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Ex situ studies on chemical and morphological variability of *Hypericum perforatum* L. in Lithuania

Edita Bagdonaitė[1,*],

Valdimaras Janulis[2],

Liudas Ivanauskas[2],

Juozas Labokas[1]

[1] *Institute of Botany, Žaliųjų Ežerų 49, LT-08406 Vilnius, Lithuania*

[2] *Kaunas University of Medicine, A. Mickevičiaus 9, LT-44307 Kaunas, Lithuania*

This study describes the variation of hypericin and flavonoid contents in different accessions of Saint John's Wort, *Hypericum perforatum* L. Twenty-one Lithuanian wild accessions as well as two cultivars, Polish 'Topas' and Russian 'Zolotodolinskaya', were studied under the same cultivated field conditions with the latter two used as control. The chemical and morphological investigations were carried out in two-year-old plants. Samples of flowering tops of *H. perforatum* were collected and analysed for hypericin and flavonoids using high performance liquid chromatography (HPLC) analysis. The results showed that hypericin contents in flowering tops ranged within 0.23–1.24 mg/g; flavonoid contents varied in different accessions as follows: rutin 2.95–17.10 mg/g, hyperoside 0.42–31.13 mg/g, quercitrin 0.16 to 7.52 mg/g, and quercetin 0.37–1.90 mg/g. The results revealed a reliable relation between the contents of hypericin and the morphotypes of *H. perforatum*. Some of the accessions of *H. perforatum* are distinguished by higher contents of the secondary metabolites studied if compared with the cv. 'Zolotodolinskaya' and 'Topas' and could be used for breeding purposes.

Key words: *Hypericum perforatum*, hypericin, flavonoids, morphotypes

INTRODUCTION

Hypericum perforatum L., the Saint John's wort, is a traditional medicinal plant containing a broad spectrum of secondary metabolites [1–4]. Hypericin, one of the photosensitizing naphthodianthrone derivatives, shows a significant antiviral and antiretroviral activity, especially in the presence of light [5]. Another group of important constituents of the plant is flavonoids. The flavonoid glycosides (rutin, hyperoside, isoquercitrine, quercitrine) and aglycons (quercetin, kaempferol, and luteolin) are also considered to be potentially therapeutic compounds due to their anti-inflammatory and spasmolytic effects [6, 7]. These pharmaceutical effects strengthen the importance of *H. perforatum* as a medicinal plant and stimulate detailed biological and pharmaceutical studies of the species.

The extracts of *Hypericum* currently used in pharmaceutical industry are being obtained from the top aerial parts collected in the flowering stage. The quality of the extracts is highly dependent on the quality of the original herbal material. Variation in the concentration of hypericin in *H. perforatum* may depend not only on the genotype, but also on environmental conditions, the stage of plant development, the ratio of plant parts (flower/leaf/stem) analysed, the time of collecting, drying and storage conditions [8–15].

The most important secondary metabolites are found in special morphological structures in *H. perforatum*. There are three types of such structures: translucent spheroidal cavities in which essential oil is accumulated, multicellular black glands and secretory canals of lengthened shape, containing hypericin and related compounds [16–20]. Inside the secretory canals, flavonoids have been identified too [21]. The studies of Ciccarelli et al. [22] on the distribution and frequency of the glands have shown that the inflorescences are certainly richest in glands and are, therefore, the best sites for extraction of secondary metabolites. In all samples of the flowers, glands were found not only on the sepals, petals, and stamens, but also within the ovary. However, the total absence of any glands in the ovary was determined as well. Identification of a positive correlation between morphotypes and the presence of secondary compounds could effectively contribute to the understanding of the underlying sources of intraspecific variability in *H. perforatum* [23].

The demand for hypericin and other secondary plant metabolites requires effective breeding strategies. There have been only several investigations attempting to dissect the chemical composition of field-grown clonal accessions of *Hypericum* as influenced by the environment or as a result of genetic variation [24–27]. From the practical point of view, it is important to find genotypes possessing high contents of separate bioactive constituents or a high total content of secondary metabolites to develop varieties suitable for cultivation under local climatic conditions. Investigations on *H. perforatum* carried out so far in Lithuania described the variation of morphological and chemical characters in wild populations [28–31]. In most cases, the performance of plants after they are transfered from wild to the cultivated field conditions is uncertain, particularly as regards the contents of active constituents.

The aim of this study was to assess peculiarities of the morphological and chemical variability of *Hypericum perforatum* cultivated in a field collection.

