll tissue structures. The study also involved collection and analyzing the plant samples of *G. kasachstanicum* from the Southeastern Region of Kazakhstan using hydrodistillation and gas chromatography-mass spectrometry (GC-MS). The GC-MS analysis revealed a complex composition of 68 compounds, including sterols, carboxylic acids, esters, aldehydes, terpenes, glycosides, phenols, and ketones, with notable concentrations of stigmasta-3,5-diene, undec-10-ynoic acid, and tetradecyl ester. The identified vitamins B1, B3, and B6 had higher content, along with a considerable level of polyphenol content, including antioxidant and anti-inflammatory properties, indicating potential health benefits. The toxic element lead (Pb), also detected, highlights the need for its careful usage. The comprehensive exploration underscores the *G. kasachstanicum*'s potential as a source of bioactive compounds with medicinal values. The promising outcomes highlight the conservation strategies to safeguard its natural habitats, potential applications in medicine and allied fields, and importance of its further investigations.

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Keywords: *G. kasachstanicum***,** diverse flora, plant extracts, chemical composition, anatomical features, pharmacological properties, medicinal potential

Key findings: The noteworthy findings emphasize the need of future research on *G. kasachstanicum* for its conservation and protection of its natural habitats, and the possibility of using the said species in various medicines.

INTRODUCTION

The genus *Gnaphalium* (locally called Kazakh Aqshair) is popular for its high medicinal values (Wang *et al*., 2024). Said plant belongs to the family Asteraceae and is prevalent in various regions worldwide, typically in temperate and subtropical climates. However, the six identified species in Kazakhstan grow in steppes, sandy areas, and foothills of small mountains (Ashirova *et al*., 2021). *Gnaphalium* species are familiar for their woolly leaves and often small and inconspicuous flowers. Some species belong to the same genus have historically served in traditional medicines for the treatment of various diseases, including pain relief, anti-inflammatory, and digestive aid (Ticona *et al*., 2022).

Gnaphalium species, such as, *Gnaphalium polycephalum,* used by herbalists and traditional medicine practitioners, are due to their analgesic (pain-relieving) properties. It has been applicable in various forms, such as, tea and extracts, to alleviate pain, particularly related to conditions like rheumatism, arthritis, and neuralgia. *G. affine* species extract has anti-inflammatory properties, which can reduce inflammation and could potentially help in conditions like arthritis and other inflammatory disorders (Zheng *et al*., 2021). *G. uliginosum* has also aided digestion, addressing the issues of indigestion, bloating, and gastrointestinal discomfort (Davydova *et al*., 2024).

G. luteoalbum acts as a diuretic, promoting urine production, and potentially aiding in conditions where increased urine flow is desirable, such as, mild edema. Past studies indicated Gnaphalium plants possess unique compounds with antioxidant properties (Uddin *et al*., 2017). *G. kasachstanicum* is one of the important endemic medicinal species, which has the common name of Kazakh cudweed or Kazakh white rabbit (Kazakhstani aqshair). The said plant is distinct with its silvery leaves covered in fine hairs with small clustered yellow flowers.

In Kazakh traditional medicines, *G. kasachstanicum* has been serving as a remedy for various ailments, including respiratory infections, coughs, and skin problems. It is also a recognized plant for anti-inflammatory and analgesic properties, believed to have immunostimulatory effects. This study investigates the antioxidant and membrane-stabilizing properties of *G. kasachstanicum* extract alone and in combination with black and green tea. Total polyphenol content ranged from 183 ± 9.4 to 312.4 ± 22.3 μg GAE/mg, indicating a considerable concentration of polyphenolic compounds in *G. kasachstanicum*. The measured total flavonoid content reached 284.2 ± 38.3 μg RE/mg, further emphasizing its antioxidant potential (Ydyrys *et al*., 2024).

