Pak. J. Bot., 56(2): 611-620, 2024. DOI: http://dx.doi.org/10.30848/PJB2024-2(8)

COMPREHENSIVE STUDY OF THE MAIN BIOLOGICALLY ACTIVE COMPOUNDS IN ARCTIUM LAPPA PLANTS GROWING IN KAZAKHSTAN

MERUYERT ABDIKERIM[1*], GULBAYRA AZIMBAEVA[1], BAKSHAT IZTELEU[1] AND KENZHEGUL SMAILOVA[1]

[1]*Department of Chemistry, Kazakh National Women's Teacher Training University, Almaty, Republic of Kazakhstan*
**Corresponding author's email: mer.abdikerim@gmail.com*

Abstract

For the first time, authors have studied biologically active compounds in Arctium lappa plants growing in Kazakhstan. The demand for biologically active substances is very high in today's global market. They are used in the food industry, in medicine, as well as in folk healing. The aim of the research is to study the total content of phytochemical components from growing Arctium lappa in Kazakhstan, located in the city of Almaty, Medeu district. Modern results of the quantitative content of pectin substances, phenolic acids, tannins, anthocyanins, flavonoids and other biologically active substances in Arctium lappa plants are presented. The macro-and microelement composition was determined by the atomic absorption method on a Shimadzu AA 7000 spectrometer, as a result of the studies, the elemental analysis of the plant showed the highest content of macronutrients, namely K and Ca, and of the trace elements Zn. The amino acid composition of the gas-liquid apparatus was also determined by the chromatographic method of the brand "Carlo-Erba-4200". 20 amino acids were identified. Of these, glutamate (2485 mg/100 g), aspartate (1295 mg/100 g) and alanine (1008 mg/100 g). A method for the determination of fat and water-soluble vitamins by sequential analysis was developed. The method is based on capillary electrophoresis. Water-soluble polysaccharides, hemicellulose A and B were isolated from the underground part of the plant Arctium lappa. Their composition and structure were determined. The isolated hemicellulose A and B were recorded with a potassium bromide tablet in the infrared spectrum of the brand "Specord M-80" the zone 400-4000 cm^{-1}. Phenolic compounds have been isolated from plants of Arctium lappa, including flavonoids pyrocatechin and polyphenols: ethylvaniline, quercetin, myricetin. The obtained compounds were identified based on the results of ultraviolet-visible, infrared, and proton nuclear magnetic resonance spectra.

Key words: Root, Polyphenol, Hemicellulose, Flavonoid, Spectroscopy.

Introduction

Medicinal plants are an important element of local medical systems in most countries. These resources are usually considered part of the traditional knowledge of a particular culture. For many years, Europe has benefited from exchanges on other continents, and many of the pure natural products and some of the herbal medicines used today are derived from plants used in local cultures. The role of the ethnobotanist in the search for new drugs was of constant importance until the second half of the 20th century when other approaches became more "fashionable" (Suleymanov & Pashayeva, 2018). The Asteraceae family of plants includes a large number of species that have been used so far as medicinal plants, especially in folk medicine (Fedoniuk *et al*., 2022). Out of more than six thousand plant species growing in the Republic of Kazakhstan (RK), about five hundred species belong to medicinal plants. One of these plants is Arctium lappa. Arctium lappa is a plant native to Europe and Asia, and it quickly spread to Kazakhstan, where it grows spontaneously in fields, forests and rural areas (Satimbekov *et al*., 2005; Ospanova *et al*., 2018). Two species grow in Kazakhstan: Arctium lappa and Arctium tomentosum. The most common is Arctium lappa. Brazilian researchers have proved that extracts from the leaves of Arctium lappa exhibit high antibacterial and antiviral activity (Holetz *et al*., 2002; Pereira *et al*., 2005; Gentil *et al*., 2006).

Korean researchers tested the ability of the Arctium lappa root to block the occurrence of neoplasts by inducing quinone reductase, a marker enzyme for chemoprophylaxis, in mouse hepatoma cells. It was found that methanol burdock extract significantly induced the activity of quinone reductase and can be used for cancer prevention (Kim & Kim, 1997). Japanese and Hungarian scientists have proved the antitumor activity of juice fractions and methanol extract from the roots of Arctium lappa (Dombradi & Foldeak, 1966; Morita *et al*., 1984; 1985; Ito *et al*., 1986; Koshimizu *et al*., 1988; Sato, 1989; Nakamura *et al*., 1998). Ferracane *et al*., (2010) studied the profile of bioactive metabolism, antioxidant activity and total content of phenolic compounds in the seeds, leaves, and roots of Arctium lappa. Huang *et al*., (2015) received four new glucoside neolignans from the fruits of Arctium lappa. Chen *et al*., (2011) isolated and purified six compounds from 95% ethanol extract of the root of Arctium lappa L. by chromatographic methods. Among them, five chemical components were identified by physico-chemical and spectroscopic analysis as arctiin (1), kaempferol (2), adenosine (3), solasonin (4) and spirosyl-3-O-α-L-rhamnopyrannosyl-(1 →)-O-β-D-galaetopyranosyl (5). Compounds 2-5 were first isolated from the root of Arctium lappa by L.

Milani *et al*., (2011), inulin was extracted from the root of Arctium lappa using high-intensity ultrasound. Wang *et al*., (2019) studied the structural characteristics of a water-soluble polysaccharide from Arctium lappa and its effect on mice with colitis. Shao *et al*., (2016) studied the IR (infrared) and UV (ultraviolet-visible) spectra of various solvents of Arctium lappa extract. Yin *et al*., (2014) An ethanol extract of the Arctium lappa root for use in cigarettes was studied. The object of the study is the aboveground and underground parts of the Arctium lappa plant collected in September 2019. But the biologically active compounds in the Arctium lappa plants growing in Kazakhstan have not yet been studied.

Preparations from the Arctium lappa plant are rich in components that promote the elimination of toxic substances from the body, stimulate the vital activity of the cell protoplasm, stimulate the activity of cells in the nervous system, create conditions for the absorption of biologically active substances (BAS) into the digestive tract (Balayeva *et al*., 2020; Garibli *et al*., 2021). All medicines used in the Republic of Kazakhstan have transported abroad. In the Republic of Kazakhstan, the isolation of medicines necessary for the population from the Arctium lappa plant is becoming relevant (Sokolova *et al*., 1990; Kostina, 2004). Therefore, it is necessary to study the chemical composition of this plant in more detail and scientifically determine its value for pharmacology.

The purpose of the research is to study the total content of phytochemical components from growing Arctium lappa in Kazakhstan, located in the city of Almaty Medeu District.

Material and Methods

The methodological basis of the study is based on a combination of various general scientific methods of knowledge. This study used the methods of analysis and synthesis of information, the comparative method, as well as the method of induction and deduction. To implement the study, the vegetable raw materials were dried on an air-vacuum apparatus at room temperature. A quantitative analysis of biologically active components of plants was carried out. Quantitative analysis of biologically active components of the plant was carried out according to the methods set out in the State pharmacopoeia of the Republic of Kazakhstan (Tulegenova, 2008).

The humidity and ash content of Arctium lappa plants were determined by gravimetric methods, ascorbic acids, pectin substances and tannins were determined by titrimetric methods, the protein composition was determined by Kjeldahl methods, the sugar composition by Bertrand methods, the composition of the clot by A.E. Ermakov methods, fatty acids were extracted using a Soxlet apparatus. As well as the composition of carotene, polyphenolic compounds, flavanoids, anthocyanins were determined by photo-calorimetric methods of the brand KFK-2 (Ermakova, 1972; Golyshenko, 2006; Korepanov *et al*., 2011). The macro-and microelement composition was determined by atomic absorption methods on the Shimadzu AA 7000 spectrophotometer (Shimadzu Europa, 2021). And also, the amino acid composition was determined by gas-liquid chromatography methods on a device of the brand "Carlo-Erba-4200" (Italy- United States of America). The results of the studies are shown in (Table 1-4).