* Corresponding author. E-mail: edita.b@botanika.lt

MATERIALS AND METHODS

Plant material

Twenty-one seed samples of *H. perforatum* L. were collected from different natural habitats in Lithuania in 2002 and transferred into the experimental field collection of the Institute of Botany (Lithuania). Each accession was assigned with the collection number: wild samples were assigned with the numbers 346, 379, 383, 385, 403, 404, 406, 410, 411, 412, 413, 414, 415, 416, 419, 421, 423, 424, 425, 426, 427, and standard cultivars were No. 485 (Polish 'Topas') and No. 278 (Russian 'Zolotodolinskaya'). The latter two were used as control. The herbarium vouchers of the accessions were deposited at the Herbarium of the Institute of Botany in Lithuania (BILAS No. 67714–67722, 67724–67728, 68040, 68105, 68109, 68119, 68125, 68126, 68134, 68153, 68176). Maps were made applying grid system [32] (Fig. 1).

The plants were grown under the same cultivated field conditions on the soil with P_2O_5 contents 202.9 mg/kg, K_2O 213.9 mg/kg, pH 5.42 and organic matter 2.21%. Harvesting of plant material of 10–15 individual plants per accession was made in July of the second year of cultivation (in 2004). In total, six quantitative phenotypic characters were measured. Material for chemical analyses (flowering tops of 30 cm in length) was also collected in July 2004. The harvested flowering tops were dried in a room at an ambient air temperature for ten days, then packed in paper bags and kept dry in the dark at room temperature. Chemical analyses were carried out in December 2004 at the Kaunas University of Medicine (Lithuania).

Identification of morphotypes

The identification of morphotypes was carried out according to Ciccarelli et al. [22]. Thirty plants per accession were studied. As far as the glands are visible with the naked eye, one flower per plant was considered sufficient to recognize a particular plant morphotype. In total, four different morphotypes were distinguished according to the presence/absence of glands on petals and pistils (Table 1): type A– no striiform black glands on petals and black hypericin glands having the shape of a dot visible on the cross-section of the pistil; type B – striiform black glands on the petals present and no glands in the pistil; type C – no striiform glands on the petals and no glands in the pistil; type D – glands both on petals and in pistils. The black dots always occur around the margin of petals.

Extraction procedures

Samples (0.5–1.0 g each) of dried flowering tops of *H. perforatum* with moisture content 10.0% were mechanically ground to obtain a homogenous drug powder and extracted with 96% EtOH (50 ml) for 72 h at room temperature. The prepared samples were kept in the dark in a refrigerator until used. Conversion of protohypericin is performed by exposure to light for 30 min before analysis by high performance liquid chromatography (HPLC) [33]. A portion of 1 ml from each of the fresh drug extracts was taken up for HPLC analyses of hypericin. Each of 1-ml aliquot of the extracts was diluted with 19 ml of EtOH for flavonoid analyses.

Chemicals

All solvents for HPLC analysis were of HPLC grade and purchased from Roth, Karlsruhe (Germany). Rutin, hyperoside, quercetin, quercitrin, and hypericin were obtained from Roth.

HPLC analysis

Calibration solutions in the concentration range of 0.5 to 100.0 μg/ml were prepared from stock solution of rutin, hyperoside, quercetin, quercitrin and hypericin in methanol (100.0 μg/ml).

Identification of flavonoids

Rutin, hyperoside, quercetin and quercitrin were detected employing the modified method of Liu et al. [34]. For this purpose,