The half-maximal inhibitory concentration (IC50) for lipid peroxidation inhibition was 9.7 ± 3.2 μg/mg protein, suggesting robust antioxidant activity. *G. kasachstanicum* extract demonstrated dose-dependent reduction of erythrocyte hemolysis in vitro, albeit with moderate effect. Its combinations with black and green tea exhibited enhanced membrane-stabilizing properties, potentially due to synergistic effects. However, the individual *G. kasachstanicum* extract showed varying IC50 values, indicating diverse membrane-stabilizing effects. These past findings highlighted the antioxidant and membrane-protective qualities of *G. kasachstanicum* extract and its potential synergistic interaction with tea extracts (Ydyrys *et al*., 2024). The presented study aimed to investigate the comprehensive exploration of the habitat, phytochemical composition, and medicinal potential of *G. kasachstanicum*.

MATERIALS AND METHODS

Habitat determination

Before conducting the research, its purpose and scope of the survey comprised the collection of hard-cartographic material, the boundaries of the territory where to conduct the survey, and the information on the study object (topography, vegetation cover, and climate). Features of phytocenotic and ecological distribution of medicinal plants determination depended on their main parameters. The scrutiny of natural conditions of phytocenoses in the plant community also ensued. During the expedition, the collection, and identification of a herbarium of plant transpired (Schroeter, 1985).

Anatomical structure determination

For anatomical structure determination, applying the FAA fixative solution (5 mL of formaldehyde, 5 mL of glacial acetic acid, and 90 mL of 50% ethanol) helped fix the leaves, ground the stems, and roots by immersing them in the fixing solution. Afterward, embedding the samples in paraffin wax continued at the Department of Biodiversity and Bioresources, Al-Farabi Kazakh National University, Almaty, Kazakhstan. Sections stained with saffron-fixed green bore cutting into slices and observed in cross-section with a microscope, and then, photographed using OLYMPUS cellSens Standard software (V4.1.1) (Akhmetova *et al*., 2015).

Plant material

The aerial parts of *G. kasachstanicum,* collected in 2022 in the southeastern region of Kazakhstan (Districts Sarkan and Urzhar), underwent drying as per standard drying of the medicinal plants, before using for the investigation. Plant material identified by Dr. Alibek Ydyrys and Raushan Kaparbay as specimens (*G. kasachstanicum*—No. 2-330) proceeded to deposit in the Biomedical Research Centre, Al-Farabi Kazakh National University, Almaty, Kazakhstan.

Plant extract preparation

Using distilled water (≈100 g), the chopped fresh samples (50 g) reached pulverization in a Waring blender and incurred hydrodistillation for three hours, following the standard procedure outlined in the European Pharmacopoeia (2020) (Leong *et al*., 2020). A well-accepted technique for extracting volatile chemicals is hydrodistillation; however, the identification of these compounds is provisional and needs more confirmation using further analytical standards. By combining peak regions found in the gas chromatography analysis, main chemicals' quantification occurred. Verifying the dependability of the results and for robustness repeated each analysis three times. In preparing the GC and GC-MS analyses, drying the essential oils (EOs) over anhydrous sodium sulfate continued, keeping sealed vials under N_2 at − 20 °C. The samples produced 0.04% of EO (w/w).

GC-MS analysis

Gas chromatography with mass spectrometric detection (7890A/5975C) application evaluated the samples. Without flow splitting, the sample injection temperature was set at 250 °C and the sample volume was 0.5 µL. The use of a DB-WAXetr chromatography capillary column of 30 m in length, 0.25 mm in internal diameter, and 0.25 µm in film thickness helped the separation process, with a constant 1 mL/min carrier gas (helium) flow rate. The set temperature for chromatography should rise from 40 °C to 260 °C over a 5-min holding period at a 5 °C per minute rate, with 49 min spent on the analysis. Employing the SCAN mode m/z 34–850 aided the detection.

Data collection progressed by recording and processing the results of the gas chromatography equipment using the HP-ChemStation software (now, Agilent Technologies, Santa Clara, CA, USA). Determining retention periods and peak regions, as well as, processing spectrum information from a mass spectrometric detector comprised the data processing procedure. The collected mass spectra reached interpretation by utilizing the Wiley 7th edition and NIST ’02 libraries, which included about 550,000 spectra in total.