The experimental part. The classical method was first purified from vegetable oils to isolate polyphenolic compounds. To do this, 10 g of raw materials are put in hexane for 3 days. It is filtered, the resulting molasses is dried, placed in a flask, 70 ml of acetone (ethyl acetate), 29.5 ml of distilled water, 0.5 ml of acetic acid are poured and shaken in a magnetic motor at a temperature of 40°C for 1 hour. This process is repeated twice. Then solid-state polyphenolic compounds were evaporated and obtained (Akhtaeva, 2019).

Results and Discussion

Quantitative analysis of biologically active components that determine the moisture content, total ash, and the content of extractive substances gives great value to plants. As a result of the study, the content or composition of ash in plant raw materials varies within certain limits and depends on the specifics of the raw material itself, the method of its collection and drying conditions. Significant deviations usually indicate contamination of raw materials with a mineral impurity or untimely collection of raw materials, etc. A complex of organic and inorganic substances extracted from plant raw materials with an appropriate solvent and quantified in the form of a dry residue is conventionally called extractive substances of medicinal plant raw materials. The amount of extractive substances in the medicinal plant is an important numerical indicator that determines its good quality in terms of the content of biological metabolites (Lyubchyk *et al*., 2019). As a rule, the solvent is used for tincture or extract from raw materials, which is more profitable when preparing (Table 1).

As a result of research, the composition and content of biologically active substances were determined in Arctium lappa plants. More BAS were detected: flavanoids, polyphenols, phenolic acids, carotenes, proteins. The amount of protein compared to the stem in the tubers is 3 times more, and in the leaves 6 times more, that is, the value is closer to the roots. The amount of coumarin content in tubers and stems is closer to the roots in value and in leaves 11 times more. The amount of fatty acid content compared to the stems in the leaves is 2 times more and in the tubers 12 times more, the roots 2 times more. The amount of phenolic acids in tubers and stems is closer in value and in leaves and roots 5 times more. The amount of polyphenols in the leaves is greater, the tubers compared to the roots are 1.5 times less, the roots compared to the tubers are 2 times more. The amount of flavonoids in the tubers and stems is less, the leaves are 4 times more than the roots (Table 2).

Table 1. Physical and chemical properties of Arctium lappa plants.

No.	Name of the raw material	pH				Humidity, %	Ash content, %	Extractivity, %	
		In the water, %	In alcohol, %					In the water	In alcohol
			40	70	90				
1.	Leaves	7.43	7.49	7.14	7.25	10	24	22.22	20.22
2.	Stems	6.06	6.34	6.22	6.51	6.7	15	21.44	0.55
3.	Tubers	6.42	6.16	6.57	6.61	6.4	3.05	35.87	23.21
4.	Roots	6.90	7.49	7.21	7.59	7.5	3.02	37.55	28.12

Table 2. Quantity and content of biologically active substances in Arctium lappa plants.

Name		Leaves	Stems	Tubers	Root
Pectin substances, %	Water-soluble	8.25	5.79	3.32	3.11
	Not water-soluble	9.10	6.63	11.71	2.48
Phenolic acids, %	Gallic acids	0.33	0.04	1.30	1.43
	Caffeic acids	0.07	0.07	7.83	8.60
Tannins, %		15.83	19.31	3.32	5.38
Anthocyanins, %		0.10	0.07	0.03	0.02
Flavonoids, %		1.92	0.46	0.38	1.45
Polyphenols, %		14.50	11.45	9.54	4.07
Inulin, %		-	-	-	37.2
Protein, %		27.0	5.63	18.88	3.72
Cellulose %		35.4	58.7	49.75	5.15
Carotenes, mkg/100g		328	94.0	289.0	149
Coumarins, %		2.12	0.19	0.17	-
Ascorbic acids, мг/%		4.71	3.21	5.42	4.53
Fats, %		1.68	0.94	12.38	2.31
Sugar, %		2.72	4.81	-	2.93

Table 3. Elemental composition of Arctium lappa plants, mg/kg.

Element	Leaves	Stems	Tubers	Roots
Cu	0.58	0.31	0.65	0.34
Zn	0.68	0.63	0.74	0.51
Mn	0.20	0.18	0.19	0.02
Fe	527	238	312	0.54
Co	0.07	0.03	0.12	0.0005
Cd	0.04	<0.02	<0.02	0.0002
Ca	380	182	152	52
Mg	171	112	74	35
K	279	189	219	29
Na	24	18	15	24

Table 4. Amino acid composition of Arctium lappa plants, mg/100g.

No.	Name of amino acids	Leaves	Stems	Tubers	Roots
1.	Alanine	1008	926	1058	1008
2.	Glycine	312	294	332	312
3.	Leucine	442	412	464	442
4.	Isoleucine	351	336	370	351
5.	Valin	248	233	265	248
6.	Glutamate	2485	2388	2608	2485
7.	Threonine	251	242	270	251
8.	Proline	822	790	842	822
9.	Methionine	148	136	160	148
10.	Serin	440	422	458	440
11.	Aspartate	1295	1246	1324	1295
12.	Cystine	42	38	48	42
13.	Oxyproline	3	2	4	3
14.	Phenylalanine	286	271	306	286
15.	Tyrosine	349	332	368	349
16.	Histidine	330	318	351	330
17.	Ornithine	4	3	5	4
18.	Arginine	531	518	550	531
19.	Lysine	342	328	365	342
20.	Tryptophan	115	108	128	115

Phenolic acids, including their derivatives, alkaloids, flavanoids, tannins, phytic acid and many sterols are typical phytochemical compounds with antioxidant activity. Among these phytocomponents, considerable attention is paid to phenolic compounds, since these compounds in the usual diet help to resist oxidative stress by eliminating free radicals, chelating pro-oxidant metals, immunomodulating action, protecting and regenerating other food antioxidants (for example, vitamin E) in the body (Gadetskaya, 2013; Tarakhovsky *et al*., 2013; Pace *et al*., 2014). 10 macro- and microelements were identified in Arctium lappa plants, as shown in (Table 3).

According to the results of Table 3, a greater amount of macro-and microelement composition was detected in the leaves of Arctium lappa plants (Baltabayeva *et al*., 2013). The value of macro-and microelements does not reach the maximum permissible concentration. Potassium plays a key role in many physiological functions, such as stomatal opening and photosynthesis, photosynthetic transfer, polypeptide synthesis and meristematic growth, enzyme activation, charge balancing and neutralization functions, osmoregulation, stress resistance and fruit quality improvement (Epstein & Bloom, 2005; Arquero *et al*., 2006; Saykhul *et al*., 2013). As a result of the studies shown in (Table 4), 20 amino acids were determined in the aboveground part of Arctium lappa medicinal plants. According to the dynamics a larger number of amino acid composition are presented: stems → leaves → roots → tubers.

A very high amount of amino acid content is glutamate, aspartate, alanine. Glutamate in tubers – 2608mg/100g, in leaves – 2485mg/100g, stems – 2388mg/100g, roots – 2485 mg/100g. The amount of asparate content compared to the stem (1246mg/100g) in the leaves (1295mg/100g) is greater. And the tuber (1324mg/100g) is larger compared to the leaves, the value of the amino acid composition is closer on the stems and roots. According to the dynamics of alanine growth, the stems (926mg/100g) → leaves (1008mg/100g) → roots (1008mg/100g) → tubers (1058mg/100g) are shown below (Table 5). As well as the amount of amino acid content in the aboveground and underground parts of plants are different. Amino acids are biomolecules that are vital for all organisms and are the building blocks of proteins and essential substances, such as neurotransmitters, nucleic acids, hormones (Aouniti *et al*., 2013).