Table 1. **Presence of black glands in the floral parts of *H. perforatum***

Morphotype	Petals	Pistil
Type A	–	+
Type B	+	–
Type C	–	–
Type D	+	+

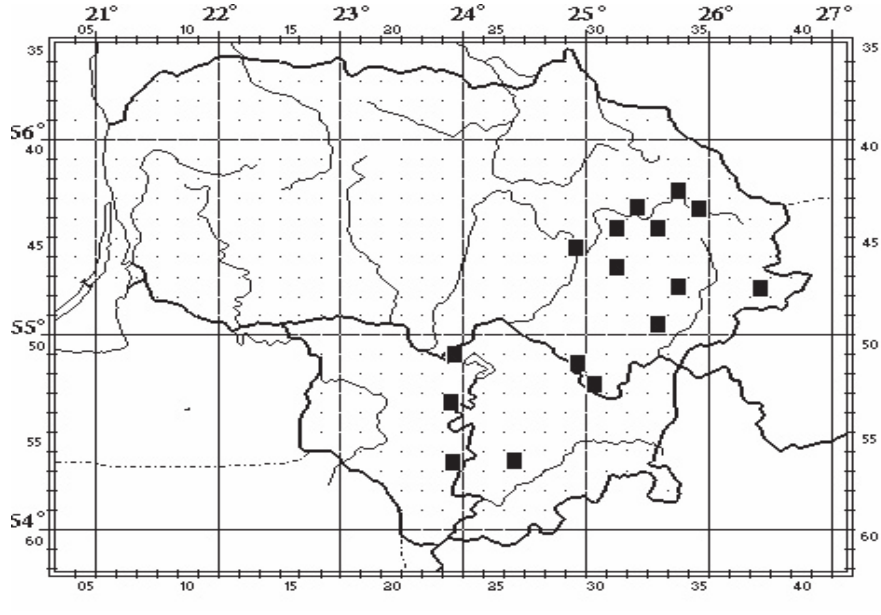

Fig. 1. Seed sampling sites of *H. perforatum* in Lithuania

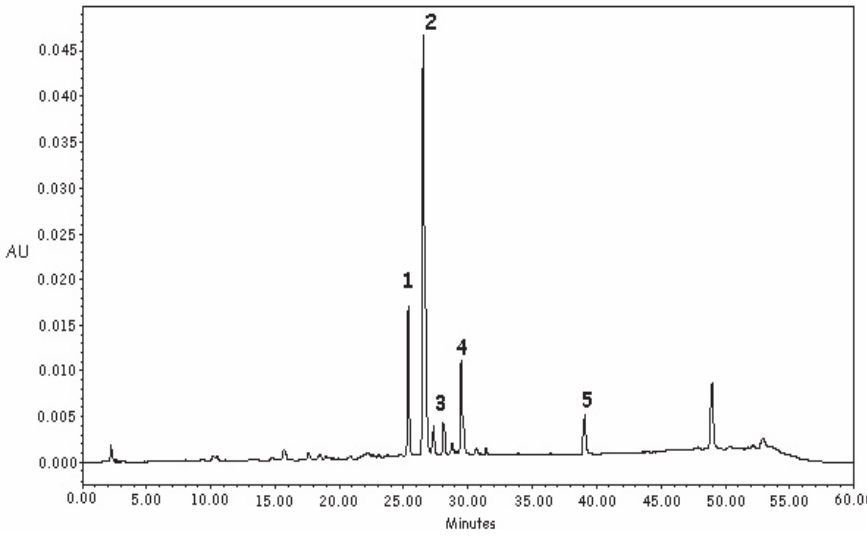

Fig. 2. HPLC chromatogram of flavonoids in *H. perforatum* extracts. Analytes by comparison of the retention time: 1 – rutin, 2 – hyperoside, 3 – apigenin-7-O-glucoside, 4 – quercitrin, 5 – quercetin

HPLC Waters 2690 with the Waters 2487 UV detector on X Terra RP 18 column (150 × 3.9 mm) was used. Ten microliters of the samples were injected. Compounds on the column were separated with 0.1% trifluoracetic acid ($C_2HF_3O_2$) in water (solvent A) and 0.1% $C_2HF_3O_2$ in acetonitrile (solvent B), using a gradient elution program: 0–45 min 95–55% A, 5–45% B; 45–50 min 55% A, 45% B; 50–55 min 55–95% A, 45–5% B. The flow rate was 0.4 ml/min. The column temperature was 20 °C. The elution was monitored at 360 nm. Peak identification was confirmed by comparison of retention times and spectral data with those of standard flavonoids [35, 36]. A typical HPLC chromatogram of flavonoids in the extracts of *H. perforatum* is presented in Fig. 2.

Identification of hypericin

Hypericin was detected according to the modified method of Pharmeuropa [37]. For this purpose, HPLC Waters 2690 with the Waters 2487 UV detector on the CC 125/4 Nucleosil 100–5 C18 column (125 mm) was used. Ten microliters of the samples were injected. The elution program was isocratic. The mobile phase was ethyl acetate / 15.6 g/l sodium dihydrogen phosphate-phosphoric acid / methanol (39:41:160). The flow rate was 1.0 ml/min. The column temperature was 20 °C. The elution was monitored at 590 nm and the obtained data were compared with those of standard samples of hypericin (Fig. 3).

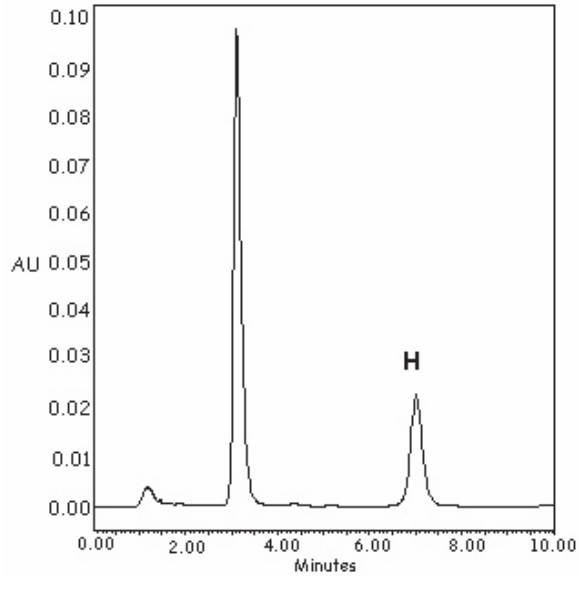

Fig. 3. HPLC chromatogram of hypericin in *H. perforatum* extracts.
H: hypericin peak

Thirty-five quantitative analyses of flavonoids and hypericin were carried out in 23 accessions of *H. perforatum*.