RESULTS AND DISCUSSION

Area distribution of *G. kasachstanicum*

Based on the results, it has been notable for *G. kasachstanicum* to exist and distribute in Altai-Zhetysu and Tarbagatai mountains. The said plant was also prevalent in the plains between the Tarbagatai Mountains and Alakol Lake. The terrain up to the southern part of Tarbagatai Mountain is uneven, dividing into four parts, i.e., Tarbagatai Mountain, plain of rolling hills, weakly undulating plain, and the northern low plains of the Alakol Basin. The hydrographic complex comprised a network of small rivers and streams. All the rivers and streams also flow to the South and flow into Alakol and Sasykkol. The studied area climate is continental, with relatively little snow in winter and dry, hot summer. The continentality of the climate manifests in its annual and daily amplitude, in the immediate transition from winter to summer.

The studied area has black soil, dark brown, and brownish soil, characteristics of the foothills-desert steppe zone, and the lake and riverbanks belong to the meadow, dark brown soil. The mountain foot plains and hollows on the lake shores are the main types of relief. The endemic plants are unique to specific geographic areas and play a crucial role in maintaining biodiversity. Studying and understanding these plants with medicinal properties can lead to better conservation efforts, ensuring the preservation of these species, and their ecosystems (Ydyrys *et al*., 2013; Kidane *et al*., 2019). Numerous indigenous cultures rely on endemic medicinal plants for healthcare (Ramazonov and Mutalov, 2024). The comprehensive scientific research can validate the traditional use of these plants, by identifying active compounds and understanding their mechanisms of action (Zubair *et al*., 2024). It can help bridge the gap between traditional knowledge and modern medicines (Pires *et al*., 2023).

Phytocenotic characteristics of *G. kasachstanicum*

From the findings, the floral composition of the region where *G. kasachstanicum* was prominent, comprised 176 species belonging to 34 families and 133 genera. The flora consists of species Asteraceae (36), Poaceae (24), Chenopodioideae (17), Fabaceae (16), Rosaceae (13), Lamiaceae (10), Umbelliferae (4), Liliaceae, Malvaceae, and two species of some other families. In the vegetation cover, the dominant number of species were 26, belonging to *G. kasachstanicum*.

Most species (98 species – 55.6%) were of fodders, five species were poisonous, and 30 species were medicinal and folk medicinal plants. The vegetation of the plain at the mountain foot comprised a community of cereals—various grasses and shrub-cereal plants. However, the sagebrush is a species forming the main plant community in dark brown and brown soil areas.

The research area was about 70,000 ha, including agricultural lands of more than 60,000 ha (pasture – more than 50,000 ha, fields – about 8,000 ha, meadows – 2,000 ha, and perennial fields – 30 ha). Other lands have more than 7,000 ha (deciduous forest – 170 ha, shrub land – 9 ha, marshy reeds – more than 4,700 ha, settlements – about 400 ha, water bodies – 1,800 ha, and gravel and gravel deposits – about 400 ha). In the studied area, on average, a harvest of 200 g of *G. kasachstanicum* can occur per 10 ha. Endemic plants often contain bioactive compounds that may have therapeutic potential. Researching these plants could lead to the discovery of new drugs and helps in the development of novel pharmaceuticals based on their natural compounds (Nida *et al*., 2023).

Features of anatomical and morphological structures

G. kasachstanicum is a perennial herb with one to two thick stems, growing in clusters for several years, mostly found in sandy and stony places of the southern parts of Tarbagatai Mountains, as well as, on rocky slopes of low mountains in Kazakhstan. The plant height