Table 5. Vitamin composition of Arctium lappa plants, mg/100 g.

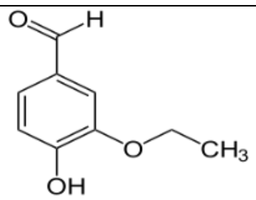
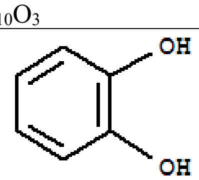
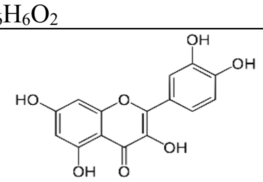
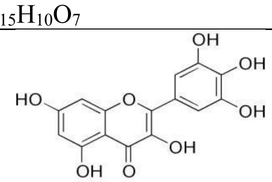
Name of vitamins	Leaves	Stems	Roots
	Water-soluble vitamins (B)		
B_1 (thiamine chloride)	-	-	0.0031
B_2 (riboflavin)	0.11	0.040	0.017
B_3 (pantothenic acids)	0.10	0.010	0.062
B_5 (nicotinic acids)	0.21	0.063	0.015
B_6 (pyridoxine)	-	0.020	0.020
B_c (folic acids)	0.0092	0.008	-
	Fat-soluble vitamins (E)		
α- tocopherol	0.94	0.06	0.0056
β- tocopherol	0.30	0.0021	0.0024
γ- tocopherol	-	-	-
δ- tocopherol	0.063	-	-

The content of vitamins B and E in Arctium lappa plants was studied. The results of the study are presented in Table 5 and Figures 1-3. As a result of the experiment, parts of plants with an increased content of vitamins B1, B2, B3, B5, B6 and Bc – in the stem were isolated. Vitamin E is found in fruits. The specified plant species Arctium lappa can be recommended as promising source of vitamins B and E. Vitamins are organic compounds that the body needs as vital nutrients in tiny amounts. Vitamins serve as biocatalysts in many chemical reactions, as well as precursors of various factors of the body (Roje, 2007).

The results of the microanalysis of the isolated polyphenol and flavonoids from the aboveground part of Arctium lappa plants are given in Table 6 (Tarakhovsky *et al*., 2013).

According to the results given in Table 6, it shows the isolated flavonoids from the leaves of Arctium lappa. The gross formula of the flavonoid $C_6H_6O_2$ is pyrocatechin. Pyrocatechin is colorless, a solid crystalline compound, with a melting point is 93-187^{0}C (Anchell, 2009). The melting point is determined on an electronic heating device of the brand "Boetius". As well as the formula of the isolated polyphenol $C_9H_{10}O_3$. It is an ethylvaniline has a colorless needle-like crystalline substance. It is used as a flavoring agent. The structure and composition of the isolated flavonoids and polyphenol were determined on the IR spectrum of the brand "Specord M-80" in the bands 400-4000 cm^{-1} in KBr (potassium bromide) tablets. The IR spectra of ethylvaniline correspond to the furan cycles of 1348 cm^{-1}. The absorption region in this spectrum corresponds to the C-H group in the aromatic ring of 2887 cm^{-1}, and the oscillation frequency of 3448 cm^{-1} corresponds to the hydroxyl groups bound by a hydrogen bond. The melting point of the isolated polyphenol corresponds to the literature data (Yakimova, 2015). According to the results of Fig. 4, the IR spectra of the polyphenol correspond to the furan cycles of 1348 cm^{-1}. The absorption region in this spectrum corresponds to the C-H group in the aromatic ring of 2887 cm^{-1}, hydroxyl groups bound by a hydrogen bond of 3448 cm^{-1}.

Table 6. Microanalysis of polyphenol and flavonoid.

No.	Raw material	Exit, %	Melting point °C	Found, %		Gross formula	Calculated, %	
				C	H		C	H
1.	Leaves	2.4	93	42.32	1.149	 Ethylvaniline $C_9H_{10}O_3$	65.6	6.2
2.	Leaves	2.1	137	44.82	2.172	 Pyrocatechin $C_6H_6O_2$	65.4	5.4
3.	Stems	3.9	187	59.55	3.3	 Quercetin $C_{15}H_{10}O_7$	58.57	3.9
4.	Roots	2.85	353	56.60	3.14	 Myricetin $C_{15}H_{10}O_8$	56.60	3.14

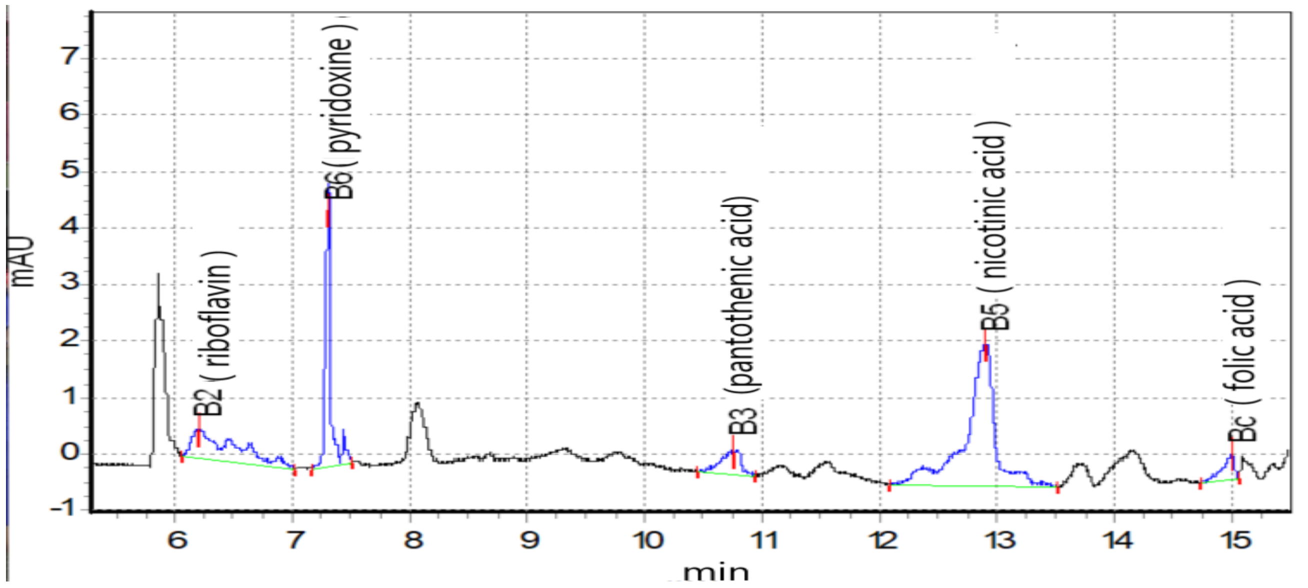


Fig. 1. The content of vitamins in the leaves of Arctium lappa plants.