Statistical analysis

In order to determine whether there was a statistically significant difference between the obtained values, the one-way analyses of variance (ANOVA) with Tukey's and Scheffe's tests were performed. For the assessment of the variability of morphologic characters within the accessions, the variation coefficient (CV, %) was employed.

RESULTS AND DISCUSSION

During the study, some new results were obtained concerning the morphotypic and phytochemical diversity of *Hypericum perforatum* L. We found that hypericin contents in flowering tops of *H. perforatum* in Lithuania ranged from 0.23 to 1.24 mg/g, with a mean value of 0.60 mg/g dry matter. Previous scientific reports cite hypericin concentrations ranging from 0.69 to 0.85 mg/g dry matter in *H. perforatum* material from Germany [38], 0.032–0.090% from Austria [39] and 0.0003–0.1250% dry weight from USA [14]. Therefore the values reported herein are within the expected ranges.

In a typical flavonoid spectrum of *H. perforatum*, rutin and hyperoside are the major components. In this study, rutin and hyperoside levels in the flowering tops varied within 2.95–17.10 mg/g and 0.42–31.13 mg/g, respectively. Rutin and hyperoside concentrations for *H. perforatum* grown in Germany have been reported to range within 0.05–20.70 mg/g dry matter and 1.10–20.00 mg/g, respectively [25]. The maximum contents of rutin (9.68 mg/g) and hyperoside (21.98 mg/g) given by Umek et al. [40] are lower than our data. Jürgenliemk & Nahrstedt [6] have reported a higher average content of rutin (16.67 mg/g dry matter) and hyperoside (17.74 mg/g) than obtained in this study (7.83 mg/g and 11.61 mg/g, respectively). As for quercitrin and

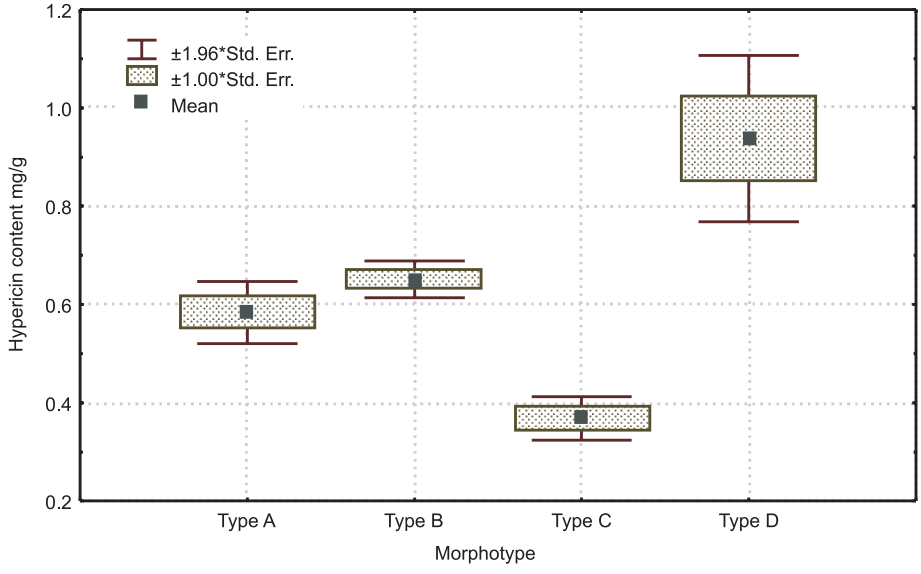

Fig. 4. Distribution of mean hypericin contents (mg/g dry matter) in *H. perforatum* morphotypes

