Antioxidant and antiradical activity of Heracleum sosnowskyi inflorescences in the Murmansk region

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Abstract. At present, there is an increased interest in the study of plant extracts in order to find promising sources of biological compounds for the pharmaceutical, cosmetic and food industries. Sosnowsky's hogweed (lat. Heracleum *sosnowskyi* Manden.) is a large herbaceous plant capable of accumulating a large volume of green biomass. Presumably, during the period of mass flowering of inflorescences, plants are in greater need of antioxidant and antiradical protection. The aim of this study was to investigate the antioxidant and antiradical activity of substances contained in the inflorescences of H. *sosnowskyi* Manden., growing in the Murmansk region. It was shown that during the period of mass flowering of the main inflorescence of H. *sosnowskyi* Manden., the content of compounds with antioxidant activity reaches higher values in the harsh conditions of the Khibiny than on the foothill plain. The data obtained will allow improve understanding of the peculiarities of plant metabolism in the conditions of the Kola Peninsula and to develop modern technologies for the extraction of biologically active compounds from the inflorescences of H. *sosnowskyi* Manden., growing in the Murmansk region.

1 Introduction

A current task for biological and medical science is the search for and study of plants containing a complex of biologically active compounds with physiological activity and therapeutic action [1]. Depending on the natural, climatic and environmental conditions, metabolic processes in plants change, affecting the nature of the synthesis and accumulation of biologically active substances (BAS). It has been established that with an increase in the extremeness of natural and climatic conditions of growth, a greater amount of biologically active substances is synthesized in the tissues of a number of plant species compounds. Changes in environmental conditions affect not only the quantity of certain substances, but can also cause profound qualitative shifts in them [2]. Promising a resource species containing a number of compounds with high biological activity is H. *sosnowskyi* Manden. [3]. H. *sosnowskyi* Manden., is a large herbaceous plant capable of accumulating a large volume of green biomass containing proteins, sugars, vitamins, polyphenols, microelements,

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coumarins, furocoumarin compounds and essential oils, which opens up the prospect of their further practical application in the pharmacological, food, cosmetic industries and the agricultural sector [4].

The Murmansk region is located beyond the Arctic Circle and belongs to the Atlantic-Arctic zone of temperate climate. Within the Murmansk region, there are different natural and climatic conditions. The Kirov district of the Murmansk region, located in the harsh conditions of the Khibiny, differs significantly from the foothill conditions of the Apatity district [5]. The main features of the growth of H. *sosnowskyi* Manden., on the Kola Peninsula are a short growing season of 90-120 days, a long but not severe winter, a short and cool summer, alternation of polar day and night, windy weather with a large amount of precipitation [6]. Thus, due to the difference in growing conditions, the accumulation of secondary metabolites in plant organs may differ [7]. However, the metabolic features of H. *sosnowskyi* Manden., in the conditions of the Far North remain insufficiently studied.

The aim of the work is to evaluate the content of compounds with antioxidant and antiradical activity in the inflorescences of H. *sosnowskyi* Manden., growing in the conditions of the Murmansk region.

2 Materials and methods

Plant inflorescences were used in the work *H. sosnowskyi* Manden., growing on the sites of the Polar-Alpine Botanical Garden-Institute (PABGI) in the cities of Apatity (67°38′ sw, 33°37′ E) and Kirovsk (67°36'53" sw 33°40'21" vd), Murmansk region. The city of Apatity is located on a flat plain, at an altitude of 175 m above sea level, where the average annual temperature is +0.5ºC. The city of Kirovsk is located in the southern part of the Khibiny mountain range at an altitude of 387 m above sea level. The average annual temperature in its territory is - 1.4ºC. Inflorescence samples *H. sosnowskyi* Manden., were collected during the mass flowering of the main inflorescence in the Apatity-Kirovsky district - July 5 and July 24, respectively. Before the extraction of biologically active compounds, fresh inflorescences of H. *sosnowskyi* Manden., were dried by keeping them on filter paper folded in several layers in a well-ventilated room at room temperature in the shade for 20 days. The dried material was crushed and passed through a laboratory sieve with a cell diameter of 1 mm. Ultrasonic extraction of a 0.05 g sample of H. *sosnowskyi* Manden., inflorescences was carried out using a Vilitek VBS-3-DP ultrasonic bath at a temperature of 60 ℃ for 90 minutes. The ratio (w/v) of raw materials and extractant (60% ethyl alcohol) was 1:30.

2.1 Chemicals and reagents

Ascorbic acid (>99.7%, China), 2,2-diphenyl-1-picrylhydrazyl (99%, Sigma-Aldrich, Burlington, MA, USA), ammonium molybdate, concentrated sulfuric (>94%, Russia), ethanol (96 %, Russia) and deionized water was obtained with water purification system “Millipore Element” (USA).

2.2 Antiradical activity measuring

Antiradical activity (free radical scavenging, FRS) was determined using a reaction with the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) [8]. 0.05 ml of the extract diluted 400 times with 96% ethanol was mixed with 0.95 ml of a DPPH solution in 96% ethanol (4 mg per 100 ml) and thermostated at 25°C for 30 min. The optical density of the solutions was then measured at 517 nm using a photocolorimeter KFK-3-01 (ZOMZ, Sergiev Posad, Russia, 2010).

