The content of phenolic compounds *Allium gunibicum* Miscz. ex Grossh

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Abstract. The article presents the results of the study of the total content of phenolic compounds in the aboveground and underground parts of *A. gunibicum*, which grows in the areas of mid-mountain limestone Dagestan. Samples from introduced and natural populations were studied using spectrophotometric methods. The variability of the content of flavonoids and anthocyanins was revealed depending on the studied part of the plants and the place of collection of raw materials. In plants from natural habitats, the content of flavonoids and anthocyanins is higher than in samples grown under culture conditions. The obtained results indicate the dependence of the accumulation of these compounds on the environmental factors of the place of growth of the samples, and can be used to solve a number of problems of the chemotaxonomic direction.

1 Introduction

Allium gunibicum. Miscz ex Grossh. - a perennial herbaceous plant from the genus Allium of the Alliaceae family. The range of the species includes Dagestan, Chechnya (a tributary of the Fartanga River) and Georgia (Khevsureti). *A. gunibicum* is found in the areas of mid-mountain limestone Dagestan (Akushinsky, Akhvakhsky, Botlikhsky, Gumbetovsky, Gergebilsky, Gunib (Gunib - locus classicus), Levashinsky, Untsukul, Khunzakhsky, Shamilsky). The species is a xerophyte. It grows at an altitude of 600-2000 meters above sea level on rocks and rocky slopes, on dry limestone and grassy slopes, on alabaster outcrops[1].

A. gunibicum is a rhizomatous-bulbous plant with ovate- or elongated-conical bulbs, up to 7.5 mm in diameter and 2-7 cm high, covered with brown leathery shells attached to a short rhizome of several pieces. Leaves 3-4 smooth, grooved, semi—cylindrical, 0.5-1 mm wide, with a length equal to the peduncle. The peduncle is thin, covered at the base with leaf sheaths, up to 15-30 centimeters high. The flowers are collected in a multi-flowered hemispherical loose umbrella. The case with a long nose is non-falling, slightly shorter than the umbrella. The tepals are elliptical, about 5 mm long, pink-purple. A. gunibicum blooms in July—August.

Work on the study of A. gunibicum in the conditions of introduction has been carried out since 1999 [1]. There is no data on the chemical composition of this species. Chromatography-mass spectrometry revealed that A. gunibicum essential oil contains sulfur compounds — 16 (32.97%), monoterpenes and their derivatives — 9 (22.90%),

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sesquiterpenes and their derivatives — 2 (1.89%), aldehydes — 4 (3.31%) components (% by weight) accordingly [2].

This paper presents the results of assessing the total content of phenolic compounds in different parts of *Allium gunibicum* from natural and introduced populations as an important indicator of plant adaptation to growing conditions.

2 Material and methods

The material for research was *A. gunibicum* from the collection site at the Tsudakhar experimental base and from natural habitats. Samples were transplanted from different points of Dagestan within the distribution area:

1. Gergebilsky district. Red Bridge. surroundings of the village of Mogoh. 750 m.
2. Sergokalinsky district. Aya-kaka Gorge. 1150 m.
3. Gunibsky district. above the village of Gunib. the southern slope. 1800 m.
4. Gunibsky district. above the village of Gunib. 1330 m.
5. Levashinsky district. surroundings of the village of Tsudakhar. 1100 m.

Plants are grown under equal conditions of introduction (soil, climate) on a collection plot at an altitude of 1100 m. above sea level.

As control samples for comparison, A. gunibicum samples were also collected from two different growing sites geographically distant from each other:

1. Levashinsky district, the vicinity of the village of Tsudakhar, 1100 m., northern slope
2. Gunib district, above the village of Gunib, 1400 m., eastern slope.

Plant raw materials for phytochemical analyses were collected during the full flowering phase. The material was dried in a well–ventilated room (in the shade at $t = 20 – 25^{O}$ C). The total content of flavonoids and anthocyanins was determined in water-ethanol extracts (70% ethanol solution).

The analyses were carried out according to generally accepted methods. The total content of flavonoids was determined by a spectrophotometric method based on the reaction of complexation of flavonoids with aluminum chloride in an acidic medium. The total content of anthocyanins was determined by direct spectrophotometric method in the visible region [3].

