Sosnowsky hogweed: new ways to use

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Abstract. The article outlines the problems of the widespread distribution of the Sosnowsky hogweed in the Novgorod region of the Russian Federation. The results of experiments on the extraction of coumarins from the dry mass of the Sosnowsky hogweed in the biotechnology laboratory of Yaroslav-the-Wise Novgorod State University are considered. Particular attention is paid to methods for the isolation of coumarins: extraction with ethyl alcohol and sublimation with magnesium oxide. The author comes to the conclusion that a better product with a minimum amount of impurities is obtained by sublimation. Based on the study of samples of Sosnowsky hogweed from different regions, it was found that the content of coumarins depends on the growing conditions. Sosnowsky hogweed, growing in the northern region, was found to be small in size, but with a greater content of coumarins. Coumarins extracted from Sosnowsky hogweed can be used as growth stimulants and as plant protection products.

1. Introduction

The fight against the rapid spread of the Sosnowsky hogweed is an extremely important and very difficult task facing agricultural enterprises. Sosnowsky hogweed began to be actively introduced into agricultural production in the late sixties of the twentieth century. Hopes were pinned on him as a promising feed crop with a number of competitive advantages. Like that: high productivity, productivity, winter hardiness. The high content of carbohydrates allowed the use of Sosnowsky hogweed as a silage culture. Under favorable conditions, the yield can reach two thousand tons per hectare. In the future, these qualities allowed Sosnowsky hogweed to capture vast territories and displace many plant species [1]. The hogweed bred uncontrollably, since until 2012 it was included in the State Register of Breeding Achievements and approved for use on the territory of the Russian Federation. Only in 2015, Sosnowsky hogweed was excluded from the All-Russian product classifier and included in the industry classifier of weeds. The fight against this plant has become legally possible [2].

An ill-conceived intervention in the ecological balance and the widespread active cultivation of this plant led to its uncontrolled spread over the territory of many regions of the Russian Federation. According to the data of 2019, Sosnowsky hogweed in the Novgorod region covers an area of about six thousand hectares.

The main danger to people is the poisonous juice of Sosnowsky hogweed, which causes burns if it comes into contact with skin. This greatly complicates the fight against the spread of this plant. The main methods of control are the destruction of thickets by a mechanized method and the use of herbicides. The search for other more effective methods of control led to a more detailed study of the chemical composition of Sosnowsky hogweed. It was found that skin lesions are caused by biologically active compounds - coumarins. The presence of coumarins was detected in the roots, vegetative organs, fruits [3, 4, 5]. Furanocoumarins, which are activated by ultraviolet solar radiation, are especially
dangerous. Coumarins, on the other hand, are valuable biologically active substances. Representatives of coumarins are used in pharmacology, medicine, cosmetology, and in plant protection methods [5, 6]. They exhibit various properties and types of activity: photosensitizing, sun-protecting [7], antitumor [8–10], antioxid and many others [11, 12].

2. Materials and methods
Coumarins are a number of natural compounds based on benzo-α-pyrone. Coumarins are unsaturated lactones of cis-ortho-hydroxycinnamic acid. In free form, they are colorless or yellowish crystals, readily soluble in organic solvents and oils. This property formed the basis for the extraction method using ethanol of 95% concentration.

When heated to one hundred degrees Celsius, coumarins are capable of sublimation and crystallize in the form of needle crystals. This property was used in experiments using the sublimation method with magnesium oxide. Most coumarins have absorption spectra in the region of 210-270 nm and 290-350 nm. Coumarins dissolve well when heated in aqueous solutions of alkalis with the formation of salts of hydroxycinnamic acid. When a small amount of acid is added, coumarins are regenerated and precipitate. This ability of coumarins formed the basis of a qualitative reaction, the so-called "lactone test", and made it possible to obtain a pure product.

3. The study of the content of coumarins
In the biotechnology laboratory of Yaroslav-the-Wise Novgorod State University in 2019-2020, work was carried out to isolate coumarins from the dry mass of leaves of Sosnovsky hogweed. Hogweed samples were prepared in June 2019 in compliance with safety regulations in two regions with different climatic conditions: in the Valdai district of the Novgorod region and in the Komi Republic in the vicinity of the city of Inta. The leaves were dried at room temperature without sunlight. In further experiments, dry mass, crushed in a porcelain mortar, was used.

Extraction was performed with ethanol of 95% concentration for four hours in a Soxhlet apparatus. The lactone test confirmed the presence of coumarins in the extract. The coumarin content in the extract was determined using a photoelectrocolorimeter at a wavelength of 360 nm. The comparison solution is ethyl alcohol of 95% concentration. The experimental results are shown in table 1.

The second method for the extraction of coumarins was the sublimation method with magnesium oxide. The crushed leaves of Sosnovsky hogweed were mixed with magnesium oxide in a ratio of 1:1. Heated at a temperature of 100 degrees Celsius for 25 minutes. A round bottom flask filled with ice was used to precipitate crystals. The mass of the obtained crystals was determined. Coumarins were isolated from crystals by adding a ten percent alcohol solution of KOH. They were heated in a water bath for five minutes. Then a solution of hydrochloric acid of 10% concentration was added. Coumarins precipitated. The precipitate was filtered off and weighed. In this case, coumarins were obtained without impurities of other substances. The results are shown in table 1.

| Table 1. The content of coumarins in Sosnowsky hogweed,%.
| Sample Number | Extraction Method | Sublimation Method |
|---------------|------------------|--------------------|
|               | Samples of the Komi Republic | Samples of Novgorod. reg | Samples of the Komi Republic | Samples of Novgorod. reg |
| 1             | 22.6             | 5.9                | 0.35             | 0.1             |
| 2             | 22.7             | 5.8                | 0.30             | 0.1             |
| 3             | 22.4             | 6.0                | 0.35             | 0.1             |
| The average   | 22.6             | 5.9                | 0.33             | 0.1             |

As a result of the experiment, it was revealed that a larger amount of coumarins can be extracted than by sublimation. But most likely, other biologically active substances with a similar absorption spectrum
affected the result of the experiment. Therefore, the result was higher than with sublimation. Sublimation method with magnesium oxide can be considered a better method for the extraction of coumarins. The results of this method are in good agreement with the results of other researchers [5]. The disadvantage of this method is the small mass of the sample subjected to sublimation.

As a result of the experiments, it turned out that the content of coumarins depends on the growing conditions of Sosnowsky hogweed. Hogweed, harvested in the Komi Republic near the city of Inta, has a greater concentration of coumarins than hogweed growing in Borovichi district of the Novgorod region. Although the plant in the northern regions is much smaller and forms in a short growing season. And also does not pose a serious danger to people and animals. Based on the studies conducted, it can be concluded that for the isolation of coumarins, Sosnowsky hogweed, growing in the Komi Republic, is the preferred sample.

4. Conclusion
The experiments performed indicate that Sosnowsky hogweed can be considered not only as an aggressive weed that has captured numerous territories. Hogweed can be harvested in ecologically safe areas and used as a valuable raw material for the production of coumarins. Coumarins isolated from Sosnowsky hogweed are planned to be used in further experiments as plant growth stimulants, as part of fungicides and other plant protection preparations.

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