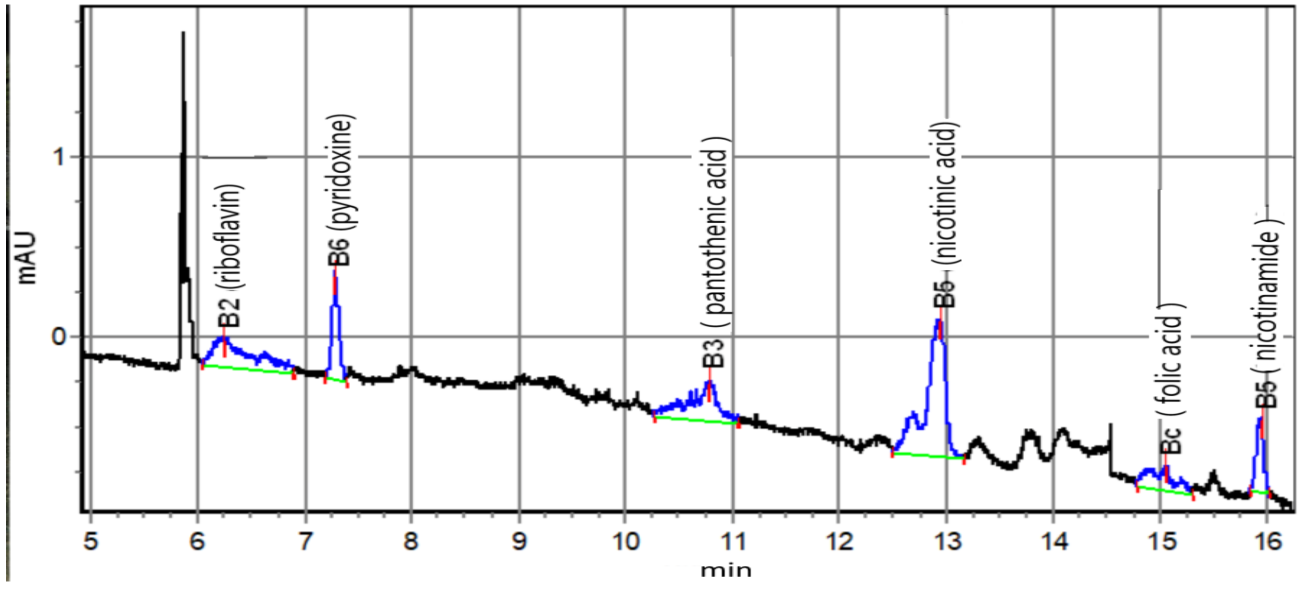


Fig. 2. Vitamin content in the stems of Arctium lappa plants.

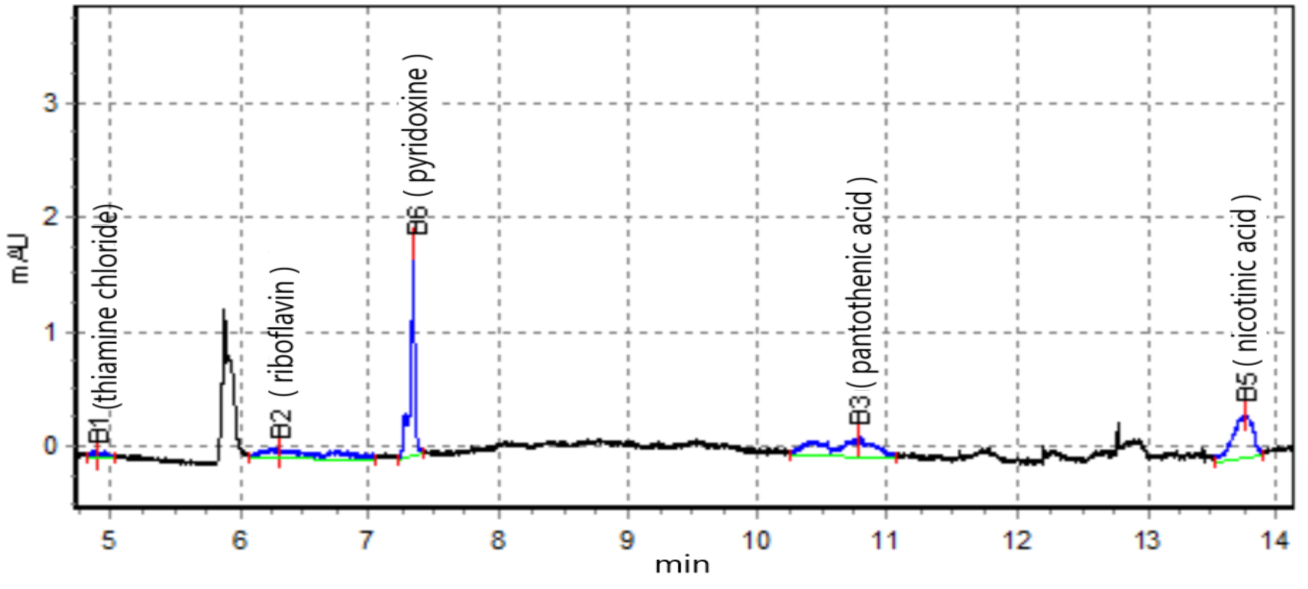


Fig. 3. Vitamin content in the roots of Arctium lappa plants.

According to the data shown in Fig. 5, the IR spectra of pyrocatechin correspond to the absorption bands of the furfural groups of 1350 cm^{-1}. And 1634 cm^{-1} corresponds to the presence of water and the deviation of the C-H group. 1632 cm^{-1} corresponds to the furan cycle. 3421 cm^{-1} corresponds to the carbonyl group-pyron.

According to Fig. 6, the structure of the isolated polyphenol was detected on a UV spectrophotometer of the brand "Uviline 9100" and the highest absorption was observed at a wavelength of 320 nm corresponding to phenolic compounds according to the literature data.

The IR of polyphenols isolated from the root of the Arctium lappa plant was recorded with a KBr tablet in the "Specord M-80" IR spectroscopy. The NMR (nuclear magnetic resonance) spectrum was captured using the JNN-EKA spectrometer of the "Jeol" company. In the ^{1}H core, the operating frequency of the spectrometer corresponds to 400 and 100 MHz. The survey was carried out at room temperature using a solution of HDO (heavy water) (Kazitsyna & Kupletskaya, 1971; Tarasevich, 2012). The data from the results of the study are presented in Figs. 6-8. In the one-dimensional ^{1}H signal, the myricetin spectrum does not occur in the high-frequency part. The resonant lines of aliphatic compounds are shown.

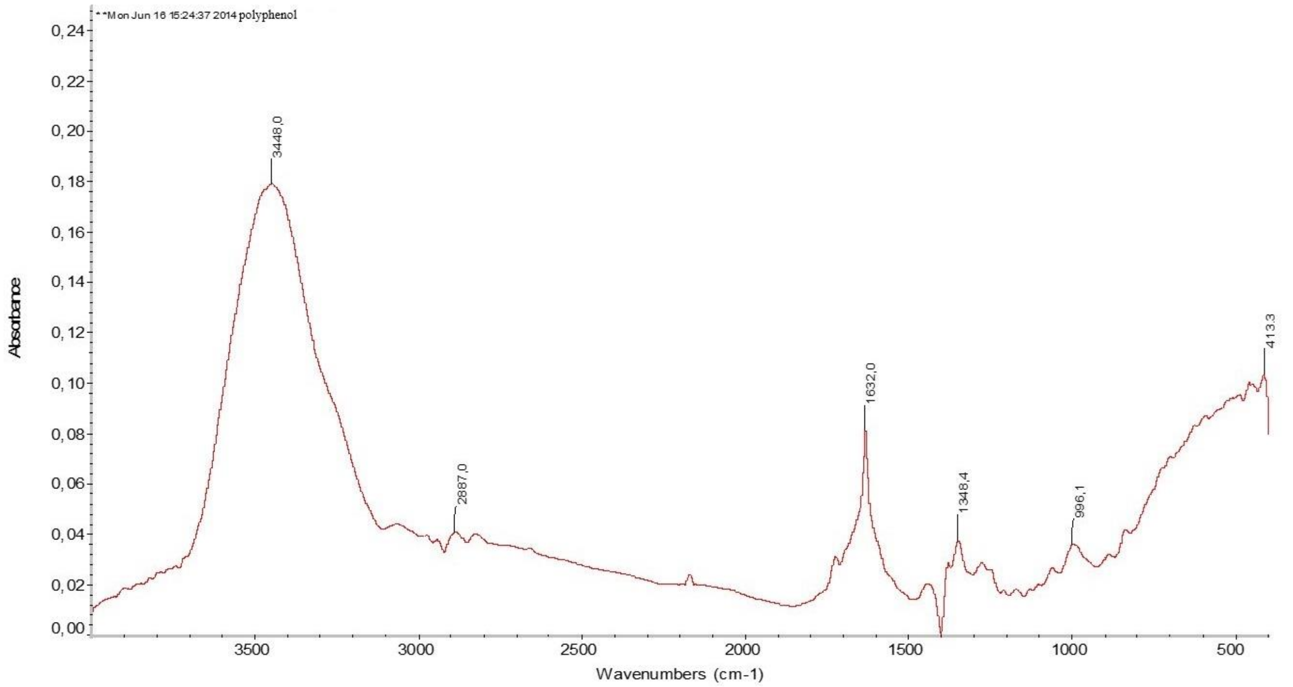


Fig. 4. IR spectrum of the isolated polyphenol.