Figure 1. Morphological structure of *G. kasachstanicum.*

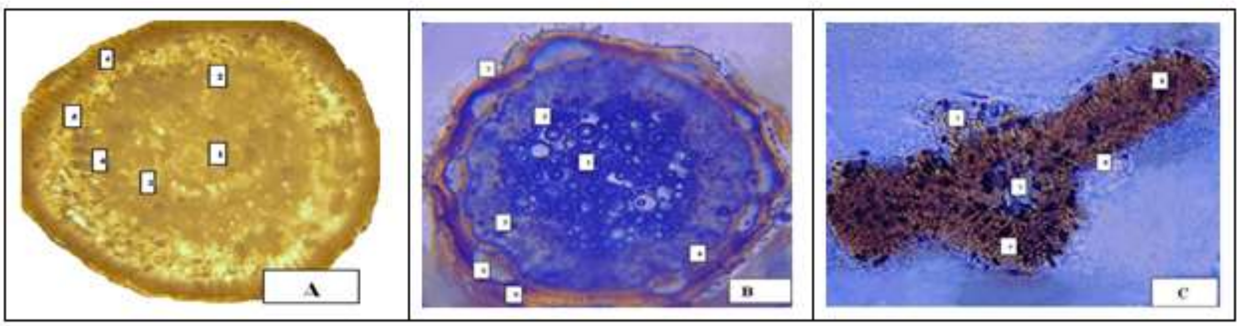

Figure 2. The anatomical structure of the stem of *G. kasachstanicum*. A: Cross-section of the stem (1 - pith, 2 - xylem, 3 - cambium, 4 - phloem, 5 - cortex, 6 - epidermis). B: Cross-section of the stem (1 - xylem, 2 - parenchyma, 3 - cambium, 4 - phloem, 5 - medullary rays, 6 - cortex layer, 7 - epidermis). C: Cross-section of the leaf (1 - stem trichome, 2 - upper epidermis, 3 - palisade parenchyma, 4 - spongy parenchyma, 5 - lower epidermis).

ranges from 10 to 35 cm, the leaves densely covered, especially towards the base. The leaves arranged alternately, and their edges were whole. The leaf length varies from 1 to 5 cm, covered with a dense layer of felt. The plants produce numerous small flowers, forming a compact or loose inflorescence. The flowers were tiny, with a length of up to 3 mm, and have tubular corollas (Figure 1.).

Microscopically, in the *G. kasachstanicum,* the epidermis cells were visible in the surface part, and more or less, were elongated on both sides. On the upper side, the epidermal cells had slightly twisted walls, while on the lower side, they strongly twist. Leaf opening was large, oval, immersed in water, surrounded by 4–5 epidermal cells and directed along the leaf length (anomocytic type), with more at the bottom. Both sides of the leaf have thin walls with 1–3 basal long cells, and numerous simple hairs. Head hairs, comprising unicellular peduncle and multicellular oval-elliptic head, had head cells arranged in one or two rows. During the study of the anatomical structure of the vegetative organs of *G. kasachstanicum*, the following micro-diagnostic signs were evident (Figure 2A-C, Table 1).

Table 1. Biometric indicators of the anatomical structure of the *G. kasachstanicum.*

Anatomical structure	Width (μm)				Length (μm)			
	Small and large sizes		Average ±		Small and large sizes		Average ±	
Root								
Epidermis	3.87	12.77	5.89	1.75	13.43	42.41	25,2	5.9
Cortex	3.93	24.63	9.13	3.5	13.33	52.24	28.64	8.2
Phloem	3.63	36.24	8.73	6.55	5.42	47.75	15.06	7.74
The vascular cambium	4.23	16.6	5.62	2.28	12.25	34.52	19.06	4.39
Xylem (dm)	2.79	38.24	11.36	9.1				
Pith (dm)	3.42	30.9	9.9	6.25				
Stem								
Epidermis	5.88	12.07	7.32	1.35	11.6	39.65	20.36	6.16
Cork	5.51	31.22	11.33	4.13	15.49	53.42	27.5	7.66
Sclerenchyma	4.3	12.77	7.44	5.88	13.66	42.47	23.69	5.88
Perivascular fibers	5.91	14.1	7.85	1.63	10.45	28.83	16.58	3.26
Phloem	2.92	9.73	5.5	1.3	7.15	21.01	12.32	2.4
Xylem (dm)	3.49	29.7	14.03	6.69				
Pith (dm)	4.83	46.99	14.07	8.04				
Leaf								
Epidermal cell	4.73	12.36	6.59	1.61	7.08	48.68	16.36	8.2
Palisade parenchyma	4.48	11.06	6.7	1.46	14.35	46.03	25.78	6.43
Sponge parenchyma	4.31	11.19	7.41	1.34	8.61	31.77	16.01	3.71
Sclerenchyma	4.84	15.33	9.13	2.72	11.05	49.11	23.59	7.85
Vascular bundle (dm)	5.22	20.9	12.18	3.97				

Root: The largest average dimension of roots of *G. kasachstanicum,* i.e., epidermis (25.2 ± 5.89 μm), cortex (28.64 ± 9.13 μm), phloem (15.06 ± 8.73 μm), cambium (19.06 ± 5.62 μm), xylem (11.36 μm), and pith (11.04 μm). In the outer layer of the initial cortex, the formation of epidermis was by elongated living cells with a well-developed cuticle, which later sloughs off, serving a protective function. Afterward, the main parenchyma (mesoderm) developed, constituting the primary mass of the initial stem. The endodermis was not clearly visible (Table 1, Figure 2).