The samples were analyzed in three repetitions. Statistical processing of the obtained data was carried out using the licensed software package Statistika 5.5.

3 Results

A. gunibicum samples from natural and introduced populations from the collection site at the Tsudakhar experimental base were analyzed for the content of phenolic compounds. The total content of flavonoids and anthocyanins in various organs of A. gunibicum plants was determined. The results of the analyses are presented in the table 1.

Table 1. Total content of some phenolic compounds in A. gunibicum, % of air-dry mass.

Sample collection site, height above sea level, m (origin)	**Part of a plant, total content of phenolic compounds, %**					
	Inflorescences		**Leaves**		**Bulbs**	
	Flavonoids	**Anthocyanins**	**Flavonoids**	**Anthocyanins**	**Flavonoids**	**Anthocyanins**
	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$
	Introduced populations					
Mogoh, 750	1.244±0.001	0.070±0.002	0.907±0.012	0.061±0.002	0.025±0.000	0.004±0.000
Tsudahar, 1100	1.287±0.001	0.059±0.001	0.984±0.010	0.050±0.001	0.014±0.000	0.005±0.001
Aya-kaka, 1150	1.164±0.002	0.062±0.001	0.823±0.009	0.043±0.001	0.024±0.001	0.005±0.001
Gunib, 1330	1.058±0.003	0.053±0.000	0.762±0.003	0.043±0.000	0.014±0.000	0.006±0.001
Gunib, 1800	0.958±0.005	0.063±0.001	0.654±0.000	0.054±0.002	0.018±0.001	0.004±0.002
	Natural populations					
Tsudahar, 1100	2.07±0.006	0.18±0.000	1.74±0.004	0.15±0.000	0.1±0.001	0.01±0.000
Gunib, 1330	1.6±0.006	0.07±0.000	1.05±0.004	0.17±0.000	0.04±0.000	0.01±0.000

Source: Compiled by the authors.

Phytochemical analysis of samples of introduced populations revealed differences in the distribution of phenolic compounds in different parts of plants. The highest content of flavonoids and anthocyanins is found in the inflorescences, and the lowest in the bulb. In inflorescences, the total content of flavonoids ranges from 0.96 to 1.24%, in leaves - 0.65-0.98%, and in bulbs 0.01-0.03%. And the total content of anthocyanins in inflorescences is 0.05-0.07%, in leaves - 0.04-0.06%, in bulbs 0.004-0.005%.