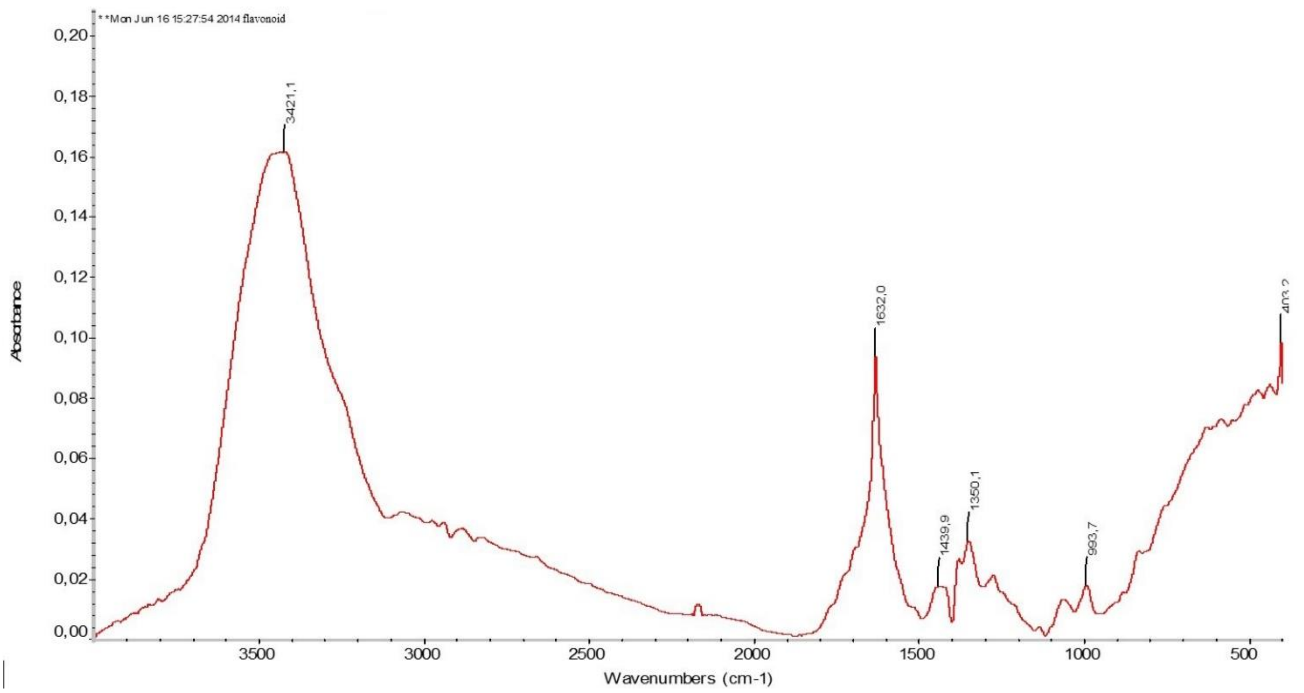


Fig. 5. IR spectra of a flavonoid.

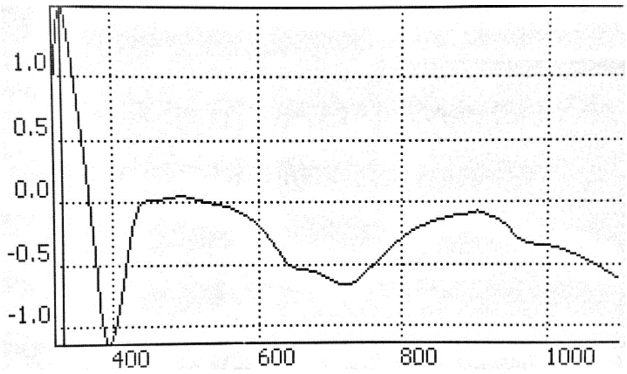


Fig. 6. UV-spectra of isolated polyphenol from the stems of Arctium lappa plants.

According to the results shown in Fig. 7, the IR spectra of the isolated polyphenol are presented. As shown in Figure 7, the data in the IR spectrum of polyphenols isolated from the root of the Arctium lappa plant, if the valence oscillation of the O-H group corresponds to the region of 3246.05-3277.41 cm^{-1}, the C-H group indicates a valence oscillation of the region of 2938.76-2925.30 cm-1, the C = O group shows a valence oscillation of 1631.39-1601.65 cm^{-1}, and the oscillation frequency of 1028.94-1019.43 cm^{-1} corresponds to the valence oscillations of the C = O group. Also, the area of 931.71-928.0 cm^{-1} reflects the α-glycoside bond of the C = O group. The numerical values of the IR spectra of pectin substances isolated from the root of the Arctium lappa plant are close to each other. Therefore, it corresponds to the literature data (Meisurov *et al.*, 2006).

The results shown in Table 7 show the isolation of hemicellulose A and B from the roots of Arctium lappa plants. In the form of an extractant is 10% NaOH. The ratio of solid to liquid corresponds to 1:10, the extraction time is 12 hours. Organoleptic properties of the isolated hemicellulose A from the roots of plants Arctium lappa is a white-brown crystalline substance. The product yield is 2.82%.

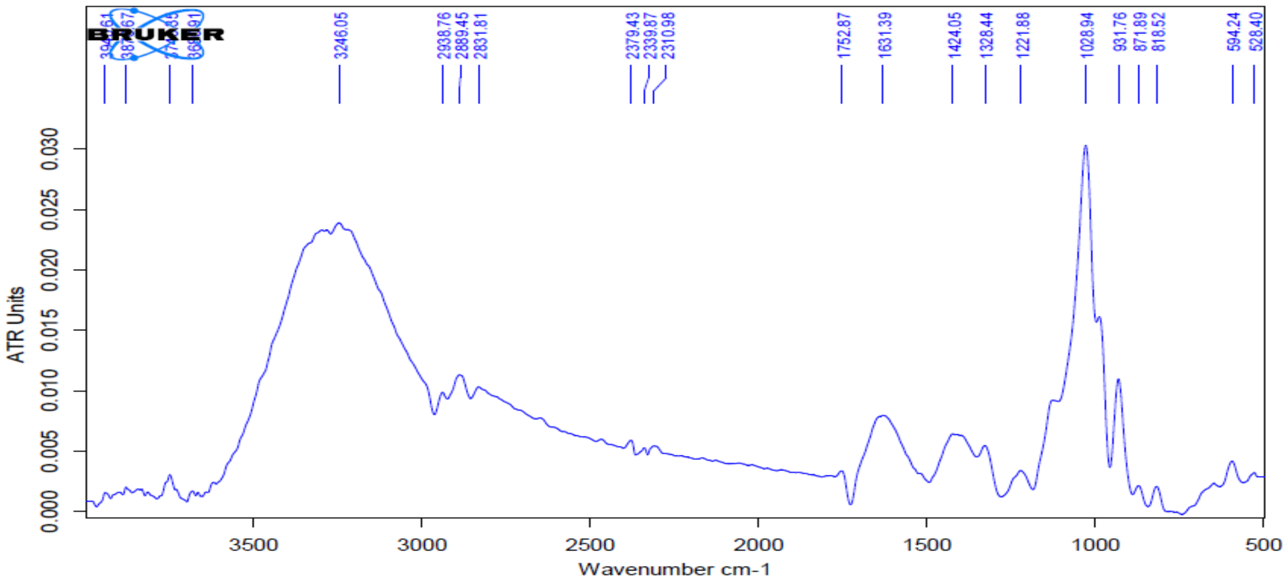


Fig. 7. IR spectra of isolated polyphenol from the roots of Arctium lappa plants.