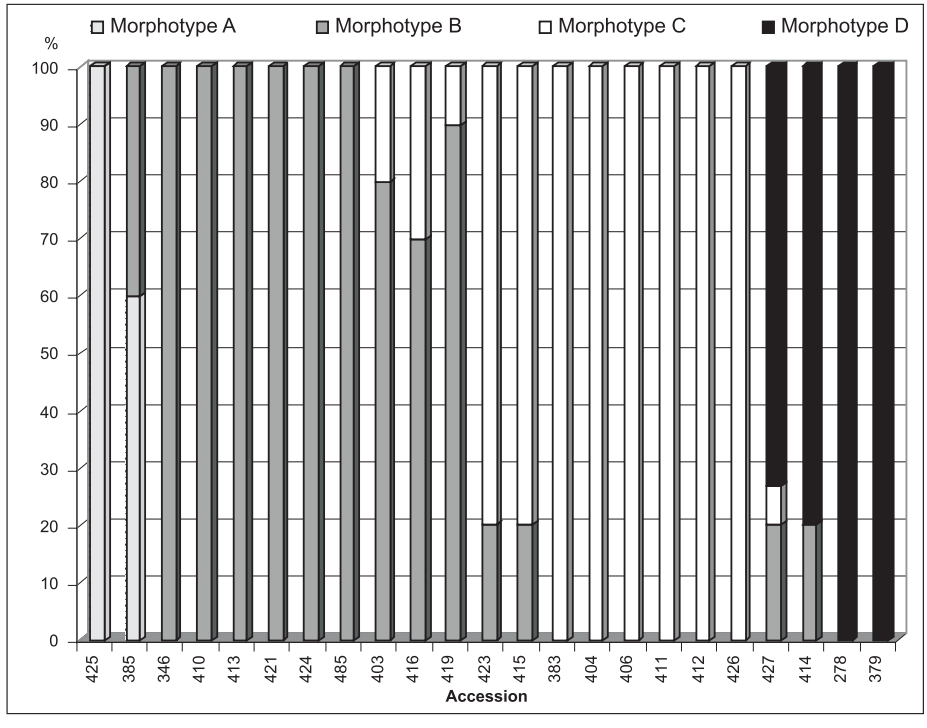

Fig. 5. Occurrence of morphotypes in *H. perforatum* accessions studied

quercetin, the obtained values (0.16–7.52 mg/g and 0.37–1.90 mg/g, respectively) correspond with those reported by Franke et al. [25] who reported the contents 0.23–8.40 mg/g and 0.02–4.00 mg/g, respectively. Quercitrin and quercetin concentrations for *H. perforatum* grown in Slovenia have been reported to range within 0.25–6.50 mg/g and 0.00–0.68 mg/g, respectively [40]. Basically, these data correspond with our data.

Several different kinds of internal secretory structures occur in *H. perforatum*. According to Southwell & Campbell [41], the count of oil glands indicated a correlation between oil gland density and hypericin content. As reported before [2, 18, 42], the occurrence of black glands in an organ is regarded as an accurate indicator of the presence of hypericin. Piovan et al. [43] reported the occurrence of red or black glands as a good indicator of the occurence of hypericins in different concentrations.

The analysis of distribution and occurrence of black glands in the study plants revealed a certain correlation between the morphological and chemical characters. Four different morphotypes were distinguished (Table 1). A relation between the contents of hypericin and morphotype was established (Fig. 4). The ANOVA revealed quantitative differences in the mean concentrations (mg/g dry mass) of hypericin between all morphotypes ($p < 0.05$), except between A and B ($p = 0.746$). The morphotype A, rare in Lithuania, was represented by only two accessions with medium values of hypericin (0.51–0.66 mg/g). Morphotype B occurred in the highest abundance among the collected accessions and also contained medium values of hypericin (0.50–0.75 mg/g). The standard variety 'Topas' also fell into this particular group B. *H. perforatum* plants of the morphotype C were poor in hypericin (0.23–0.48 mg/g). Morphotype D contained four ac-

cessions with the highest levels of hypericin (0.70–1.24 mg/g). The standard variety 'Zolotodolinskaya' fell into group D. The contents of hypericin in the morphotype D were 2–5 times higher than in C. Based on the analysis of the occurrence of morphotypes in *H. perforatum* accessions, we have found 15 accessions which represented stable morphotypes (Fig. 5): morphotype A (No. 425), morphotype B (No. 346, 410, 413, 421, 424 and 485), morphotype C (No. 383, 404, 406, 411, 412 and 426) and morphotype D (No. 278 and 379). The results suggest that the morphotypes varied very much within eight accessions. Both morphotypes B and C occurred in accessions 403, 415, 416, 419 and 423. The only accession 385 was represented by both morphotypes B and A. Both morphotypes B and D occurred in accession 414. In accession 427 three morphotypes were observed.

The height of the plant, the length and width of inflorescence and some other morphological characters are indicative of the selection. In general, the accessions of Lithuanian origin were taller than 'Topas' (Table 2). The length of inflorescence did not differ significantly among the accessions. The width of inflorescence varied from 10.90 cm to 15.50 cm ('Topas' – 14.20 cm). Accession 423 was the most distinguished from this point of view. Among the accessions studied, broad-leaved individuals occurred with the highest abundance.