Leaf: In the cross-section of the leaf, three main parts were clearly visible, i.e., epidermis, mesophyll tissue, and vascular system. The mesophyll tissue comprised two types of elongated cells: palisade parenchyma and spongy parenchyma. After the cuticle, the upper and lower epidermis of leaf cells can be noticeable as a single layer. Nonsignificant difference emerged between the lower and upper epidermis layers of leaf cells (Table 1, Figure 2C). Past studies reported the anatomical study of endemic plants play an essential role in its further exploration (Akhmetova *et al*., 2018). Sustainable harvesting, anatomical and morphological structure, cultivation, and commercialization of these plants could develop the livelihoods while also preserving the plant genetic resources (PGR) and their traditional knowledge (Haskah *et al*., 2024,; Ydyrys *et al*., 2020a).

Properties of plant extract

The study based on physicochemical indicators involved the identification of polyphenols, flavonoids, antioxidants, vitamins, and toxic elements in the composition of the food. The concentration of these specific nutrients, as determined, used the absolute graduation method for developing a calibration curve to establish standard values for the content of specific vitamins in the food products (Table 2). The obtained results provided the higher content of vitamins B1, B3, and B6 in the plant

Table 2. Vitamins in *G. kasachstanicum.*

Time	Component	Height	Start	End	Area	Concentration, mg/100 g
5.445	B1 (thiamine chloride)	24.389	5.358	5.537	1489.0	2,850±0,570
7.242	B2 (riboflavin)	0.523	6.960	7.348	56.06	0,090±0,038
7.900	B6 (pyridoxine)	15.329	7.548	8.612	2695.0	3,000±0,600
10.963	C (ascorbic acid)	2.044	10.663	11.090	200.5	1,800±0,612
11.540	B3 (pantothenic acid)	2.890	11.140	12.017	891.1	3,400±0,680
12.483	B5 (nicotinic acid)	1.665	12.217	12.717	267.1	0,260±0,047
15.763	Bc (folic acid)	1.383	15.638	15.892	65.86	0,037±0,007

Table 3. Toxic elements in *G. kasachstanicum.*

No.	Toxic elements	mg/kg
1	-As	was not identified
2	-Pb	0,0097±0,002
3	-Cd	was not identified
4	-Hg	was not identified

extracts. Vitamins B1 (thiamine), B3 (niacin), and B6 (pyridoxine) are significant in both plant metabolism and human physiology. However, in human metabolism, some key functions of these vitamins include:

Vitamin B1 (thiamine): Thiamine serves as an essential cofactor for various enzymatic reactions in the human body. It also plays a crucial role in converting carbohydrates, particularly pyruvate, into energy via acetyl-CoA during cellular respiration. Adequate thiamine levels are necessary to prevent the conditions, such as, beriberi, neuritis, Wernicke-Korsakoff syndrome, and other related disorders.

Vitamin B3 (niacin): Niacin is vital for the metabolism of carbohydrates, fats, and proteins. It is crucial in energy production processes and also essential in the synthesis of particular hormones and regulation of blood cholesterol levels. Niacin deficiency can lead to symptoms, such as, dermatitis, diarrhea, dementia, and pellagra, a condition characterized by the presence of the "4 D's" – dermatitis, diarrhea, dementia, and death.

Vitamin B6 (pyridoxine): Pyridoxine participates in the synthesis of neurotransmitters, such as, serotonin, dopamine, and gamma-aminobutyric acid (GABA), as well as, in the metabolism of amino acids. It also contributes to the formation of red blood cells and supports the immune function. However, the toxic element, such as, Pb (lead) with a concentration of 0.0097 ± 0.002 also emerged using the standard GOST (state standard specification) 30178-96 (Table 3).

