The accumulation of biologically active substances by the leaves of stinging nettle, collected in various urban and agrobiocenoses of the Voronezh region

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Accumulation of biologically active substances by leaves of urtica dioica in various urban and agrobiocenoses of voronezh region

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SUMMARY

An important and little-studied aspect of the influence of human economic activity on medicinal plants is that in response to an increase in anthropogenic load, additional synthesis of secondary metabolites is induced, in particular, oxycinnamic acids, which play an important role in plant adaptation to changing conditions. The aim of the study was to study the accumulation of oxycinnamic acids in nettle leaves collected in agro- and urban-biogeocenoses of the Voronezh region, different from the point of view of anthropogenic impact. Within the framework of the study, the content of the sum of hydroxycinnamic acids in terms of chlorogenic acid was determined in 51 samples of stinging nettle leaves. All samples meet the existing regulatory requirements for this indicator. The content of the sum of hydroxycinnamic acids in samples of leaves of stinging nettle, collected in agrobiogeocenoses, on average, does not differ from the content of this group of biologically active substances in samples collected in biocenoses of protected areas. The content of the studied group of biologically active substances in the samples collected in some urban biogeocenoses of the Voronezh region is, on average, 1.5–2 times higher than in the samples of natural biocenoses of the reserved zones. This is due to the fact that the enzyme phenylalanine ammonia lyase has a pronounced stress inducibility, which enhances the synthesis of oxycinnamic acids, which play the role of membrane stabilizers that prevent the penetration of xenobiotics. It was also noted that as a result of the complex toxic effect on the plant organism, which is observed, for example, near major roads, industrial enterprises,

Key words: Voronezh region, stinging nettle, oxycinnamicacids, chlorogenic acid.

RESUME

An important and little-studied aspect of the effect of human economic activity on medicinal plants is that in response to increased anthropogenic load, additional synthesis of secondary metabolites, particularly oxycoric acids, is induced, which play an important role in the adaptation of plants to changing conditions. The purpose of the study was to study the accumulation of oxycoric acids in the leaves of nettle collected in different agro-

and urbobiogeocenoses of the Voronezh region from the point of view of anthropogenic impact. As part of the study, 51 samples of nettle leaves determined the content of the sum of oxycoric acids in terms of chlorogenic acid. All samples meet the regulatory requirements of this indicator. On average, the content of the sum of oxycoric acids in samples of nettle leaves collected in agrobiogeocenoses does not differ from the content of this group of biologically active substances in samples collected in biocenoses of protected areas. The content of the analyzed group of biologically active substances of samples collected in some urbobiogeocenoses of the Voronezh region is on average 1.5–2 times higher than in samples of natural biocenoses of protected areas. This is due to the fact that the enzyme phenylalanine myacliase has a pronounced stress inducibility, which enhances the synthesis of oxycoric acids, which play the role of membrane stabilizers, preventing the penetration of xenobiotics. It was also noted that as a result of the complex toxic effect on the plant organism, which is observed, for example, near large roads, industrial enterprises, it is possible to reduce biosynthesis of oxycoric acids in the leaves of nettle.

Keywords: Voronezh region, nettle, hydroxycoric acids, chlorogenic acid.

INTRODUCTION

Today, in the medical and pharmaceutical practice of our country, more than 6 thousand medicines are used based on medicinal herbal raw materials. Considerable interest in such medicines is explained by the fact that herbal medicines have a good therapeutic effect and relative harmlessness. A large proportion of the harvesting of phyto-raw materials is located in the European part of the Russian Federation, which is characterized by a significant population density, high economic activity, and the development of transport routes [1, 2]. In this regard, the threat of collecting plant materials in ecologically unfavorable areas increases, and the relevance of identifying the influence of anthropogenic pollution on the chemical composition of plants increases [3].

A synanthropic species, the raw material of which is harvested from wild-growing individuals, is stinging nettle (Urtica dioica L.) is a perennial, ubiquitous herb, widely used in medicine and pharmacy, with a pronounced hemostatic, multivitamin effect. Widespread use is due to the rich chemical composition of the leaves of stinging nettle, which is based on carotenoids, vitamins B, K, C, chlorophyll, tannins, flavonoids, a large amount of organic and phenol carboxylic acids [4].