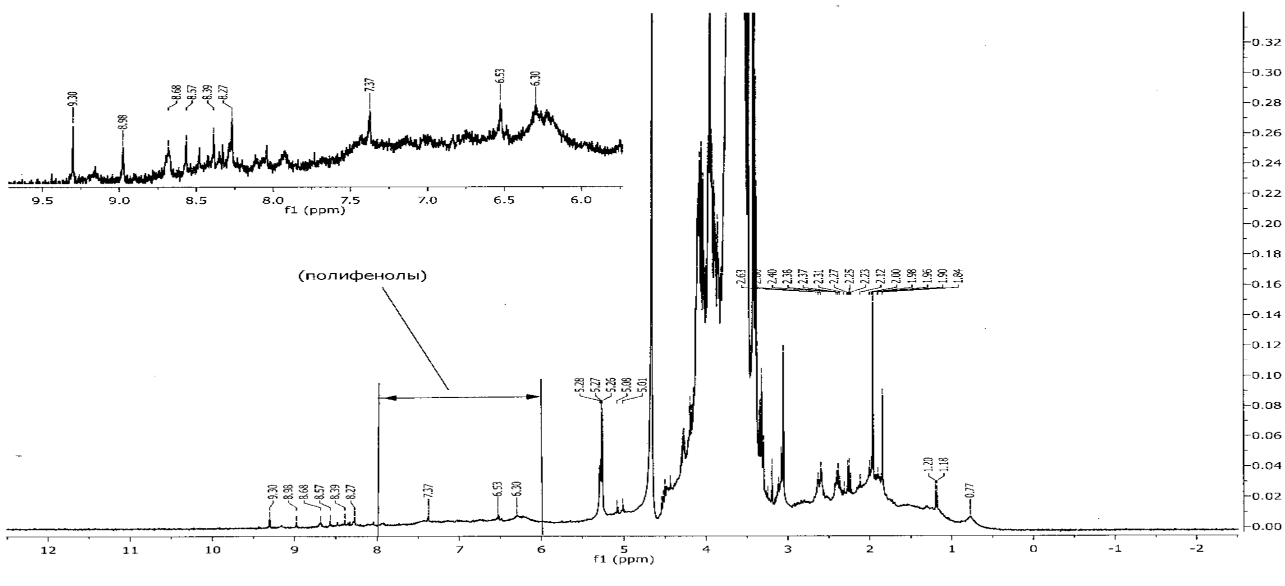


Fig. 8. [1]H NMR spectra of isolated myricetin.

Table 7. Optimal conditions for the isolation of hemicellulose A from the roots of Arctium lappa plants and organeptic properties.

Name of the raw material	Molasses, g	Extraction 10% NaOH		Precipitation in acetic acid		Yield hemicellulose A, %	Organoleptic properties	
		S:L	τ, hour	S:L	τ, hour		Colour	Aggregate state
Roots	7,95	1:10	12	1:3	24	2.82	White-brown	Crystal

Table 8. Optimal conditions for the isolation of hemicellulose B from the roots of Arctium lappa plants and organeptic properties.

Name of the raw material	Molasses, g	Precipitation of 96% alcohol		Yield hemicellulose B, %	Organoleptic properties	
		S:L	τ, hour		Colour	Aggregate state
Roots	7.95	1:3	24	2.76	Brown	Crystal

According to the results given in Table 8, it shows that the yield of isolated hemicellulose B from the roots is – 2.76%, a brown crystalline substance.

The determination of the structural formula of hemicellulose A and B isolated from the root of Arctium lappa was recorded with a KBr tablet on an IR spectrometer of the brand “Specord M-80”. The data of the IR spectra of the isolated hemicelluloses A and B are shown in Figures 9, 10 and in Table 8. According to the data shown in Figure 9, the valence vibrations of the OH group in the IR spectra of hemicellulose B isolated from the root of the Arctium lappa plant are 3564.71-3563.36 cm^{-1} the region 1426.84-1402.06 cm^{-1} reflects the deformation vibrations of the COOH group. The CH group indicates deformation vibrations of the zones 787.50-638.52 cm^{-1} and 772.54-637.77 cm^{-1}, the C = C group shows valence vibrations of 1572.62-1564.60 cm^{-1}, and the oscillation frequency of 1713.60-1712.38 cm^{-1} corresponds to the COOH group. The valence oscillations of the CO group are observed in the region of 1023.59-1027.51 cm^{-1}. Therefore, it corresponds to the literature data. The numerical values of the IR spectra of hemicellulose A isolated from the root of Arctium lappa are close to each other, they correspond to the literature data (Brienzo *et al*., 2009).

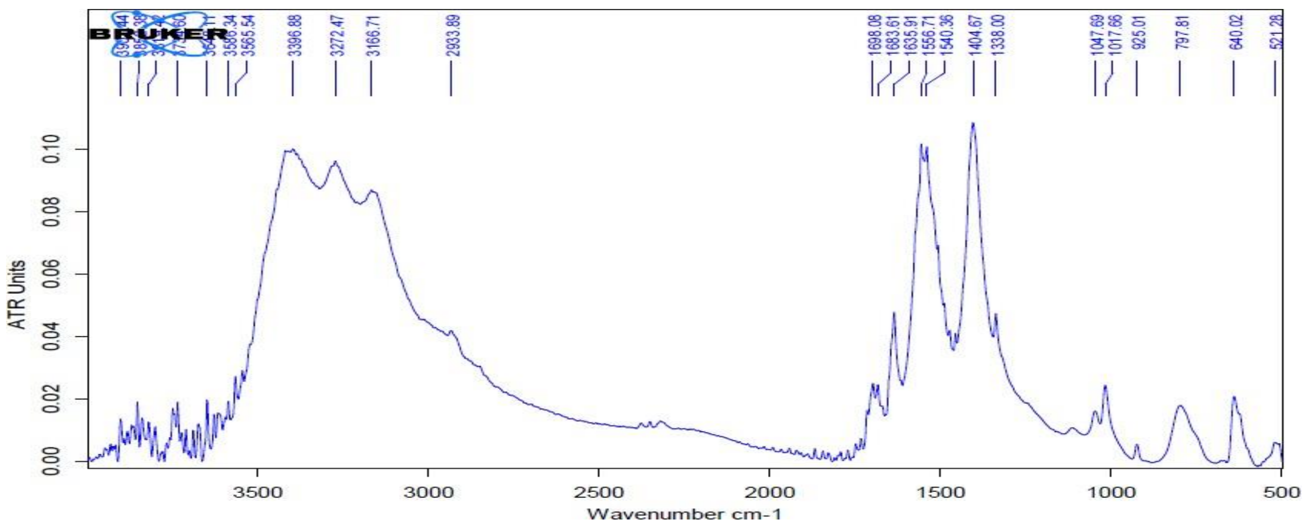


Fig. 9. IR spectra of isolated hemicellulose A.

