Flavonoid Content in Plants of the Forest-Steppe Zone of West Siberia (Novosibirsk Region)

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Abstract

The content of flavonoids in 76 plant species of 25 families growing over the territory of the Novosibirsk Reigon was studied. It has been established, that the content of flavonoids in 33 plant species under investigation is higher than 3.0 %. Habitats and times of harvesting are listed for plants promising to be used as the sources of flavonoids. It has been revealed that the maximum amount of flavonoids is contained in the representatives of such families as Asteraceae, Rosaceae, Lamiaceae.

Key words: vegetative resources, herbs, flavonoids, West Siberia

INTRODUCTION

At the present stage of Siberian productive forces development a special consideration is given to the territorial planning and management of large economic regions. The plant riches of Siberia represent extremely valuable and almost untouched reserve of raw material for many industries. The studies on wild flora of Siberia as a source of high-quality medicinal raw material can render a considerable assistance in satisfying the demands of the medical industry on a state scale [1].

Flavonoid-containing plants draw a steadfast attention of researchers as a raw material for obtaining a wide scope of medical products exhibiting anti-inflammatory, capillary restorative, choleretic, radioprotective, antineoplastic, immunomodulatory, *etc*. actions [2–6]. Within recent decades much importance is attached to the antioxidative action of flavonoids and their ability to capture and remove free radicals from an organism [7–9].

The investigations of herbs growing over the territory of Siberia for determining the content of flavonoids were carried out by the researchers of Central Siberian Botanical Garden (CSBG), SB RAS (Novosibirsk) in 1960–1980 [10–15] within the framework of complex resource studies for the analysis and rational use of the vegetative resources of Siberia. At the initial stage of these works a reconnaissance inspection was carried out to rate the content of flavonoids in Siberian plants growing mainly over the areas of Southern Siberia. During the examination of plants growing over the territories of Mountain Altai, Khakassia, Sayan Mountains and Tyva for the content of flavonoids, more than 350 plant species belonging to 185 genuses and 54 families of higher plants have been studied.

There are two ways to particularly mobilize the vegetative resources. They are either utilizing a useful plant as a natural raw material or introducing the plant into cultivation [16]. Using data on natural flora of the region and the methods of experimental knowledge of plants one could solve independent problems in revealing natural sources of highly active medicinal raw material and initial material for se-

lection in a particular region. In order to intensify the results of an introduction experiment one should select the most valuable initial material persistent within the region [17].

The cultivation of herbs cannot be relied on unlimited increasing in sown areas therefore an economical use of medicinal raw material should be realized. One of the basic conditions of this consists in obtaining a raw material with the maximum content of effective agents. In this connection a particular significance is attached to biochemical research of plants including not only biochemical inventory of fodder, medicinal, technical and other groups of plants, but also forecasting rational ways of vegetative resources consumption. The important stage of these studies consists in choosing the plants promising from the standpoint of the further profound investigation. In order to mobilize useful plants of the region the organization of biochemical research and the creation of a Databank covering all the useful plants of the region are of most importance. The presence of comprehensive information concerning every plant species would accelerate involving these species in various fields of the national economy [18, 19].

The present work is aimed at revealing wild plants of the forest-steppe zone of West Siberia (within the Novosibirsk Region) rich in flavonoids, at the subsequent studies on the conditions promoting the accumulation of these substances as well as at establishing the laws of flavonoid accumulation during the process of plants growth and development.

EXPERIMENTAL

The choice of plant species for the investigation of flavonoid content was made taking into account their natural resource (the most widespread species were chosen) as well as the data from the literature concerning medicinal properties of the plants. The species examined for the content of flavonoids were sampled once.

Quantitative determination of flavonoids was carried out using the technique described in [20], with the use of a complexation reaction of flavonoids with aluminium chloride.