The results further revealed detecting 68 individual compounds in the *G. kasachstanicum* extract using chromatography-mass spectrometry. The substances found in *G. kasachstanicum* can include three groups based on their relative quantities: those occurring in large quantity (above 2%), medium quantity (around 1%–2%) (Table 4), and in small quantity (below 1%) (Table 5). In the first category, the compounds found in large amounts were Stigmasta-3,5-diene (9.27%), Undec-10-ynoic acid, tetradecyl ester (5.26%), 3′,5-Dihydroxy-2-(4-hydroxybenzyl)-3-methoxybibenzyl (5.64%), 9,19-Cyclolanostan-3-ol, acetate (3β) (5.01%), cis-1-Chloro-9-octadecene (7.18%), Lipophilic aglycone 5,7-dihydroxy-3,8-dimethoxyflavone (3.47%), Friedelan-3-one (3.03%), and Heptadecanoate (2.11%).

The second category comprised compounds occurring in medium quantity, i.e., Cholesta-4,6-dien-3-ol (3β) (1.95%), Butyrolactone (1.91%), Cholest-5-en-3-ol (1.91%), cis-9-Hexadecenal (1.86%), Quercetin-3-O-rutinoside-7-O-glucoside (1.76%), 9,19-Cyclolanostan-3-ol, acetate (3β)

Table 4. Chemical composition (%) of *G. kasachstanicum*: stems + leaves (medium and large quantity above 1%).

No.	Compounds	Molecular Formula	Percentage Content (%)
1.	Isoverbascoside	$C_{17}H_{20}O_9$	1.01
2.	γ-Sitostenone	$C_{29}H_{48}O$	1.03
3.	Luteolin 7-O-beta-D-glucoside	$C_{21}H_{20}O_{11}$	1.07
4.	6-methoxy galangin (alnusin)	$C_{16}H_{12}O_6$	1.08
5.	γ-Sitosterol monohydrate	$C_{29}H_{52}O_2$	1.14
6.	4-((1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol	$C_{10}H_{12}O_3$	1.17
7.	Chlorogenic acid	$C_{16}H_{18}O_9$	1.22
8.	Stigmasta-4,22-dien-3-one	$C_{29}H_{46}O$	1.24
9.	Octacosanol	$C_{28}H_{58}O$	1.27
10.	2-[4-Methyl-6-(2,6,6-trimethylcyclohex-1-en-1-yl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	$C_{28}H_{37}O$	1.31
11.	3-Hexenyl-β-D-glucopyranoside	$C_{12}H_{22}O_6$	1.34
12.	3-Eicosyne	$C_{20}H_{38}$	1.42
13.	Palmitoleic acid	$C_{16}H_{30}O_2$	1.46
14.	Cholesta-3,5-dien-7-one	$C_{27}H_{42}O$	1.52
15.	9,19-Cyclolanostan-3-ol, acetate, (3β)	$C_{32}H_{54}O$	1.67
16.	Quercetin-3-O-rutinoside-7-O-glucoside	$C_{33}H_{40}O_{21}$	1.76
17.	1,3-Propanediol, 2-(hydroxymethyl)-2-nitro	$C_4H_9NO_5$	1.80
18.	cis-9-Hexadecenal	C16H30O	1.86
19.	Cholest-5-en-3-ol	$C_{27}H_{46}O$	1.91
20.	Butyrolactone	$C_4H_6O_2$	1.91
21.	Cholesta-4,6-dien-3-ol, (3β)	$C_{27}H_{44}O$	1.95
22.	Heptadecanoate	$C_{17}H_{34}O_2$	2.11
23.	Friedelan-3-one	$C_{30}H_{50}O$	3.03
24.	lipophilic aglycone 5,7-dihydroxy-3,8-dimethoxyflavone	$C_{20}H_{24}O_6$	3.47
25.	9,19-Cyclolanost-24-en-3-ol, acetate, (3beta)	$C_{32}H_{52}O$	5.01
26.	Undec-10-ynoic acid, tetradecyl ester	$C_{25}H_{46}O$	5.26
27.	3′,5-Dihydroxy-2-(4-hydroxybenzyl)-3-methoxybibenzyl	$C_{21}H_{20}O_5$	5.64
28.	cis-1-Chloro-9-octadecene	$C_{18}H_{35}C_l$	7.18
29.	Stigmasta-3,5-diene	$C_{29}H_{48}$	9.27
30.	Other components		43.22

