ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 13(1) 2014, 55-65*

CHEMICAL CHARACTERISTICS OF EUROPEAN GOLDENROD (*Solidago virgaurea* L. subsp. *virgaurea*) FROM NATURAL SITES IN CENTRAL AND EASTERN POLAND

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Abstract. In Poland European goldenrod grows all over the country. The raw material of this species is herb characterised by diuretic, detoxifying, anti-inflammatory, and bile secretion enhancing properties. Pharmacological activity of European goldenrod results from the presence of many biologically active compounds, among which phenolic compounds are considered to be most valuable. In this work differences in accumulation of flavonoids and polyphenolic acids in the herb of European goldenrod from natural sites in central and eastern Poland were determined. Flavonoid content ranged from 600 to 1850 mg·100 g^{-1}, and polyphenolic acids from 440 to 1200 mg·100 g^{-1}. High content of these compounds was characteristic for the herb collected at the vegetative stage of plant development (in June). Chromatographic analysis (HPLC) showed the presence of three flavonoid compounds (hyperoside, rutin, and astragalin) and two polyphenolic acids (rosmarinic and chlorogenic) in all studied populations. Rutin was the main compound in the flavonoid fraction. Its content ranged from 87.78 to 387.87 mg·100 g^{-1}. The content of rosmarinic acid was higher than the content of chlorogenic acid (mean value: 577.52 and 267.03 mg·100 g^{-1}, respectively).

Key words: light indicator, rutin, hyperoside, astragalin, chlorogenic acid, rosmarinic acid

INTRODUCTION

In Poland European goldenrod (*Solidago virgaurea* L.) grows all over the country, mainly in the lowlands and low mountains, in dry meadows, brushwoods, forest glades and margins, and on roadsides. It is regarded as a native species [Matuszkiewicz 2001, Wysocki and Sikorski 2002]. The raw material of this species is herb (flowering above-

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ground plant parts) characterised by sour and bitter taste. Diuretic, detoxifying, anti-inflammatory, and bile secretion enhancing properties of this raw material have been known and used for a long time [Yarnell 2002, Melzig 2004, Kołodziej et al. 2011]. Apart from the positive effect on the urinary system, herb and extracts of European goldenrod show analgesic, antifungal, antispasmodic, diaphoretic, and immunostimulant action. The effect on reducing permeability of the blood vessels was also observed [Thiem and Goślińska 2002, Yarnel 2002, Choi et. al. 2004, Melzig 2004, Starks et al. 2010]. Pharmacological activity of the European goldenrod herb results from the presence of many biologically active compounds, among which flavonoids, polyphenolic acids, saponins, triterpenes, and essential oil are considered to be most important [Budzianowski 1990, Pietta et al. 1991, Bader et al. 1995, Thiem et al. 2001, Kalemba and Thiem 2004, Tkachev et al. 2006]. In Poland goldenrod herb is collected mainly from natural sites. This way of raw material obtaining makes it not uniform in respect of the content of biologically active compounds that affect its pharmacological activity. Detailed characteristics of the natural sites can provide valuable information about the profitability of harvesting and the range of variation of chemical characteristics of the raw material, which is often affected by the environmental conditions [Bagdonaitė et al. 2006, Rosłon and Suchorska-Tropiło 2007, Kosakowska et al. 2008].

The aim of the study was to characterise 10 natural sites of European goldenrod in central and eastern Poland and to compare the populations of this species occurring on these sites in respect of accumulation of flavonoids and polyphenolic acids in herb.

MATERIAL AND METHODS

The study was conducted in 2009 and 2010. In June 2009 in two provinces of Poland (Mazowieckie and Podlaskie) 10 natural sites of European goldenrod (*Solidago virgaurea* L. subsp. *virgaurea*) were selected for investigation. The selected sites have been known to be the places of European goldenrod herb harvesting for commercial purposes. The identity of goldenrod was confirmed using the plant identification key [Rutkowski 2006].

In the Mazowieckie province the natural sites were located near Warsaw (Rembertów, Otrębusy, Podkowa Leśna Główna, Podkowa Leśna Zachodnia, Kazimierówka), and in the Podlaskie province in Koryciny (3 sites), Śpieszyn, and Siemiony.

Geographic location of the investigated natural sites was determined using the GPS (tab. 1).