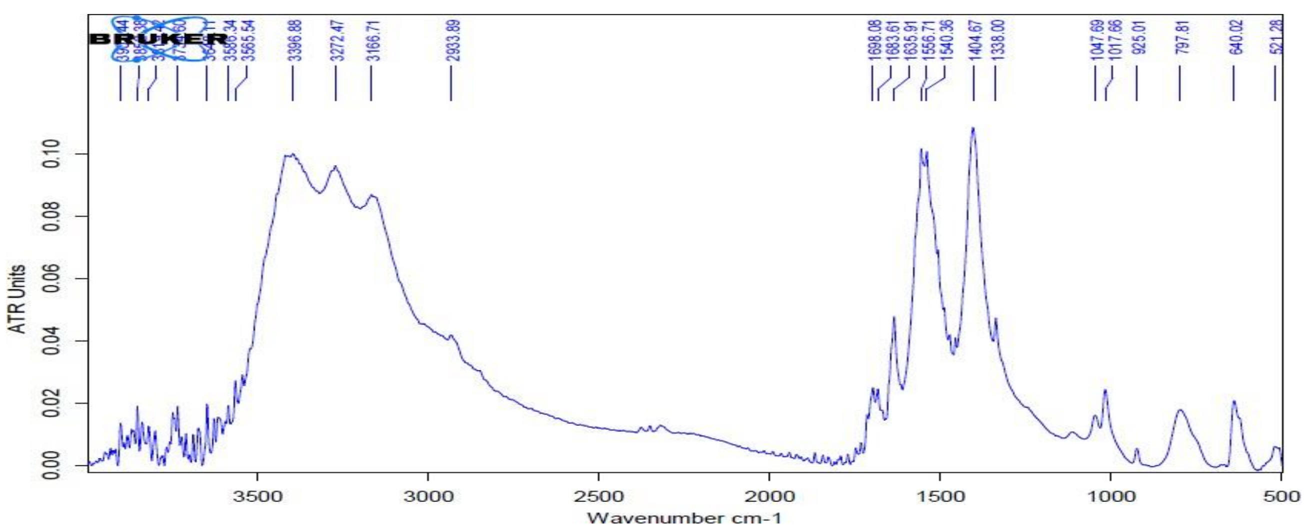


Fig. 10. IR spectra of isolated hemicellulose B from the roots of Arctium lappa plants.

According to the data shown in Figure 10, in the IR spectra of hemicellulose B isolated from the root of the Arctium lappa plant from two places, the valence vibrations of group B correspond to the region 3564.71-3563.36 cm^{-1}, and the zone 1426.84-1402.06 cm^{-1} reflect the deformation vibrations of the COOH group. The CH group indicates deformation vibrations of the zones 787.50-638.52 cm^{-1} and 772.54-637.77 cm^{-1}, the C = C group shows valence vibrations of 1572.62-1564.60 cm^{-1}, and the oscillation frequency of 1713.60-1712.38 cm^{-1} corresponds to the COOH group. The valence oscillations of the CO group are observed in the region of 1023.59-1027.51 cm^{-1}. Therefore, it corresponds to the literature data (Galletti *et al.*, 2015).

Conclusions

The research work shows that Arctium lappa plants, due to the availability of raw materials, a wide range of biological activity, are promising for creating effective medicines and other types of products that are in demand in various industries. The chemical composition and biologically active substances of the Arctium lappa plant were determined. As a result, it was found that the Arctium lappa plant contains a large amount of inulin, protein, fat, and polyphenol. The content of 10 macro- and microelements in the plant was determined. These are copper, zinc, manganese, iron, cobalt, cadmium, calcium, magnesium, potassium, sodium. The content of 20 amino acids in the plant Arctium lappa was established. Of these, the largest amount of glutamate and aspartate is contained in all organs of the plant. The formula of the flavanoid $C_6H_6O_2$ (pyrocatechin), isolated from the leaves of Arctium lappa. The melting point is 137°C. The formula of polyphenol $C_9H_{10}O_3$ (ethylvaniline), isolated from the leaves of Arctium lappa. The melting point is 93°C. The formula of polyphenol $C_{15}H_{10}O_7$ (quercetin), isolated from the stem of Arctium lappa. The melting point is 187°C.

The melting point of the polyphenol isolated from the roots of the Arctium lappa plant corresponds to the literature data. The formula of the polyphenol isolated from the root of Arctium lappa is $C_{15}H_{10}O_8$ (myricetin). Hemicelluloses A and B were isolated from the Arctium lappa plant. The yield of hemicellulose A is 2.82%, and the yield of hemicellulose B is 2.76%. The composition and structure of polyphenols, hemicellulose A and B isolated from the Arctium lappa plant were identified by IR, UV, NMR spectroscopy, and elemental analysis.

Acknowledgements

The authors are grateful to the Kazakh National Women's Teacher Training University, the Department of Chemistry and also, Ph.D., Acting Professor G.E. Azimbaeva, Laboratory of Organic Synthesis of the National Research Tomsk State University, leading researcher Professor, Doctor of Chemical Sciences A.A. Bakibaev.

References

Akhtaeva, M.B. 2019. Separation of polyphenolic compounds from the territorial plant of Urctica Dioica L. available at: https://cutt.ly/eTKFL2d.

Anchell, S. 2009. The darkroom cookbook. Elsevier, Oxford, UK.

Aouniti, A., K. Khaled and B. Hammouti. 2013. Correlation between inhibition efficiency and chemical structure of some amino acids on the corrosion of armco iron in molar HCl. *Int. J. Electrochem. Sci*., 8: 5925-5943.

Arquero, O., D. Barranco and M. Benlloch. 2006. Potassium starvation increases stomatal conductance in olive trees. *Hort-Science*, 41(2): 433-436.

Balayeva, E.Z., T.A. Suleymanov, J. Hanaee and A. Jouyban. 2020. Liquid chromatographic determination of thymol in a pharmaceutical formulation. *Lat. Am. J. Pharm.*, 39(8): 1509-1514.

Baltabayeva, Zh. T., G. Ye. Azimbayeva and B.M. Butin. 2013. Determination of the chemical composition of alcoholic extracts of Arctium lappa by gas-chromatographic method. *Bull. Karaganda Univ*., 3(71): 10-17.

Brienzo, M., A.F. Siqueira and A.M.F. Milagres. 2009. Search for optimum conditions of sugarcane bagasse hemicellulose extraction. *Biochem. Engin. J*., 46: 199-204.

Chen, S., S. Bao, T. Shao and K. Chen. 2011. Chemical constituents of the root of Arctium lappa L. *Tianran Chanwu Yanjiu Yu Kaifa*, 23(6): 1055-1057.

Dombradi, C.A. and S. Foldeak. 1966. Screening report on the antitumor activity of purified Arctium Lappa extracts. *Tumori J*., 52(3): 173-175.

Epstein, E. and A.J. Bloom. 2005. Mineral nutrition of plants: Principles and perspectives. Sinauer Associates, Sunderland, USA.

Ermakova, A.I. (Ed.). 1972. Biochemical research methods of plants. Kolos, Leningrad, Russian Federation.

Fedoniuk, T., M. Bog, O. Orlov and K.J. Appenroth. 2022. Lemna aequinoctialis migrates further into temperate continental Europe—A new alien aquatic plant for Ukraine. *Feddes Repertor.*, 133(4): 305-312.

Ferracane, R., G. Graziani, M. Gallo, V. Fogliano and A. Ritieni. 2010. Metabolic profile of the bioactive compounds of burdock (Arctium lappa) seeds, roots, and leaves. *J. Pharmaceut. Biomed. Anal*., 51(2): 399-404.

Gadetskaya, A.V. 2013. Biologically active compounds plants Limonium Gmelinii and Limonium Myrianthum. Available at: https://www.pdau.edu.ua/sites/default/files/node/1239/21gadeckaya.pdf.

Galletti, A.M.R., A. D'Alessio, D. Licursi, C. Antonetti, G. Valentini, A. Galia and O.N.N. Di Nasso. 2015. Midinfrared FT-IR as a tool for monitoring herbaceous biomass composition and its conversion to furfural. *J. Spectr*., 2015(1): 1-12.