The weight of raw material as a quality indicator of the herbal drug was also estimated in the study. The mean weight of raw material ranged from 2.27 g to 4.22 g ('Topas' – 3.81 g) and did not differ significantly among the accessions. However, high variations were established within the accessions in the length (CV = 22.5–46.0%) and width (CV = 11.4–37.8%) of inflorescence as well as weight of raw material (CV = 32.0–53.3%). Significant differences among the morphotypes in plant height and weight of raw material were established. The morphotype D individuals were significantly different ($p < 0.05$) from the others (Fig. 6). They were low, weighty and, therefore, could be prospective for the breeding purposes [45].

As expected, the highest morphological heterogeneity was observed in the accessions of wild origin. The examined peculiarities of the morphological variability of *H. perforatum* comply with the results reported by Pluhár et al. [26] and Erkara & Tokur [44]. Previous studies in *H. perforatum* demonstrated a wide range of its ecological adaptation scale occurring on several soil types and in a broad range of plant communities [46]. This species is the most abundant in the *Agropyretalia repentis* communities (accessions 385, 415, 416). The second group of habitats comprises the communities of the *Trifolio–Geranietea sanguinei* class (accessions 403, 414). Seeds of accession 419

Table 2. **Summary statistics of *H. perforatum* characters and the level of differentiation of accessions according to each character by ANOVA Tukey test**

No.		Character					
		Height of plant, cm	Lenght of inflorescence, cm	Width of inflorescence, cm	Length of leaf, mm	Width of leaf, mm	Weight of raw material, g
385	M	*d* 92.36	*a* 27.36	*bc* 12.09	*abc* 24.09	*ab*10.18	*a* 3.22
	SE	2.05	1.91	0.72	1.17	0.81	0.31
	CV, %	7.40	23.20	19.70	16.10	26.30	32.00
403	M	*bd* 84.90	*a* 30.50	*bc* 11.90	*b*22.40	*a* 7.60	*a* 2.97
	SE	2.40	3.11	0.78	1.39	0.76	0.35
	CV, %	8.90	32.20	20.80	19.70	31.80	37.80
414	M	*bd* 84.44	*a* 23.89	*c* 11.33	*abc* 25.00	*ab* 8.11	*a* 2.27
	SE	1.64	2.87	0.82	1.57	0.56	0.31
	CV, %	5.80	36.10	21.60	18.90	20.90	41.40
415	M	*bd* 87.00	*a* 27.70	*bc* 11.90	*a* 29.40	*ab* 9.90	*a* 3.21
	SE	1.53	1.97	0.62	0.64	0.62	0.40
	CV, %	5.60	22.50	16.50	6.80	19.80	39.30
416	M	*bd* 85.60	*a* 22.90	*c* 10.90	*abc* 26.50	*ab* 10.00	*a* 2.98
	SE	1.62	2.21	0.78	0,69	0.59	0.50
	CV, %	6.00	30.50	22.70	8.20	18.90	53.30
419	M	*a* 67.60	*a* 28.00	*bc* 13.90	*ac* 28.00	*b* 10.70	*a* 4.02
	SE	1.26	4.08	1.66	1.32	0.72	0.59
	CV, %	5.90	46.00	37.80	15.00	21.10	46.30
423	M	*bc* 83.60	*a* 28.70	*ab* 15.50	*abc* 24.10	*ab* 10.00	*a* 4.22
	SE	1.12	2.41	1.03	1.19	0.74	0.46
	CV, %	4.20	26.50	21.10	16.00	23.60	34.30
427	M	*bd* 85.80	*a* 24.10	*bc* 13.50	*bc* 23.40	*ab* 9.00	*a* 4.00
	SE	1.47	2.27	0.70	0.96	0.39	0.52
	CV, %	5.40	29.80	16.40	12.90	13,90	41.50
485 'Topas'	M	*bc* 82.40	*a* 27.30	*bc* 14.20	*bc* 23.80	*ab* 8.60	*a* 3.81
	SE	2.26	2.42	0.51	1.77	0.48	0.45
	CV, %	8.70	28.00	11.40	23.60	17.50	37.70

M – mean; SE – standard error of mean; CV – coefficient of variation.

Values in columns marked with the same letter do not differ at $\alpha = 0.05$.