For each natural site plant species composition was described and light indicator was determined basing on ecological numbers [Zarzycki et al. 2002]. Abundance of European goldenrod on the investigated sites was determined using the Braun-Blanquet scale [Wysocki and Sikorski 2002].

From each natural site in both years of the study the herb was collected three times. The first harvest was performed in the second decade of June (at the vegetative stage of plant development), the second one in the first decade of July (at the initial phase of flowering), and the third one in the first decade of September (at the stage of flowering). In each term 2 kg of fresh herb were harvested. After harvesting the raw material was

dried naturally (in a well-ventilated, shaded place). In the air-dry raw material the content of flavonoids and polyphenolic acids were determined [according to the Polish Pharmacopoeia VI, 2002].

Total content of flavonoids was determined by spectrophotometric method based on fluorescent properties of the chelates these compounds form with $AlCl_3$. The raw material was extracted with acetone. The hydrolysis of flavonoids was performed by using hydrochloric acid (28 $g \cdot l^{-1}$). Flavonoids were extracted from acetone extract with ethyl acetate. Absorbance of the obtained solution was measured at 425 nm wave length. The content of flavonoids was expressed as quercetin equivalents.

Total content of polyphenolic acids was determined by spectrophotometric method, too. The raw material was extracted with water. Absorbance of the solution consisting of this extract, Arnov reagent, 1 n HCL, and 1 n NaOH was measured at 490 nm. The content of polyphenolic acids was calculated as caffeic acid equivalents.

For the plants harvested in July 2009 both qualitative and quantitative analysis of the fraction of polyphenols was carried out using high performance liquid chromatography (HPLC) on Shimadzu chromatograph with diode array detector (SPD-M10A VP). Herb (1 g) was extracted with methanol (10 ml). For the separation of phenolic compounds the gradient of solvents (10% acetonitrile in water and 55% acetonitrile in water) at a flow rate 1.0 $ml \cdot min^{-1}$ was applied. The analysis was carried out on the column Luna 5 mm C18 (2) 250 mm × 4.6 mm (Phenomenex) at 35°C for 40 min. The signals from the diode detector were recorded as a series of chromatograms at the wavelength range 190–900 nm. Peaks were identified by comparison of retention time and spectral data with the adequate parameters of standards (purchased from ChromaDex). For the quantitative analysis the calibration curve method based on the peak area was used. The results were integrated at a wavelength of 254 nm (hyperoside and rutin), 264 nm (astragalin), and 330 nm (rosmarinic acid and chlorogenic acid) in 7.3 CLASS VP Shimadzu. The content of the determined phenolic compounds was calculated in $mg \cdot 100\ g^{-1}$ dry matter.

All analyses were performed in triplicate. The obtained results were subjected to statistical analysis using the computer programs ANOVA 1 and ANOVA 2. The significance of differences was determined with the Fisher's Least Significant Difference test at the significance level 95%.

As the data concerning the content of determined groups of active compounds were similar in both years of the study, the results presented in this paper are means from two years.

RESULTS AND DISCUSSION

Natural sites of European goldenrod described in this study were located in the habitats typical for this species. These were mixed forests (4 sites), meadows (2 sites) and wastelands near roads and railway tracks (4 sites). In these communities despite of European goldenrod other plants were present, namely: *Pinus sylvestris*, *Picea abies*, *Quercus robur*, *Betula pendula*, *Corylus avellana*, *Hieracium umbellatum*, *Vaccinium myrtillus*, *Fragaria vesca*, *Dryopteris filix-mas*, and *Melampyrum pratense*, which are