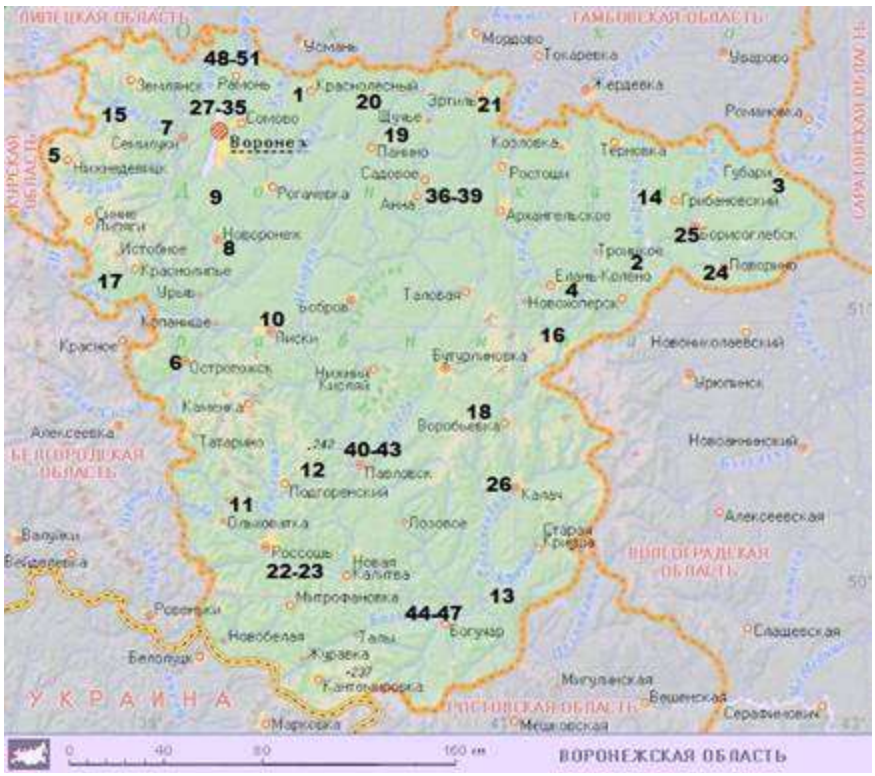
An important and little-studied aspect of the influence of human economic activity on medicinal plants is how an increase in anthropogenic load affects the synthesis of biologically active substances. It is known that ligands for the chelation of toxic substances are organic acids, amino acids, peptides, while some secondary metabolites, for example, phenolic compounds, can act as chelators and take part in the detoxification of pollutants in the plant body. The most important role among low molecular weight phenolic compounds is played by flavonoids, an increase in their content is one of the nonspecific responses to stress.

environment [5–8]. At the same time, the influence of anthropogenic impact on the accumulation of hydroxycinnamic acids in plants, which also belong to phenylpropanoid compounds, representatives of secondary plant metabolites, remains poorly studied.

Purpose of the study: to study the accumulation of the amount of hydroxycinnamic acids inin terms of chlorogenic acid in the leaves of stinging nettle collected in various, from the point of view of anthropogenic impact, agro- and urban-biogeocenoses of the Voronezh region.

MATERIALS AND RESEARCH METHODS

The choice of territories for the selection of samples of plant raw materials is conditioned by the peculiarities of anthropogenic impact (Fig. 1, Table 1): chemical industrial enterprises (Fig. 1: 23, 24, 28); combined heat and power plant (CHP) (Fig. 1: 27); nuclear power plant (NPP) in Novovoronezh (Fig. 1: 8); international airport. Peter I (fig. 1: 30); street of Voronezh (Dimitrov street) (fig. 1: 31); high-voltage power lines (VLE) (Fig. 1: 9); Voronezh reservoir (Fig. 1: 29); small towns (Borisoglebsk (Fig. 1: 25), Kalach (Fig. 1: 26)); zone of significant deposits of nickel ores (Fig. 1: 4); areas located in the zone of radioactive contamination after the accident at the Chernobyl nuclear power plant (Fig. 1: 5–7); active agricultural areas (Figure 1: 10-22); background (for comparison) - protected areas (Fig. 1: 1, 2, 3)).



Rice. 1. Map of sampling of medicinal plant materials (transcript designations in table. 1)

Determination of the content of the sum of hydroxycinnamic acids in terms of chlorogenic acid in selected samples of stinging nettle leaves was carried out according to the standard pharmacopoeial method [9] on an SF-2000 spectrophotometer. Each determination was carried out three times. The data obtained in the course of the research were statistically processed in Microsoft Excel.