Garibli, A.S., T.A. Suleymanov, E. Ollivier and G. Herbette. 2021. Flavonoids from Medicago falcata from the Flora of Azerbaijan. *Chem. Nat. Compd.*, 57(1): 150-151.

Gentil, M., J.V. Pereira, Y.T.C. Silva-Sousa, R. Pietro, M.D.S. Neto, L.P. Vansan and S. de Castro França. 2006. In vitro evaluation of the antibacterial activity of Arctium lappa as a phytotherapeutic agent used in intracanal dressings. *Phytother. Res*., 20(3): 184-186.

Golyshenko, P.P. 2006. Medicinal plants and their use. Mordovskoe Izdatelstvo, Saransk, Russian Federation.

Holetz, F.B., G.L. Pessini, N.R. Sanches, D.A. Garcia Cortez, C.V. Nakamura and B.P.D. Filho. 2002. Screening of some plants used in the Brazilian folk medicine for the treatment of infectious diseases. *Mem. Inst. Oswaldo Cruz,* 97(7): 1027-1031.

Huang, X.Y., Z.M. Feng, Y.N. Yang, J.S. Jiang and P.C. Zhang. 2015. Four new neolignan glucosides from the fruits of Arctium lappa. *J. Asian Nat. Prod. Res*., 17(5): 504-511.

Ito, Y., S. Maeda and T. Sugiyama. 1986. Suppression of 7.12-dimethylbenz[a]anthracene-induced chromosome aberrations in rat bone marrow cells by vegetable juices. *Mutat. Res*., 172(1): 55-60.

Kazitsyna, L.A. and N.B. Kupletskaya. 1971. Application of UV, IR and NMR spectroscopy in organic chemistry. Vysshaya Shkola, Moscow, Russian Federation.

Kim, S.M. and J.S. Kim. 1997. Induction of anticarcinogenic ensyme by some Korean vegetable extracts. *FASEB J.*, 3: 369-373.

Korepanov, S.V., T.G. Openko and N.D. Veryaskina. 2011. In vivo study of the antitumor properties of a wild medicinal plant, cocklebur (xanthium strumarium). *World Sci. Cult. Educ.*, 4(29): 230-234.

Koshimizu, K., H. Ohigashi, H. Tokuda, A. Kondo and K. Yamaguchi. 1988. Screening of edible plants against possible anti-tumor promoting activity. *Cancer Letters*, 39(3): 247-257.

Kostina, L.A. 2004. Burdock treatment. Aveont, Moscow, Russian Federation.

Lyubchyk, S., O. Shapovalova, O. Lygina, M.C. Oliveira, N. Appazov, A. Lyubchyk, A.J. Charmier, S. Lyubchik and A.J.L. Pombeiro. 2019. Integrated Green Chemical Approach to the Medicinal Plant Carpobrotus edulis Processing. *Sci. Rep.*, 9(1): 18171.

Meisurov, A.F., S.D. Khizhnyak, S.M. Dementieva and P.M. Pakhomov. 2006. IR-spectroscopic study of the samples of Hypogymnia physodes (l.) nyl., subjected to atmospheric pollution. Model experiment. *Polzunovsky Bull*., 2: 350-360.

Milani, E., A. Koocheki and Q.A. Golimovahhed. 2011. Extraction of inulin from Burdock root (Arctium lappa) using high intensity ultrasound. *Int. J. Food Sci. Technol*., 46(8): 1699-1704.

Morita, K., T. Kada and M. Namiki. 1984. A desmutagenic factor isolated from burdock (Arctium lappa Linne). *Mutat. Res.*, 129(1): 25-31.

Morita, K., Y. Nishijima and T. Kada. 1985. Chemical nature of a desmutagenic factor from burdock (Actium lappa Linne). *Agric. Biol. Chem*., 49(4): 925-932.

Nakamura, Y., E. Suganuma, N. Kuyama, K. Sato and K. Ohtsuki. 1998. Comparative bio-antimutagenicity of common vegetables and traditional vegetables in Kyoto. *Biosci. Biotechnol. Biochem*., 62(6): 1161-1165.

Ospanova, A., L. Anuarova, A. Spanbayev, Z. Tulegenova, T. Yechshzhanov, S. Shapalov, B. Gabdulkhayeva, B. Zhumabekova, S. Kabieva and B. Baidalinova. 2018. Cytospora cankers on tree plants in urban areas (Karaganda, Astana, Pavlodar) of central and northern Kazakhstan. *Ekoloji*, 27(106): 63-69.

Pace, G., G. Lima, F. Vianello, C.R. Correa, R. Arnoux, R.A. da Silva Campos and M.G. Borguini. 2014. Polyphenols in fruits and vegetables and its effect on human health. *Food Nutrit. Sci.*, 5(11): 1065-1082.

Pereira, J.V., D.C.B. Bergamo, J.O. Pereira, S. de Castro França, R.C.L.R. Pietro and Y.T.C. Silva-Sousa. 2005. Antimicrobial activity of Arctium lappa constituents against microorganisms commonly found in endodontic infections. *Brazil. Dent. J*., 16(3): 192-196.

Roje, S. 2007. Vitamin B biosynthesis in plants. *Phytochemistry*, 68(14): 1904-1921.

Satimbekov, R., R. Alimkulova and B. Zairova. 2005. Biology. Zhazshi Publishing House, Almaty, Republic of Kazakhstan.

Sato, A. 1989. Studies on anti-tumor activity of crude drugs. I. The effects of aqueous extracts of some crude drugs in short-term screening test. *J. Pharm. Soc. Jpn*., 109(6): 407-423.

Saykhul, A., T. Chatzistathis, C. Chatzissavvidis, S. Koundouras, I. Therios and K. Dimassi. 2013. Potassium utilization efficiency of three olive cultivars grown in a hydroponic system. *Sci. Hortic.*, 162: 55-62.

Shao, J., X. Wen, L. Wang, and M. Guo. 2016. Study on IR, UV spectrum of different solvent extract of Arctium lappa. *J. Anhui Agric. Univ*., 44(7): 147-150.

Shimadzu Europa GmbH. 2021. Available at: https://www.shimadzu.ru/.

Sokolova, N.S., T.G. Panfilova and G.A. Panfilov. 1990. Wild and cultivated plants in folk medicine. Impex, Moscow, Russian Federation.

Suleymanov, T.A. and N.H. Pashayeva. 2018. Study of flavonoids composition the herb of veronica crista-galli stev. *Azerb. Pharm. Pharmacother. J.*, 18(2): 10-13.

Tarakhovsky, Yu. S., Yu. A. Kim, B.S. Abdrasilov and E.N. Muzafarov. 2013. Flavonoids: Biochemistry, biophysics, medicine. Synchrobook, Pushchino, Russian Federation.

Tarasevich, B.N. 2012. IR spectra of the main classes of organic compounds. Moscow State University named after M.V. Lomonosov, Moscow, Russian Federation.

Tulegenova, A.U. (Ed.). 2008. State pharmacopoeia of the Republic of Kazakhstan. Zhibek Zholy, Almaty, Republic of Kazakhstan.

Wang, Y., N. Zhang, J. Kan, X. Zhang, X. Wu, R. Sun, S. Tang, J. Liu, C. Qian and C. Jin. 2019. Structural characterization of water-soluble polysaccharide from Arctium lappa and its effects on colitis mice. *Carbohydr. Polym.*, 213: 89-99.

Yakimova, L.S. 2015. UV spectroscopy method and its application in organic and physical chemistry. Kazan Federal University, Kazan, Russian Federation.

Yin, Y., H. Zhang, Y. Bo, M. Que, H. Zhang, C. Ding, P. Xu, X. Chen and G. Liu. 2014. Ethanol extract of Arctium lappa root for use in cigaret. China Light Industry Press, Beijing, China.

(Received for publication 12 October 2022)