Table 1. List and characteristics of natural sites of European goldenrod

Site number	Site name	Geographical coordinates	Site characteristics	Light indicator	Abundance of European goldenrod		Major accompanying species
					2009	2010	
1	Koryciny 1	N: 52º38'356'' E: 22º45'845''	glade in the mixed forest	3.9	3	3	*Betula pendula, Pinus sylvestris, Quercus robur, Hieracium pilosella, Hieracium umbellatum, Veronica chamaedrys, Achillea millefolium*
2	Koryciny 2	N: 52º38'429'' E: 22°45'550''	mixed forest near the farm	2.9	3	2	*Betula pendula, Picea abies, Carpinus betulus, Quercus robur, Corylus avellana, Rubus idaeus, Dryopteris filix-mas, Hypericum maculatum, Fragaria vesca, Geum urbanum, Dactylis glomerata, Achillea millefolium*
3	Koryciny 3	N: 52º37'873'' E: 22º45'542''	mixed forest, a place locally called "fox mountain"	2.9	1	+	*Pinus sylvestris, Quercus robur, Corylus avellana, Frangula alnus, Convallaria majalis, Dryopteris filix-mas, Vaccinium myrtillus, Fragaria vesca, Anemone nemorosa, Stellaria holostea, Poa pratensis*
4	Śpieszyn	N: 53º22'253'' E: 18°00'446''	edge of the mixed forest (fire road)	3.1	1	1	*Betula pendula, Picea abies, Carpinus betulus, Pinus sylvestris, Sarothamnus scoparius, Melampyrum pratense, Fragaria vesca, Vaccinium myrtillus, Dactylis glomerata, Poa pratensis*
5	Siemiony	N: 52º38'062'' E: 22º47'827''	meadow near the gravel-pit	5.0	4	3	*Knautia arvensis, Achillea millefolium, Hieracium pilosella, Potentilla reptans, Helichrysum arenarium, Erigeron canadensis, Plantago lanceolata, Poa pratensis, Elymus repens, Elymus arenarius*
6	Rembertów	N: 52º25'700'' E: 21º14'501''	meadow situated near the communication route and the railway tracks	4.3	1	1	*Agrostis vulgaris, Solidago canadensis, Plantago lanceolata, Plantago major, Trifolium arvense*
7	Otrębusy	N: 52º12'521'' E: 20º76'002''	meadow situated near the railway tracks	4.5	2	2	*Achillea millefolium, Artemisia vulgaris, Cerastium arvense, Melilotus alba, Plantago major, Poa trivialis, Rumex acetosa, Solidago canadensis, Tanacetum vulgare, Trifolium arvense*
8	Podkowa Leśna Główna	N: 52º12'111'' E: 20º72'203''	green belt near the railway tracks	4.5	2	2	*Betula pendula, Robinia pseudoacacia, Salix alba, Carpinus betulus, Achillea millefolium, Aethusa cynapium, Anthriscus sylvestris, Artemisia vulgaris, Chelidonium majus, Ranunculus ficaria, Tanacetum vulgare, Taraxacum officinale*
9	Podkowa Leśna Zachodnia	N: 52º12'099'' E: 20º71'306''	slope near railway tracks	4.0	2	3	*Quercus robur, Sorbus aucuparia, Achillea millefolium, Taraxacum officinale, Trifolium aureum, Vicia cracca, Chamaecytisus ratisbonensis*
10	Kazimierówka	N: 52º11'200'' E: 20º70'004''	slope near the railway tracks	4.0	1	1	*Quercus robur, Achillea millefolium, Agrostis vulgaris, Hieracium pilosella, Hypericum perforatum, Rubus fruticosa, Taraxacum officinale, Trifolium arvense*

the species typical of mixed forests, according to Wysocki and Sikorski [2002], and *Trifolium arvense*, *Hieracium pilosella*, *Veronica chamaedrys*, *Hypericum perforatum*, and *Helichrysum arenarium*, which occur in sandy grasslands, on the sunny and dry sites. Both of these types of plant communities exist in central and eastern Poland [Matuszkiewicz 2001, Wysocki and Sikorski 2002].

Specific habitat requirements of all wild plants, including European goldenrod, can be described using the so-called ecological numbers [Zarzycki et al. 2002]. Among these numbers noteworthy is light indicator. For European goldenrod it usually ranges from 3.0 to 4.0, which shows that this species prefers partially shaded to moderately lit places. At the described natural sites light indicator ranged from 2.9 to 5.0. On 4 of 10 described sites (Siemiony, Rembertów, Otrębusy, Podkowa Leśna Główna) it was higher than 4.0, and on 2 sites (Koryciny 2 and Koryciny 3) lower than 3.0. On these latter two sites reduction of the population of European goldenrod was observed in 2010 comparing to 2009, which probably resulted from the excessive shading, although overharvesting of plants may also be the reason. Tendency towards the decreased abundance of European goldenrod as a result of tree development (increased shading) was observed by Czerepko [2004]. Reduction of area coverage by European goldenrod plants have also been reported in the case of the site located near the village of Siemiony, where the light indicator was the highest. There was no evidence of the negative effect of excessive light intensity on the development of populations of European goldenrod in Rembertów, Otrębusy, and Podkowa Leśna Główna, where the light indicator was higher than 4.0. Only at the natural site located in Podkowa Leśna Zachodnia (light indicator 4.0) an increase in the number of plants was reported, which indicates that at this site European goldenrod found optimal conditions for growth and development (tab. 1).