(1.67%), Chlorogenic acid (1.62%), Palmitoleic acid (1.46%), 3-Eicosyne (1.42%), 3-Hexenyl-β-D-glucopyranoside (1.34%), 2-[4-Methyl-6-(2,6,6-trimethylcyclohex-1-en-1-yl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde (1.31%), Octacosanol (1.27%), Stigmasta-4,22-dien-3-one (1.24%), and Isoverbascoside (1.01%). In the third category, the remaining 46 biologically active substances showed with less than 1% content.

Examining *G. kasachstanicum* with potential health benefits can be reliant on the biologically active substances it contains. Among these bioactive substances, sterols were the most prevalent (22.74%). Plant sterols are a widely recognized substance remarkable in lowering the cholesterol levels. The sterols are also effective in managing vital conditions, such as, heart disease, colon cancer, stomach cancer, obesity, and heart attacks. However, limited scientific evidence existed supporting many of these additional uses. Researching endemic plants allows for in-depth analysis of their phytochemical composition (Islam *et al*., 2023).

The carboxylic acids were the most dominant, constituting 5.26% of the *G. kasachstanicum* composition. Carboxylic acids, a class of fatty acids, are highly beneficial for human health. The carboxylic acids play a crucial role in maintaining cell membrane integrity and regulating metabolism and nutrient absorption. Esters, making up 1.38% of the plant composition, typically enhance

Table 5. Chemical composition (%) of *G. kasachstanicum*: stems + leaves (small quantity below 1%).

No.	Compounds	Molecular Formula	Percentage Content (%)
1.	2,5,6-Trimethyloctane	$C_{11}H_{24}$	0.13
2.	Jaceosidin	$C_{17}H_{14}O_7$	0.14
3.	5,7,4'-Trihydroxy-3'-methoxyflavone 7-O-β-d-glucopyranoside	$C_{22}H_{28}O_{15}$	0.17
4.	Apigenin 7-O-β-d-glucopyranoside	$C_{21}H_{20}O_{10}$	0.18
5.	2-Octylcyclopropene-1-heptonol	$C_4H_6O_3$	0.21
6.	Isoquercitrin	$C_{21}H_{20}O_{12}$	0.22
7.	betulinic acid	$C_{30}H_{48}O_3$	0.25
8.	(Z,Z)-Heptadeca-1,8,11-triene	$C_{17}H_{30}$	0.26
9.	6-hydroxykaempferol-6,4'-dimethyl ether	$C_{17}H_{14}O_7$	0.31
10.	Apigenin	$C_{15}H_{10}O_5$	0.31
11.	Methyl(25rs)-3.beta.-acetoxy-5-cholesten-26-oate	$C_{30}H_{50}O_4$	0.32
12.	5-Hydroxy-3,6,7,8-tetramethoxyflavone	$C_{19}H_{22}O_{10}$	0.34
13.	1-Butyl(dimethyl) silyloxypropane	$C_{12}H_{28}OSi$	0.36
14.	2,3-Dihydro-2-(1-methylethenyl)benzofuran	$C_{11}H_{14}O$	0.37
15.	3,5-Dihydroxy-6,7,8-trimethoxyflavone	$C_{18}H_{16}O_7$	0.38
16.	(2S)-2-bromotetradecane	$C_{14}H_{29}Br$	0.41
17.	(E)-Dodec-2-enyl ethyl carbonate	$C_{15}H_{28}O_3$	0.42
18.	n-hexadecyl alcohol	$CH_3(CH_2)_{15}OH$	0.42
19.	Bicyclo [3,1,1]hept-2-ene-2-methanol, 6,6-dimethyl-	$C_{10}H_{16}O$	0.42
20.	14-Methyl-8-hexadecen-1-ol	$C_{17}H_{34}O$	0.46
21.	Luteolin	$C_{15}H_{10}O_6$	0.46
22.	7-Methoxy-8-acetoxygalangin	$C_{18}H_{14}O_7$	0.47
23.	2-Methoxy-4-vinylphenol	$C_9H_{10}O_2$	0.48
24.	7-Octodecyne, 2-methyl-	$C_{19}H_{36}$	0.48
25.	Adenosine	$C_{10}H_{13}N_5O_4$	0.49
26.	1-Eicosanol	$C_{20}H_{42}O$	0.51
27.	Cyclododecanol	$C_{12}H_{24}O$	0.51
28.	Dibutyl phthalate	$C_{16}H_{22}O_4$	0.54
29.	Cyclodecanol	$C_{10}H_{20}O$	0.61
30.	Ethyl 9-hexadecenoate	$C_{18}H_{34}O_2$	0.64
31.	Phthalic acid, cyclohexyl 2-pentyl ester	$C_{19}H_{26}O_4$	0.70
32.	1,6-Anhydro-beta-D-glucopyranose	$C_6H_{10}O_5$	0.71
33.	5-Hydroxymethylfurfural	$C_6H_6O_3$	0.72
34.	10-Heneicosene(c,t)	$C_{21}H_{42}$	0.73
35.	Benzofuran, 2,3-dihydro	C_8H_8O	0.78
36.	1-Methyl-1-n-pentyloxy-1-silacyclobutane	$C_{10}H_{22}OSi$	0.84
37.	Dihydroxyanthraquinone	$C_{16}H_{12}O_4$	0.88
38.	α-, β-, and γ-carotenes	$C_{40}H_{56}$	0.93
39.	24-Norursa-3,12-diene	$C_{29}H_{46}$	0.95