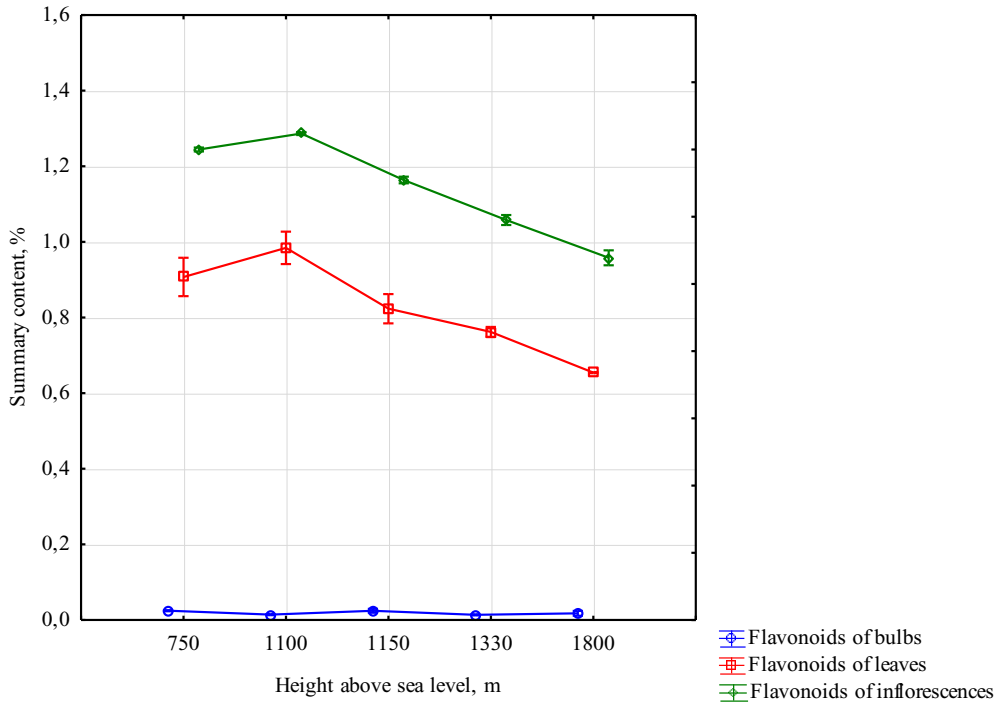

Fig. 1. Variability of flavonoid content in A. gunibicum raw materials (%).

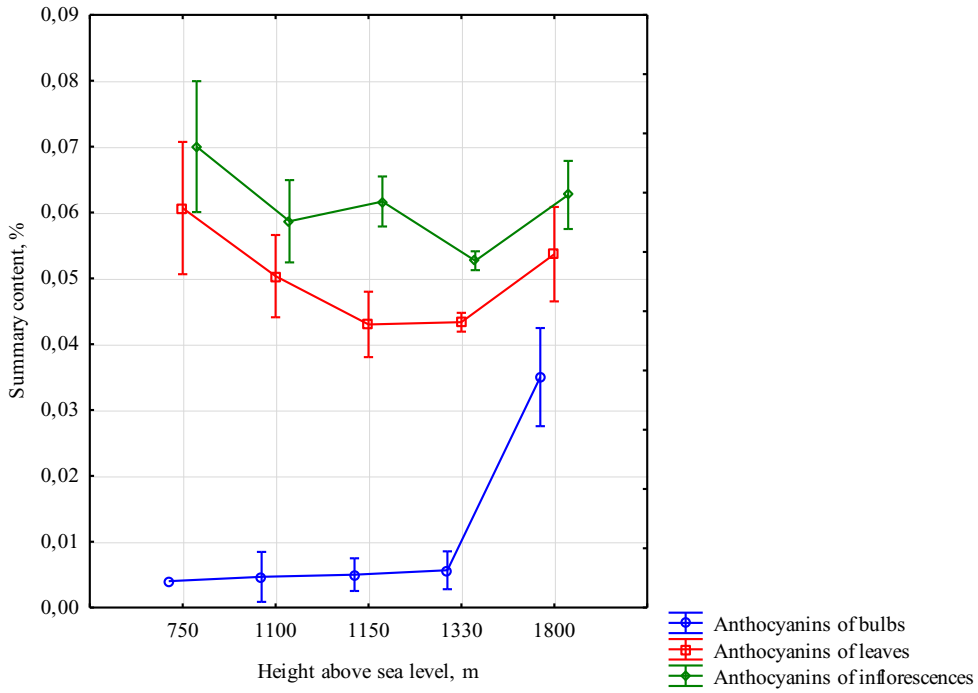

Fig. 2. Variability of anthocyanin content in A.gunibicum raw materials (%).

In natural populations, the accumulation of phenolic compounds also differs: in the aboveground part it is higher. The total content of flavonoids in the inflorescences of the sample "Tsudakhar, 1100" is greater (2.07%) than in the sample "Gunib, 1330" (1.6%), in the leaves - 1.74 and 1.05%, in the bulbs 0.1 and 0.04%, respectively. In terms of the amount of anthocyanins, there is a big difference only in inflorescences – 0.18 and 0.07%, respectively, in leaves 0.15% and 0.17%, and in bulbs only 0.01%.

Comparison of the total content of flavonoids and anthocyanins in A. gunibicum samples from the collection of the Mountain Botanical Garden and from natural habitats showed that these indicators are significantly higher in natural conditions (Fig. 1). This indicates a great influence of environmental stress factors (light, soil, moisture, altitude, etc.) in natural conditions, which leads to the stimulation of the synthesis of phenolic compounds in plants.