European goldenrod abundance evaluated according to Braun-Blanquet scale [Wysocki and Sikorski 2002] ranged from a few individuals in the site Koryciny 3 to any number of individuals covering 60% of the site area (Siemiony). Four of the described natural sites (Koryciny 3, Śpieszyn, Rembertów, and Kazimierówka) were characterised by a low area coverage by European goldenrod plants (abundance of "+" to "1"), which indicates that in these places collection of raw material for commercial purposes should not be executed, since there is a risk of disappearance of this species from these sites.

Phytochemical studies on European goldenrod herb indicate the presence of many biologically active compounds. Important chemical compounds that affect the therapeutic activity of this raw material are polyphenolics, including flavonoids and polyphenolic acids [Budzianowski 1990, Pietta et al. 1991, Jaiswal et al. 2011].

The content of flavonoids in European goldenrod herb ranges from 350 to 2400 mg·100 g^{-1} [Kalemba et al. 1993, Thiem et al. 2001, Kołodziej et al. 2011]. In the present study the content of flavonoids ranged from 850 to 1380 mg·100 g^{-1}. Significant differences in the content of these compounds were observed depending on raw material origin. The highest content of flavonoids was found in the herb collected in Podkowa Leśna Zachodnia (1380 mg·100 g^{-1}) and Podkowa Leśna Główna (1350 mg·100 g^{-1}), whereas the lowest one in the herb collected in Koryciny 1. Many authors report that the content of flavonoids in plants is directly proportional to the amount of light reaching the plants [Germ et al. 2010, Muzitano et al. 2011]. In the present study such relation

was not observed. Herb of European goldenrod harvested in the natural site characterised by the highest light indicator (Siemiony) and in Rembertów, where the light indicator was also high (4.3), contained significantly lower amount of these compounds in comparison with the raw material obtained from the populations in Koryciny 2 and Koryciny 3 growing in shaded areas (light indicator 2.9). Moreover, populations characterised by the lowest (Koryciny 1) and the highest (Podkowa Leśna Zachodnia) content of flavonoids grew in places of a similar light indicator (3.9 and 4.0, respectively).

No effect of light intensity on the flavonoid content in plants was observed by Awad et al. [2001]. Hashiba et al. [2006] in the study on *Campanula punctata* found weak correlation between sunlight intensity and accumulation of flavonoids and suggested that the synthesis of these compounds could be influenced by various microenvironmental factors. The time of harvest of raw material affects the content of the analysed group of compounds. Studies concerning accumulation of flavonoids in plants during their growing season give ambiguous results. In the studies of Baraldi et al. [2008] the content of flavonoids in the herb of *Artemisia annua* decreased during plant development. Karlová [2006] in the studies on *Achillea collina* noted that the amount of flavonoids increased continuously from the stage of flower differentiation till the stage of full flowering, and then decreased. The results obtained in this work show that the content of flavonoids in the herb of European goldenrod was highest at the vegetative stage of plant development (in June). Lower content of these compounds was found in the herb harvested at the initial phase of flowering (in July) and during flowering (in September). In the case of populations No. 1 (Koryciny 1) and No. 3 (Koryciny 3) herb collected in September was characterised by the significantly higher flavonoid content in comparison with the raw material harvested in July (tab. 2).

Table 2. Accumulation of flavonoids in the herb of European goldenrod (mg·100 g^{-1})

Site number*	Harvest time			Mean
	June	July	September	
1	1060d	600f	900de	850E
2	1230cd	1010de	780ef	1010C
3	1660c	950de	1250cd	1290B
4	820e	990de	990de	930D
5	1170cd	790e	890de	950D
6	1120d	800e	890de	940D
7	1950a	920de	900de	1270B
8	1850ab	1160cd	1030de	1350A
9	1790b	1240cd	1120cd	1380A
10	1100d	1040de	930de	1020C
Mean	1380A	950B	970B	

The same letters indicate homogeneous groups.
* Sites are numbered as in Table 1.