The spectrophotometric determination of the total content of flavonoids in leaves was carried out as it follows. An accurately weighed sample of air-dry raw material (~0.5 g) grinded and sifted through a 1 mm mesh sieve was placed into a flask of 100 mL in volume and extracted exhaustively with 70 % ethyl alcohol. The completeness of the extraction was monitored via the reaction with 5 % NaOH solution (until yellow colouring disappeared); the volume of the filtered joint extract was then measured. Further, 0.1 mL of the extract was put into a graduated test tube; then 0.2 mL of 2 % $AlCl_3$ solution in 96 % ethyl alcohol was added, the volume was brought up to 5 mL adding ethanol of the same concentration. For the reference, to 0.1 mL of the extract were added 1–2 drops of 30 % acetic acid and the volume was then brought up to 5 mL. Solutions were stirred; the optical density (absorbance) value was measured in 40 min for the solution with aluminium chloride with the help of a SF-26 spectrophotometer at the wavelength of 415 nm using a cell with 1 cm layer thickness. For comparison used a solution with an acid.

The total content of flavonoids X (percentage with respect to the mass of air-dry raw material) was determined as

$$X = YV_1V_2100/(MV_3 \cdot 10^6)$$

Here Y is the content of flavonoids in 1 mL of the solution under investigation, determined according to the calibration curve plotted for rutin, μg; V_1 is the extract volume, mL; V_2 is the volume of dilution, mL; V_3 is the extract volume for the analysis, mL; M is the mass of air-dry raw material, g.

RESULTS AND DISCUSSION

According to the data presented in [21], as much as 1333 plant species of 123 families grow over the territory of the Novosibirsk Region. We have studied 5.7 % of total amount of plant species. Figure 1 displays data concerning the content flavonoids in 76 plant species of 25 families.

The main task while studying and mobilizing the gene pool consists in the preservation of biomorphological variety with respect to each species. For some plant species the content of flavonoids was determined using the material sampled within various habitats of the plants. Figure 1 displays only maximal values of the content