The degree of inhibition of DPPH free radical is calculated as:

$$I = \frac{\left(A^0_{517} - A_{517}\right)}{A^0_{517}} \times 100\%$$

Where A^0_{517} is the extinction of the blank solution, A_{517} is the extinction of the measured solution. Extraction and, accordingly, measurements of antiradical activity were performed in triplicate. Data are presented as mean ± standard deviation.

2.3 Antioxidant activity measuring.

Total antioxidant activity (TAC) was determined by the phosphomolybdate method 5 ml of the initial extract was added to 2 ml of the reaction solution (4 mM ammonium molybdate + 28 mM potassium dihydrogen phosphate + 0.6 M sulfuric acid) in glass screw flasks. The resulting mixture was thermostated at 95°C for 90 minutes. The optical density of the solutions was measured at a wavelength of 805 nm using a KFK-3-01 photocolorimeter (ZOMZ, Sergiev Posad, Russia, 2010). Calibration was performed using ascorbic acid in the concentration range of 100–1000 μg/ml. The total content of antioxidant substances in the extract was expressed as mg of ascorbic acid equivalent (AAE) per 1 g of plant material:

$$TAC = \frac{(A_{805} - b) \times V_{ext}}{a \times m_{plant}}, mgAAE/g$$

Where A_{805} – optical density at 805 nm, a and b – coefficients of the linear equation of the calibration graph (slope and shift, respectively), V_{ext} – volume of extractant, m_{plant} – mass of plant material. Extraction and, accordingly, measurements of antioxidant activity were performed in triplicate. Data are presented as mean ± standard deviation.

3 Results and discussion

Results of the study of the content of compounds with antioxidant and antiradical activity in inflorescences H. *sosnowskyi* Manden., growing in the mountainous and flat parts of the cities of Kirovsk and Apatity in the Murmansk region are shown in Figures 1-2.

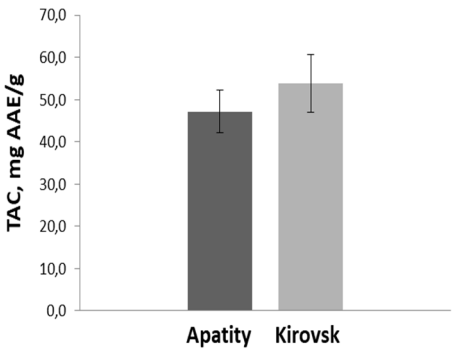

Fig. 1. Content of compounds with antioxidant activity in inflorescences H. sosnowskyi Manden in the cities of Kirovsk and Apatity.

The data presented in Figure 1 indicate a 12.5% increase in antioxidant activity in inflorescences H. sosnowskyi Manden., in the city of Kirovsk, than in inflorescences H. sosnowskyi Manden., growing in the city of Apatity, 53.87 ± 1.1 mg AAE/g and 47.15 ± 1.1 mg AAE/g, respectively.

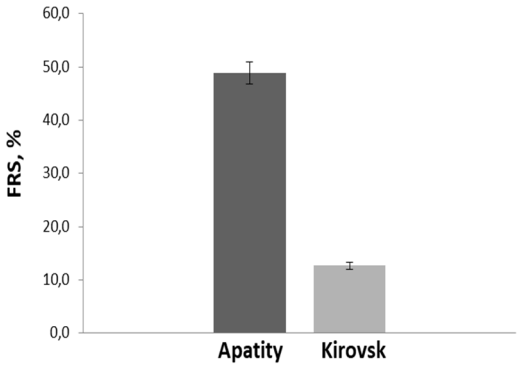

Fig. 2. Content of compounds with antiradical activity in inflorescences H. sosnowskyi Manden. in the cities of Kirovsk and Apatity.

Figure 2 shows that the content of compounds with antiradical activity in the inflorescences of H. *sosnowskyi* Manden. Apatity is significantly higher - by 74.1%, than in plants growing on the sites of Kirovsk, 48.87± 2.12% and 12.67± 0.71%, respectively.

Thus, the antioxidant and antiradical activity of plant extracts is determined by the chemical composition of the raw materials and may differ depending on the place of collection and growing plants. The variability of the content of such a composition of biologically active substances ensures the adaptability of plants to unfavorable natural and climatic conditions and other stress factors.

4 Conclusion

The work has shown that during the period of mass flowering of the main inflorescence of H. Sosnowskyi Manden. The content of compounds with antioxidant activity reaches higher values in the conditions of the Khibiny than on the foothill plain. At the same time, the content of compounds with antiradical activity reaches higher values on the foothill plain. Presumably, this is due to the fact that the integral protective reactions of H. *sosnowskyi* Manden. plants - an increase in antioxidant activity - is activated earlier and develops more dynamically in the harsher conditions of the Khibiny. The increase in the antiradical activity of H. *sosnowskyi* Manden. inflorescence extracts on the foothill plain is due to the chemical composition of the raw materials and the adaptability of plants to unfavorable natural and climatic conditions.

The data obtained will allow improve understanding of the peculiarities of plant metabolism in the conditions of the Kola Peninsula and to develop modern technologies for the extraction of biologically active compounds from the inflorescences of H. *sosnowskyi* Manden., growing in the conditions of the Murmansk region.

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