Qualitative assessment of the flavonoid fraction in European goldenrod herb was done by a number of authors [Borkowski and Skrzypczakowa 1962, Skrzypczakowa 1962, Budzianowski 1990, Pietta et al. 1991, Apáti et al. 2003, Choi et al. 2004]. The results of their studies indicate the presence of quercetin, quercetin-3-O-glucoside, quercetin-3-O-galactoside, quercetin-3-O-rhamnoside, quercetin-3-O-rutinoside (rutin), kaempferol-3-O-glucoside, kaempferol-3-O-rhamnoside, kaempferol-3-O-rutinoside, kaempferol-3-O-robinobioside, isorhamnetin-3-O-rutinoside, as well as O-glycosylflavones, mono-C-glycosylflavones, and di-C-glycosylflavones.

In this work three flavonoid compounds were identified in the herb of all investigated populations: hyperoside (quercetin-3-O-galactoside), astragalin (kaempferol-3-O--glucoside), and rutin (quercetin-3-O-rutinoside). Rutin turned out to be a dominant compound (mean content 196.42 mg·100 g^{-1}), which is consistent with the results obtained by Borkowski and Skrzypczakowa [1962]. Astragalin content ranged from 20.66 to 60.55 mg·100 g^{-1}, and hyperoside content from 17.65 to 83.89 mg·100 g^{-1} (tab. 3).

Table 3. Content of identified flavonoid compounds in the herb of European goldenrod harvested in July (mg·100 g^{-1})

Site number*	Hyperoside	Rutin	Astragalin
1	58.80b	317.65c	52.43c
2	40.06d	135.30f	44.24d
3	21.32g	87.78j	31.11f
4	48.34c	219.53d	58.23b
5	58.82b	387.87a	59.54b
6	29.41f	92.52i	34.85e
7	83.89a	329.41b	60.44a
8	17.65h	100.00h	20.66g
9	41.18d	170.59e	60.55a
10	38.24e	123.53g	44.29d
Mean	43.77C	196.42A	46.83B

The same letters indicate homogeneous groups.
* Sites are numbered as in Table 1.

Another important phenolic compounds present in European goldenrod herb are polyphenolic acids. Many studies show that they are in part responsible for antioxidant, anti-inflammatory, and bile flow enhancing properties of goldenrod herb [Kähkönen et al. 1999, Demir et al. 2009]. According to the assessment report on *Solidago virgaurea* [EMEA 2008] the content of these compounds is about 400 mg·100 g^{-1}, while according to Kähkönen et al. [1999] it reaches 820 mg·100 g^{-1}. The results obtained in the present study ranged from 440 mg·100 g^{-1} to 1200 mg·100 g^{-1}. The content of these compounds depended on the location and time of raw material harvest. The highest average content of polyphenolic acids was characteristic for the raw material from Siemiony (1080 mg·100 g^{-1}) and the lowest one for that from Koryciny 3 site (490 mg·100 g^{-1}) (tab. 4).

Table 4. Accumulation of polyphenolic acids in the herb of European goldenrod (mg·100 g^{-1})

Site number*	Harvest time			Mean
	June	July	September	
1	990bc	680de	990bc	870D
2	730d	740d	790cd	750F
3	590e	450f	440f	490I
4	750d	660de	800cd	740F
5	1170a	880c	1200a	1080A
6	930bc	850cd	1000b	930C
7	990bc	980bc	950bc	970B
8	850cd	770de	810cd	810E
9	600e	680de	700de	660G
10	600e	560ef	700de	620H
Mean	820A	730B	840A	

The same letters indicate homogeneous groups.
* Sites are numbered as in Table 1.

Assessment of accumulation of these compounds in the European goldenrod herb showed that the herb harvested at the vegetative stage of plant development (in June) and during flowering (in September) was characterised by higher content of polyphenolic acids in comparison with the raw material collected at the initial stage of flowering (in July). Similar dependence was observed by Węglarz and Rosłon [1998] in the study on the accumulation of these compounds in the herb and underground parts of *Lycopus europaeus* L.