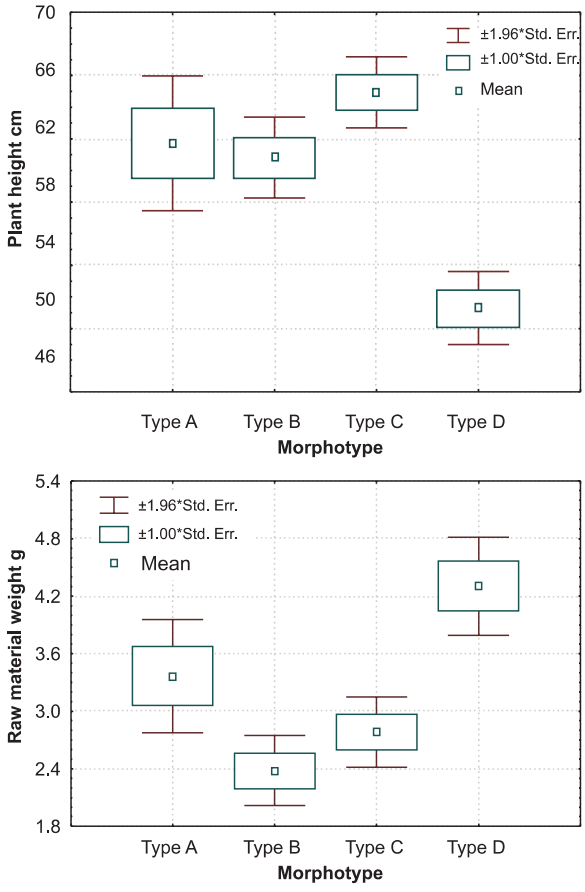

Fig. 6. Variability of plant height and raw material weight among *H. perforatum* morphotypes

were gathered in *Festuco–Sedetalia* community. Accessions 423 and 427 originated in the *Cynosurion cristati* association.

In the current study, we compared hypericin and flavonoid contents in the most morphologically variable accessions of wild origin with the standard Polish cultivar 'Topas' (No. 485) and Russian 'Zolotodolinskaya' (No. 278). The contents of hypericin in 'Topas' and 'Zolotodolinskaya' were 0.66 and 1.01 mg/g, respectively, while the highest content of the compound (1.24 mg/g) was detected in accession 414 (Sėliškės, Utena district). The highest quercitrin and quercetin concentrations as well as high contents of rutin and hyperoside were found in this accession, too (Table 3). Morphotype D prevailed in this accession (Fig. 5).

The contents of rutin in 'Topas' and 'Zolotodolinskaya' ranged within 9.79–9.98 mg/g and of hyperoside within 9.18–11.6 mg/g, while the highest values of the both were found in accession 403 (southern slope of the Kaunas Reservoir, Kaunas district). Regarding the content of flavone glycosides, Franke et al. [25] reported on *H. perforatum* plants with high contents of rutin and hyperoside as well.

The contents of quercitrin in 'Topas' and 'Zolotodolinskaya' amounted to 1.23 and 2.71 mg/g, while the content of quercetin amounted to 0.85 and 0.87 mg/g, respectively. Taking into consideration that flavonoid content is the major criterion for the evaluation of raw material in *H. perforatum,* accession 419 (Rudesa, Molėtai district) seems to be equivalent or even better than the standard cultivars. Accession 423 (Pavirinčiai, Molėtai district) stood out for the contents of active compounds, too, which was characterized by high contents of rutin, hyperoside and quercetin. Thus, quite a lot of different accessions with high-

Table 3. **Hypericin and flavonoid contents (mg/g dry matter) in morphologically most variable accessions of *H. perforatum***

No.		Compound, mg/g dry matter				
		Hypericin	Rutin	Hyperoside	Quercitrin	Quercetin
385	Mean	0.52	12.18	12.01	1.49	1.01
	Std. Dev.	0.01	1.77	6.07	0.70	0.34
	Min	0.51	10.92	7.72	1.00	0.77
	Max	0.53	13.43	16.30	1.99	1.25
403	Mean	0.73	10.43	19.54	2.30	1.08
	Std. Dev.	0.16	9.43	16.39	1.47	0.39
	Min	0.62	3.76	7.95	1.26	0.80
	Max	0.84	17.10	31.13	3.34	1.36
414	Mean	0.88	7.71	18.21	4.60	0.88
	Std. Dev.	0.31	5.18	8.48	2.54	0.96
	Min	0.70	3.17	12.49	2.86	0.00
	Max	1.24	13.35	27.95	7.52	1.90
415	Mean	0.37	7.01	9.80	1.02	0.81
	Std. Dev.	0.19	3.03	0.35	1.44	0.03
	Min	0.23	4.87	9.55	0.00	0.79
	Max	0.50	9.15	10.05	2.04	0.84
416	Mean	0.53	8.56	11.41	0.56	0.59
	Std. Dev.	0.31	3.12	3.80	0.57	0.31
	Min	0.31	6.35	8.72	0.16	0.37
	Max	0.75	10.76	14.10	0.97	0.81
419	Mean	0.55	7.29	17.37	4.46	0.75
	Std. Dev.	0.10	4.54	12.38	3.57	0.04
	Min	0.48	4.08	8.61	1.94	0.72
	Max	0.62	10.50	26.12	6.99	0.78