RESULTS AND ITS DISCUSSION

The determined indicators of the content of biologically active substances in the leaves of stinging nettle are given in table. 1.

Table 1

The content of biologically active substances in samples of stinging nettle leaves (Urtica dioica L.)

No. p / p	Collection area	Contents of the amount hydroxycinnamic acids in terms of chlorogenic acid,%
1	Voronezh Natural Biosphere Reserve	3.25 ± 0.12
2	Khopersky State Nature Reserve	3.62 ± 0.13
3	with. Makashevka (Borisoglebsky district)	3.19 ± 0.19
4	with. Elan-Koleno	2.71 ± 0.15
5	with. Nizhnedevitsk	4.66 ± 0.10
6	Ostrogozhsk	2.52 ± 0.09
7	Semiluki	4.66 ± 0.16
eight	Novovoronezh	4.39 ± 0.14
nine	VLE	3.32 ± 0.19
ten	Liskinsky district	3.50 ± 0.16
eleven	Olkhovatsky district	2.86 ± 0.12
12	Podgorensky district	2.64 ± 0.15
13	Petropavlovsk district	3.05 ± 0.09
fourteen	Gribanovsky district	3.25 ± 0.13
15	Khokholsky district	2.87 ± 0.16
16	Novokhopersky district	2.51 ± 0.15
17	Repyevsky district	2.63 ± 0.15
eighteen	Vorobievsky district	3.21 ± 0.13
19	Paninsky district	3.07 ± 0.12
twenty	Verkhnekhavsky district	3.04 ± 0.11
21	Ertilsky district	3.03 ± 0.11
22	Rossoshansky district	3.51 ± 0.15
23	Near OJSC "Minudobreniya"	2.41 ± 0.13
24	Close to LLC "Bormash"	2.23 ± 0.12

25	Borisoglebsk	2.13 ± 0.18
26	Kalach	2.05 ± 0.17
27	Near CHP VOGRES	2.64 ± 0.18
28	Close to Sibur LLC	1.67 ± 0.09
29	Along the Voronezh Reservoir.	1.76 ± 0.17
thirty	Airport them. Peter I	3.04 ± 0.18
31	Street in Voronezh (st.Dimitrov)	2.67 ± 0.16
32	Along the M4 highway (Ramonsky district)	2.22 ± 0.16
33	100 m from the M4 highway (Ramonsky district)	2.24 ± 0.12
34	200 m from the M4 highway (Ramonsky district)	2.62 ± 0.17
35	300 m from the M4 highway (Ramonsky district)	3.32 ± 0.12
36	Along the A144 highway (Anninsky district)	2.83 ± 0.13
37	100 m from the A144 highway (Anninsky district)	2.93 ± 0.12
38	200 m from the A144 highway (Anninsky district)	4.79 ± 0.11
39	300 m from the A144 highway (Anninsky district)	5.88 ± 0.18
40	Along the M4 highway (Pavlovsky district)	1.49 ± 0.17
41	100 m from the M4 highway (Pavlovsky district)	1.82 ± 0.18
42	200 m from the M4 highway (Pavlovsky district)	2.49 ± 0.19
43	300 m from the M4 highway (Pavlovsky district)	2.46 ± 0.10
44	Along the low-speed road (Bogucharsky district)	2.22 ± 0.13
45	100 m from the low-speed road (Bogucharsk district)	2.73 ± 0.14
46	200 m from the low-speed road (Bogucharsky district)	3.05 ± 0.14
47	300 m of a low-speed road (Bogucharsky district)	3.92 ± 0.16
48	Along the railway (Ramonsky district)	2.13 ± 0.18
49	100 m from the railway (Ramonsky district)	2.77 ± 0.19
50	200 m from the railway (Ramonsky district)	4.42 ± 0.10
51	300 m from the railway (Ramonsky district)	6.03 ± 0.09
	Numerical indicator for FS [9]	Not less than 0.3

The research results showed that all samples of stinging nettle leaves meet the requirements of the FS for the content of the sum of hydroxycinnamic acids in terms of chlorogenic acid. The samples collected in the control territories contain this group of biologically active substances more than 10 times higher than the lower permissible numerical value [9].