Table 5. Content of identified polyphenolic acids in the herb of European goldenrod harvested in July (mg·100 g^{-1})

Site number*	Rosmarinic acid	Chlorogenic acid
1	660.26d	200.00e
2	482.43h	158.99j
3	499.89f	183.76f
4	306.89i	165.50g
5	898.70a	360.67d
6	256.38j	161.21h
7	863.97b	425.74b
8	497.60g	160.57i
9	645.91e	441.50a
10	663.21c	412.05c
Mean	577.52A	267.03B

The same letters indicate homogeneous groups.
* Sites are numbered as in Table 1.

In the fraction of polyphenolic acids occurring in European goldenrod herb Kalemba [1992] identified salicylic, p-hydroxybenzoic, p-coumaric, protocatechuic, gentisic, ferulic, synapic, caffeic, and chlorogenic acid. Research performed by Jaiswal et al. [2011] showed the presence of a number of hydroxycinnamates. In our study chlorogenic acid and rosmarinic acid were detected in the herb of the investigated populations of European goldenrod. In all analysed samples rosmarinic acid was present in a higher amount than chlorogenic acid. Rosmarinic acid content ranged from 256.38 mg·100 g^{-1} (Rembertów) to 898.70 mg·100 g^{-1} (Siemiony), while chlorogenic acid from 158.99 mg·100 g^{-1} (Koryciny 2) to 441.85 mg·100 g^{-1} (Podkowa Leśna Zachodnia). Mean content of rosmarinic acid in herb was twice as high as chlorogenic acid content (tab. 5).

Content of the identified polyphenolic acids was higher than the content of the identified flavonoids (tabs 3 and 5). Similar results were obtained by Thiem et al. [2001].

CONCLUSIONS

1. Described natural sites of European goldenrod in central and eastern Poland differed in the abundance of this species. However most locations were characterised by a low degree of area coverage.

2. There was no clear relation between light conditions at the site and the abundance of European goldenrod.

3. Content of flavonoids and polyphenolic acids in the herb of European goldenrod was affected by the place and time of the raw material harvesting.

4. Taking into consideration accumulation of flavonoids and phenolic acids in the herb of European goldenrod, this raw material should be harvested at the vegetative stage of plant development (in June).

5. Irrespective of the site of collection of European goldenrod herb, three flavonoids (rutin, astragalin, and hyperoside) and two polyphenolic acids (rosmarinic and chlorogenic one) were identified in this raw material.

6. Rutin was the dominant constituent of the flavonoid fraction, and rosmarinic acid was present in a higher amount in comparison with chlorogenic acid.

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CHARAKTERYSTYKA CHEMICZNA NAWŁOCI POSPOLITEJ (*Solidago virgaurea* L. subsp. *virgaurea*) ZE STANOWISK NATURALNYCH W ŚRODKOWEJ I WSCHODNIEJ POLSCE

Streszczenie. W Polsce nawłoć pospolita występuje na terenie całego kraju. Surowcem pozyskiwanym z tego gatunku jest ziele, które wykazuje właściwości diuretyczne, detoksykujące, a także przeciwzapalne, żółciotwórcze i żółciopędne. Aktywność farmakologiczna nawłoci uwarunkowana jest obecnością wielu substancji biologicznie czynnych, z których związki polifenolowe uważane są za najbardziej wartościowe. W pracy oceniono różnice w gromadzeniu się flawonoidów i kwasów polifenolowych w zielu zebranym z naturalnych stanowisk nawłoci pospolitej w centralnej i wschodniej Polsce. Zawartość flawonoidów wynosiła od 600 do 1850 mg·100 g^{-1}, a polifenolokwasów od 440 do 1200 mg·100 g^{-1}. Wysoką zawartością tych związków charakteryzowało się ziele zebrane w fazie wegetatywnego rozwoju roślin (w czerwcu). Analiza chromatograficzna (HPLC) wykazała obecność trzech związków flawonoidowych (hiperozydu, rutyny i astragaliny) oraz dwóch kwasów polifenolowych (rozmarynowego i chlorogenowego). We frakcji flawonoidowej najwięcej było rutyny (jej zawartość wynosiła od 87,78 do 387,87 mg·100 g^{-1}). Zawartość kwasu rozmarynowego (średnio 577,52 mg·100 g^{-1}) była większa niż kwasu chlorogenowego (średnio 267,03 mg·100 g^{-1}).

Słowa kluczowe: wskaźnik świetlny, rutyna, hiperozyd, astragalina, kwas chlorogenowy, kwas rozmarynowy

Accepted for print: 27.05.2013