Table 3 (continued)

423	Mean	0.57	13.05	17.21	1.34	1.28
	Std. Dev.	0.18	1.21	15.49	0.86	0.58
	Min	0.44	12.19	6.26	0.73	0.87
	Max	0.69	13.90	28.16	1.95	1.69
427	Mean	0.64	6.61	10.63	2.26	0.71
	Std. Dev.	0.27	2.16	4.24	0.49	0.31
	Min	0.38	4.40	6.12	1.70	0.47
	Max	0.91	8.71	14.54	2.64	1.06

Std. Dev. – standard deviation; Min – minimum value; Max – maximum value.

385 – Dūkštos, Širvintos district, 403 – Slope of Kaunas Reservoir, Kaunas district, 414 – Sėliškės, Utena district, 415 – Čekonys, Anykščiai district, 416 – Svėdasai, Anykščiai district, 419 – Rudesa, Molėtai district, 423 – Pavirinčiai, Molėtai district, 427 – Labanoras, Molėtai district.

er contents of hypericin and / or other compounds in comparison with the standard cultivars 'Topas' and 'Zolotodolinskaya' are available for the further breeding. Smelcerovic et al. [47] have shown that significant differences in the contents of active compounds of samples collected from the same location suggests that genetic factors may play a certain role.

In conclusion, the results of our investigation indicate a large chemical and morphological variability of *H. perforatum*. Four different morphotypes were observed both within and among accessions. A relation between the contents of hypericin and morphotype was established. The contents of hypericin in morphotype D were 2–5 times higher than in morphotype C. Significant differences among the morphotypes in plant height and weight of raw material were also established. The individuals of morphotype D were low, weighty and, therefore, prospective for the breeding purposes because of both relatively longer flowering tops and a higher mass of raw material.

The results of the study have indicated that accessions 403, 414, 419 and 423 accumulate high contents of secondary metabolites and are an important source for breeding. These findings demonstrate that the provenance of the accessions of *H. perforatum* certainly plays a decisive role in the content of secondary metabolites as well as in the intraspecific diversity of the species.

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Edita Bagdonaitė, Valdimaras Janulis, Liudas Ivanauskas, Juozas Labokas

LIETUVOJE AUGANČIOS PAPRASTOSIOS JONAŽOLĖS (*HYPERICUM PERFORATUM* L.) CHEMINIS IR MORFOLOGINIS ĮVAIRAVIMAS *EX SITU*

Santrauka

Straipsnyje pateikta paprastosios jonažolės (*Hypericum perforatum* L.) cheminio ir morfologinių požymių įvairavimo *ex situ* sąlygomis analizė. Tyrimams vaistinė augalinė žaliava (žydinčios viršūnės) 2004 m. buvo surinkta Botanikos instituto vaistinių ir aromatinių augalų lauko kolekcijoje. Augalo veikliųjų medžiagų kiekybė analizuota efektyviosios skysčių chromatografijos metodu Kauno medicinos universitete. Tyrimų rezultatai rodo, kad hipericino kiekis paprastosios jonažolės vaistinėje žaliavoje įvairuoja nuo 0,23 iki 1,24 mg/g, rutino – 2,95–17,10 mg/g, hiperozido – 0,42–31,13 mg/g, kvercitrino – 0,16–7,52 mg/g, kvercetino – 0,37–1,90 mg/g. Nustatyta, kad hipericino ir flavonoidų kiekiai įvairuoja ne tik tarp kolekcinių pavyzdžių, bet ir jų viduje – tarp morfotipų. Palyginus veikliųjų medžiagų kiekį vietinės kilmės paprastosios jonažolės kolekciniuose pavyzdžiuose (21) ir užsieninėse veislėse 'Zolotodolinskaya' (Rusija) bei 'Topas' (Lenkija), nustatyta, kad kolekciniai pavyzdžiai Nr. 403 (labai daug rutino ir hiperozido, daug hipericino), Nr. 414 (labai daug hipericino, kvercitrino ir kvercetino), Nr. 419 (daug flavonoidų) ir Nr. 423 (daug rutino, hiperozido ir kvercetino) yra ekvivalentiški šioms veislėms arba net labiau išsiskiriantys. Tyrimų rezultatai yra svarbūs įvertinant paprastosios jonažolės genetinius išteklius bei vykdant tolesnę selekciją.