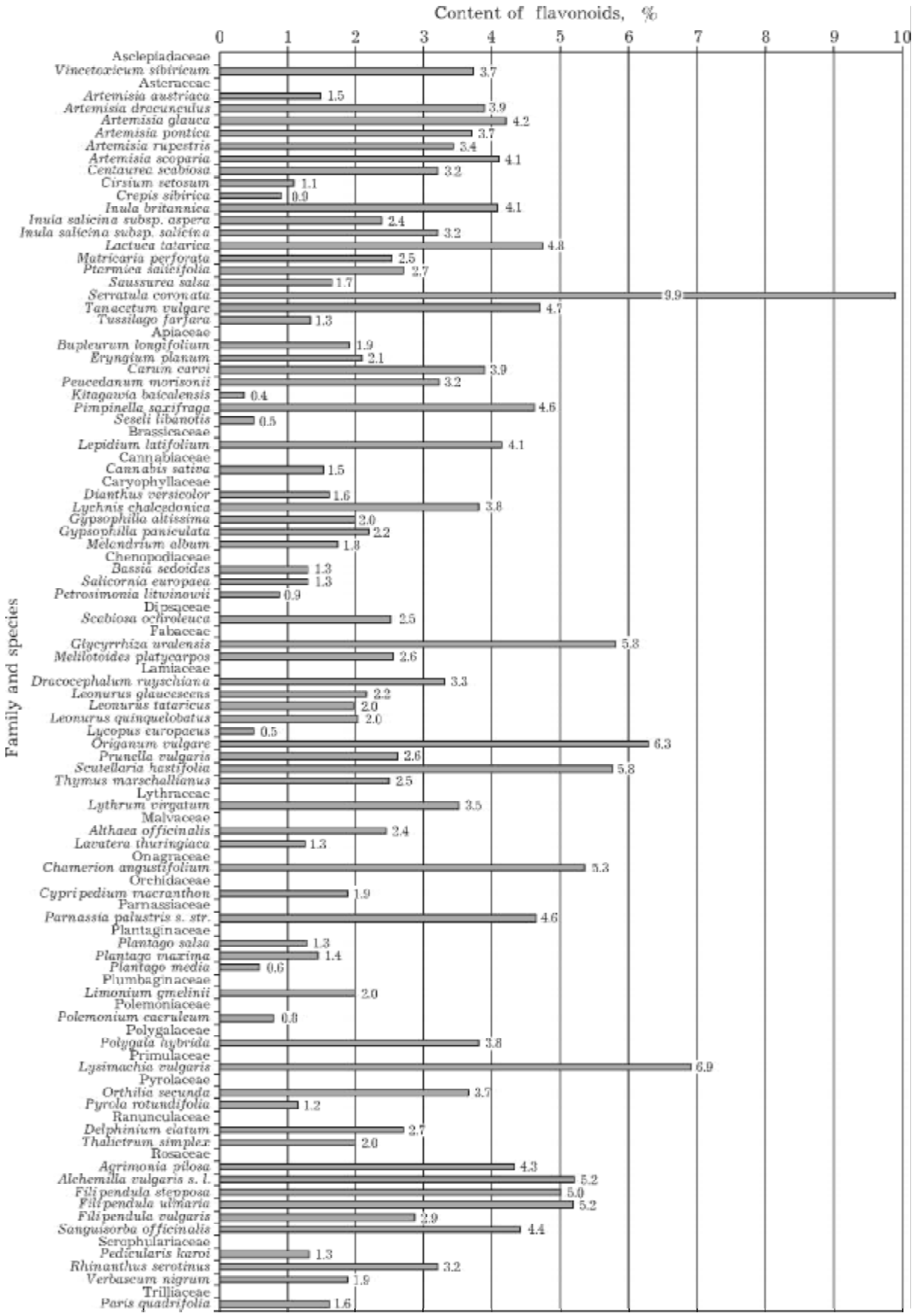

Fig. 1. Content of flavonoids in the plants of the forest-steppe zone of West Siberia (Novosibirsk Region).

TABLE 1

Location of flavonoid-containing plant cenopopulations of the West-Siberian forest-steppe zone (Novosibirsk Region)

Species	Family	District, harvesting location	Harvesting date	Content, %
Serratula coronata L.	Asteraceae	Toguchin District, on the outskirts of the Dergausovo village, forb meadow	17.07.05	9.9
Lysimachia vulgaris L.	Primulaceae	Ubinka District, on the outskirts of the Aleksandro-Nevskoe village; waterlogged ditch	14.07.05	6.9
Origanum vulgare L.	Lamiaceae	Kargat District, on the outskirts of the Filino village; forb meadow	15.07.05	6.3
Glycyrrhiza uralensis Fischer	Fabaceae	Karasuk District, on the outskirts of the Chernokur'ya village, cereal-wermuth steppe	09.07.05	5.8
Scutellaria hastifolia L.	Lamiaceae	Toguchin District, Bugotak village, the Inya riverside, floodplain meadow	19.07.05	5.8
Chamerion angustifolium (L.) Holub.	Onagraceae	Kochenevo District, route M-51, 91 km from Novosibirsk, forb meadow	15.07.05	5.3
Alchemilla vulgaris L.	Rosaceae	Toguchin District, Bugotak village, the Inya riverside, floodplain meadow	19.07.05	5.2
Filipendula ulmaria (L.) Maxim.	Rosaceae	Toguchin District, route Novosibirsk–Leninsk-Kuznetsk, 86 km from Novosibirsk, tall-grass meadow	18.07.05	5.2
Filipendula stepposa Juz.	Rosaceae	Kochki District, on the outskirts of the Reshety village, the Karasuk riverside, cereal-wermuth steppe	08.07.05	5.0
Lactuca tatarica (L.) C. A. Mey	Asteraceae	Toguchin District, Bugotak village, the Inya riverside, floodplain meadow	19.07.05	4.8
Tanacetum vulgare L.	Asteraceae	Kochki District, on the outskirts of the Reshety village, the Karasuk riverside, cereal-wermuth steppe	08.07.05	4.7
Parnassia palustris L.	Parnassiaceae	Toguchin District, Gremyachinskiy village, intermittent hummocky swamp in a birch forest	18.07.05	4.6
Pimpinella saxifrage L.	Apiaceae	Chulym District, on the outskirts of the Kokoshino village, forb meadow	15.07.05	4.6
Sanquisorba officinalis L.	Rosaceae	Toguchin District, route Novosibirsk–Leninsk-Kuznetskiy, 86 km from Novosibirsk, tall-grass meadow	18.07.05	4.4
Agrimonia pilosa Ledeb.	Rosaceae	Kargat District, on the outskirts of the Filino village, forb meadow	15.07.05	4.3
Artemisia glauca Pall. ex Willd.	Asteraceae	Kochki District, on the outskirts of the Zhulanka village, Karasuk riverside, cereal-wermuth steppe with birch islets	08.07.05	4.2
Artemisia scoparia Waldst. et Kit.	Asteraceae	Krasnozersk District, on the outskirts of the Lobino village, Gor'koe Lake, saline lakeside	09.07.05	4.1
Inula britannica L.	Asteraceae	Ubinka District, on the outskirts of the Aleksandro-Nevskoe village, cereal-forb meadow	14.07.05	4.1
Lepidium latifolium L.	Brassicaceae	Barabinsk District, on the outskirts of the Peschanka village, Peschanoe Lake, cereal-wermuth steppe	13.07.05	4.1