In agrocenoses of the Voronezh region, the content of the total hydroxycinnamic acids in terms of chlorogenic acid in the leaves of stinging nettle varies in the range from 2.51% to 3.51% (in Borisoglebsky, Rossosh, Novokhopersky, Paninsky, Olkhovatsky, Liskinsky, Khokholsky, Repyevsky, Verkhnekhavsky districts). The average content of the sum of hydroxycinnamic acids in the samples collected near agricultural land is 3.05%, which is about 10 times higher than the numerical indicator established by the regulatory documentation and correlates with the data obtained for the samples of control protected areas. In these places, active crop production is carried out, which is characterized by the introduction of a large amount of fertilizer into the soil, which is an activating

factor for the enzyme phenylalanine ammonia lyase, which is a key enzyme in the phenylpropanoid pathway of biosynthesis of the precursor of oxycinnamic acids, transcinnamic acid [5, 6, 10].

In the urbanobiocenoses of the Voronezh Region, the content of the sum of hydroxycinnamic acids in terms of chlorogenic acid in the leaves of stinging nettle varies from 1.49% (for the sample collected along the M4 route in Pavlovsk region) to 6.03% (for the sample collected at a distance of 300 m from the railway). For the samples collected at a distance of 200-300 m from the A144 highway, from the railway, a significant induction of the synthesis of oxycinnamic acids is noticeable, the content of which is 1.5-2 times higher than the concentration of these biologically active substances in the samples collected in control protected areas and agrobiocenoses ... The revealed induction of the synthesis of this group of polyphenols is probably associated with their membrane-stabilizing effect under conditions of oxidative stress. Hydroxycinnamic acids bind to non-phenolic polymers of cell walls, contribute to their strengthening and thus prevent the penetration of xenobiotics. Thus, this fact can be considered a mechanism of natural protection against environmental pollution, aimed at preserving the plant organism of intracellular components susceptible to redox effects [5, 6, 11].

At the same time, a 1.2–2-fold decrease in the total content of hydroxycinnamic acids in terms of chlorogenic acid in samples of stinging nettle leaves collected under conditions of significant anthropogenic load (near OOO Sibur, along the Voronezh reservoir, on the street of Voronezh, along and at a distance of 200 m from the M4 highway in the Ramonsky district, along and at a distance of 100 m from the A144 highway in the Anninsky district, along and at a distance of 300 m from the M4 highway in the Pavlovsky district, along and at a distance of 100 m from the low-speed road in the Bogucharsky district , along and at a distance of 100 m from the railway in the Ramon region) compared to samples from control protected areas and agrobiocenoses. This can be explained by the fact that the synthesis of secondary metabolites is activated in response to stimulating factors, in particular to high concentrations of toxic chemical elements, Moreover, each factor has certain limits of positive influence on organisms, both insufficient and excessive action of a factor can adversely affect the vital activity of an individual. The action of the sum of factors, such as increased dustiness, the presence of a large amount of exhaust gases in the air, as well as a high concentration of toxic substances in the soil, affects the physiological characteristics of plants and affects the strength of the toxic effect of pollutants. In this case, the excessive effect of emissions from industrial enterprises, transport, probably suppresses the antioxidant system of the plant and inhibits the production of polyphenols [5, 6]. Another possible explanation for the decrease in the total content of hydroxycinnamic acids in samples collected near motorways is the fact that that this group of compounds, due to the presence of a large number of OH-substituents in the chemical structure, are chelators of metal ions, which determines their antioxidant properties. Probably formed

complexes interfere at spectrophotometric defining sums hydroxycinnamic acids [9], and therefore we get a reduced absorption rate of the analyzed extract from the leaves of stinging nettle.

CONCLUSIONS

More than 50 samples of stinging nettle leaves collected in various agro- and urban-biogeocenoses of the Voronezh region were analyzed, in which the content of the sum of hydroxycinnamic acids was determined in terms of chlorogenic acid. All selected medicinal plant raw materials, according to the results of our studies, were recognized as benign for this indicator. The content of the sum of hydroxycinnamic acids in samples of stinging nettle leaves collected in agrobiogeocenoses, on average, does not differ from the content of this group of biologically active substances in samples collected in biocenoses of protected areas. The content of the studied group of biologically active substances in the samples collected in some urban biogeocenoses of the Voronezh region is, on average, 1.5–2 times higher than in the samples of natural biocenoses of the reserved zones. This is because that the enzyme phenylalanine ammonia lyase has a pronounced stress inducibility, which enhances the synthesis of oxycinnamic acids, which play the role of membrane stabilizers that prevent the penetration of xenobiotics. It was also noted that as a result of the complex toxic effect on the plant organism, which is observed, for example, near major roads, industrial enterprises, a decrease in the biosynthesis of hydroxycinnamic acids in the leaves of stinging nettle is possible.

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