4 Discussion

Statistical data processing was carried out to assess the variability of phenolic compounds. Correlation analysis showed that there is a significant positive correlation between the content of flavonoids and anthocyanins (r= - 0.99.at the level of $p < 0.05$), and there are negative connections between the content of flavonoids and anthocyanins and the collection site, that is, the indicators change along the altitude gradient (table 2).

Table 2. Correlation analysis of data on the content of phenolic compounds of *A. gunibicum*

Signs	**Height above sea level, m**	**Flavonoids of bulbs**	**Flavonoids of bulbs**	**Flavonoids of bulbs**	**Flavonoids of bulbs**	**Flavonoids of bulbs**	**Flavonoids of bulbs**
Flavonoids of bulbs	-0,64***	1,00	0,10	0,24	-0,14	0,26	0,75***
Flavonoids of leaves	-0,73***	0,10	1,00	0,98***	-0,77***	0,17	0,16
Flavonoids of inflorescences	-0,81***	0,24	0,98***	1,00	-0,78***	0,21	0,28
Anthocyanins of bulbs	0,82***	-0,14	-0,77***	-0,78***	1,00	0,20	0,10
Anthocyanins of leaves	-0,15	0,26	0,17	0,21	0,20	1,00	0,79***
Anthocyanins of inflorescences	-0,44	0,75***	0,16	0,28	0,10	0,79***	1,00

Note: *** - significant at the level of $p < 0.05$

A one–factor variance analysis of the data obtained was carried out for populations where the factor is the height above sea level of the place of collection of plant raw materials (table 3).

Table 3. Analysis of variance.

Signs	**F**	**p**	**h^2, %**
Flavonoids of bulbs	36,171	0,000006	93,63
Flavonoids of leaves	248,355	0	99,00

Flavonoids of inflorescences	2481,202	0	99,90
Anthocyanins of bulbs	200,159	0	98,74
Anthocyanins of leaves	23,41	0,000046	90,44
Anthocyanins of inflorescences	20,33	0,000086	88,99

The evaluation of the dispersion components based on the results of a one-factor analysis of variance revealed the influence of the height of the material collection site for the experiment. The influence of the factor is high - above 90%.

Thus, the variability of these indicators along the altitude gradient was revealed both in natural and introduced populations.

It is known that, different types of onions accumulate different amounts of flavonoids and anthocyanins. Data on the content of flavonoids in representatives of the genus Allium in the literature are contradictory. The content of flavonoids in the aboveground part of plants according to various data is 1.8-9.2 mg/g of dry weight, the leaves of rhizomatous onions accumulate 0.13-2.72% of flavonoids [4].

Due to the protective function in plant tissues, phenolic compounds are considered universal physiological adaptogens to adverse environmental factors, both biotic and abiotic. The adaptation of plants to new conditions of existence is accompanied by both a change in the number of secondary metabolites and the size of plants, which allows the species to adapt to the living conditions as much as possible, both within and outside the range [5-7].

5 Conclusion

The analysis showed that the accumulation of secondary metabolites in plant organs of the introduced populations of A. gunibicum in the conditions of culture at the Tsudakhar experimental base in the Botanical Garden differs: the total content of flavonoids and anthocyanins is higher in aboveground organs than in other parts of plants, for example, in inflorescences. At the same time, the relationship between the content of phenolic compounds and the origin of the studied populations is traced. In the content of flavonoids and anthocyanins in plant organs in natural populations A. gunibicum also has differences depending on the geographical location of the studied populations.

The study of the variability of the flavonoid trait in plants from natural populations makes it possible to understand the features of the accumulation of these compounds depending on environmental conditions, which, in turn, is important for predicting the content of both individual flavonoids and anthocyanins, and the sum of phenolic compounds as a whole.

The obtained data make it possible to explain the mechanisms of variability in the content of secondary metabolites under the influence of a complex of abiotic environmental factors and adaptation of plants to environmental conditions. The adaptation of plants to new conditions of existence is accompanied by both a change in the number of secondary metabolites and the size of plants, which allows the species to adapt to the living conditions as much as possible, both within and outside the range.

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