TABLE 1 (End)

Location of flavonoid-containing plant cenopopulations of the West-Siberian forest-steppe zone (Novosibirsk Region)

Species	Family	District, harvesting location	Harvesting date	Content, %
Artemisia dracunculus L.	Asteraceae	Kochki District, on the outskirts of the Reshety village, the Karasuk riverside, cereal-wermuth steppe	08.07.05	3.9
Carum carvi L.	Apiaceae	Kargat District, on the outskirts of the Filino village, forb meadow	15.07.05	3.9
Lychnis chalcedonica L.	Caryophyllaceae	Toguchin District, Bugotak village, the Inya riverside, floodplain meadow	19.07.05	3.8
Polygala hybrida DC	Polygalaceae	Kupino District, on the outskirts of the Pokrovka village, Sakhalin Lake, cereal-wermuth steppe	11.07.05	3.8
Vincetoxinum sibiricum (L.) Decne	Asclepiadaceae	Krasnozersk District, on the outskirts of the Lobino village, Gor'koe Lake, saline lakeside	09.07.05	3.7
Artemisia pontica L.	Asteraceae	Krasnozersk District, on the outskirts of the Krasny Khutor village, the Karasuk riverside, forest tree nursery	08.07.05	3.7
Orthilia secunda (L.) House	Pyrolaceae	Toguchin District, Bugotak village, the Inya riverside, pine-birch forest	19.07.05	3.7
Lythrum virgatum	Lythraceae	Tatarsk District, on the outskirts of the Novo-Mikhailovka village, cereal-forb meadow	13.07.05	3.5
Artemisia rupestris L.	Asteraceae	Barabinsk District, on the outskirts of the Peschanka village, Peschanoe Lake, cereal-wermuth steppe	13.07.05	3.4
Dracocephalum ruyschiana L.	Lamiaceae	Ubinka District, on the outskirts of the Aleksandro-Nevskoe village, waterlogged ditch	14.07.05	3.3
Centaurea scabiosa L.	Asteraceae	Kupino District, on the outskirts of the Pokrovka village, Sakhalin Lake, cereal-wermuth steppe	11.07.05	3.2
Inula salicina ssp. *Salicina* L.	Asteraceae	Kochenevo District, route M-51, 91 km from Novosibirsk, forb meadow	15.07.05	3.2
Rhinanthus serotinus (Schöenheit) Oborny	Scrophulariaceae	Chulym District, on the outskirts of the Kokoshino village, forb meadow	15.07.05	3.2
Peucedanum morisonii Besser ex Sprengel	Lamiaceae	Kochki District, on the outskirts of the Bystrukha village, cereal-forb steppe	07.07.05	3.2