flavor and serve as effective emulsifiers. Aldehydes, comprising 2.07%, are versatile compounds used in the production of resins, dyes, organic acids, and fragrances for colognes, detergents, and soaps. The following information can aid in conservation strategies and may guide future cultivation practices (Seilkhan *et al*., 2021).

In *G. kasachstanicum*, the terpenes (3.45%), glycosides (2.81%), and phenols (2.29%) also emerged abundantly and possess significant properties. Research has highlighted their benefits, including anti-aging, anti-inflammatory, antibacterial, antimicrobial, anticancer, antioxidant, and sedative effects, as well as, their considerable role as antiproliferative agents. Additionally, these compounds help regulate antioxidant enzymes to counteract oxidative stress (Syraiyl *et al*., 2022). Ketones, found at 3.03%, serve as alternative fuel for the human body, produced by the liver through fats when glucose level is low. Exploring endemic medicinal plants may provide an alternative for the treatment of various health conditions (Bukenova *et al*., 2019; Prasher *et al*., 2023; Rajkovic *et al*., 2023).

The profound investigation involves identifying and characterizing bioactive compounds, which can provide a basis for developing standardized formulations for medicinal use. Understanding the cultural and societal significance of endemic medicinal plants through ethnobotanical studies helps preserve traditional knowledge and practices, while integrating them into modern healthcare systems. This could offer solutions for diseases that are challenging to treat and by using conventional medicines could lead to the development of more effective and affordable treatments (Ydyrys *et al*., 2021). Studying how endemic medicinal plants respond to environmental changes, including climate change, can offer insights into their adaptability and potential vulnerabilities (Seilkhan *et al*., 2016, 2018; Ydyrys *et al*., 2020b).

CONCLUSIONS

Based on the results, *G. kasachstanicum* thrives in the unique climatic and geological conditions of Southeastern Kazakhstan, particularly within the Tarbagatai Mountain ranges. Phytochemical analysis reveals *G. kasachstanicum* contains a diverse array of biologically active compounds. Its rich phytochemical composition and adaptation to local environmental conditions emphasize the importance of preserving the endemic plant species and leveraging their medicinal potential. Continued research is essential to fully understand the medicinal properties and potential applications of this plant. Integrating ethnobotanical knowledge with scientific research can provide valuable insights into its uses and further support its preservation. In conclusion, leveraging the medicinal potential of *G. kasachstanicum* while ensuring its conservation in its natural habitat will require a collaborative approach involving researchers, local communities, and policymakers. Sustainable practices will be crucial in harnessing the full benefits of this valuable medicinal plant, ensuring its legacy for future generations.

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