those demonstrate the potentialities of each plant species being determined both by the conditions of flavonoid biosynthesis, and by genetics. It should be noted that the content of flavonoids varies to a considerable extent depending on habitat and harvesting time. So, for the three species under investigation belonging to *Tanacetum* L., *Filipendula* L. and *Sanquisorba* L. genuses we obtained the following data concerning the content of flavonoids, %: *T. vulgare* L. – 1.7, 3.9, 4.7; *F. stepposa* Juz. – 3.2, 3.4, 4.8, 4.9, 5.0; *S. officinalis* L. – 1.6, 1.9, 2.2, 2.4, 4.4.

Flavonoids have been revealed in all the samples under investigation, which confirms the data from the literature that these substances exhibit a wide distribution in flora [22, 23]. Among 25 plant families under our investigation a special consideration is deserved by the families of Asteraceae, Rosaceae, Lamiaceae, and 33 plant species with a high content of

flavonoids (3.2–9.9 %) represent promising sources of flavonoids (Table 1). The highest content of flavonoids has been revealed in the plants such as *Serratula coronata* (on the outskirts of the Dergausovo village, Toguchin District) being of 9.9 %; for *Lysimachia vulgaris* (on the outskirts of the Aleksandro-Nevskoe village, Ubinka District) this value amounts to 6.9 %, for *Origanum vulgare* (on the outskirts of the Filino village, Ubinka District) the content is equal to 6.3 %. The content of flavonoids ranging within 4.1–5.8 % is inherent in 16 plant species (*Glycyrrhiza uralensis*, *Scutellaria hastifolia*, *Chamerion angustifolium, Alchemilla vulgaris*, *Filipendula ulmaria*, *F. stepposa*, *etc.*). For 14 plant species (*Artemisia dracunculus*, *Carum carvi*, *Lychnis chalcedonica*, *Polygala hybrida*, *Vincetoxinum sibiricum*, *Artemisia pontica*, *etc.*) this value varies within the range of 3.2–3.9 %. For comparison, the content of flavonoids in the plants used as a medicinal raw material should be higher than 6.0 % for flowers of Sandy everlasting, (*Helichrysum arenarium*), higher than 2.5 % for flowers of Tansy (*Tanacetum*), higher than 1.5 % for grass of St. John's Wort (*Hypericum*), higher than 1.0 % for leaves of Water Shamrock (*Menyanthes trifoliata*) and higher than 0.5 % for grass of Doorweed (*Polygonum aviculare*) [24].

Table 1 displays the list of plant species with a sufficiently high content of flavonoids (3.2 % and higher), particular places and dates of harvesting the plants are indicated therein. These cenopopulations could be used not only for harvesting wild herbs with high content of flavonoids, but also as an initial material for the subsequent plant introduction and the creation of industrial plantations. There is no doubt that the extension of the utilization scale for the Siberian herbs and the necessity for their protection determine an increasing value of introduction studies, and the first stage of such studies consists in comprehensive studies on plant species in the nature.

CONCLUSION

33 species have been distinguished as promising sources of flavonoids among 76 plant species belonging to 25 families of the forest-steppe zonal flora of West Siberia (within the Novosibirsk Region) studied from the standpoint of flavonoid content. Three species among the 33 are characterized by very high values of flavonoid content (higher than 6 %), 16 species are characterized by high values (4.0–6.0 %) and 14 species are characterized by high enough values (>3.0 %) as compared to the USSR State pharmacopoeia requirements for the content of these substances.

Among the Novosibirsk regional flora species under investigation the greatest amount of flavonoids is contained in the representatives of Asteraceae, Rosaceae, Lamiaceae families.

The data we have obtained indicate that the flora of the West-Siberian forest-steppe zone (Novosibirsk Region) is rich in plants with a high content of flavonoids those could serve as a raw source for medicine as well as a material for the creation of industrial plantations.

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