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Flowers of C*ampanula* species as a source of biologically active substances

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Abstract. The content of the major groups of biologically active substances in flowers of 7 *Campanula* species, cultivated in the forest-steppe of Western Siberia, were investigated for the first time. Freshly collected flowers were found to contain 0.06-0.15 % of catechins, 0.31-3.17 % of flavonols, 3.31-6.47 % of tannins, 3.10-15.57 % of pectic substances, and 0.66-16.4 mg% of carotenoids calculated per absolute dre weight of raw material. The amount of ascorbic acid was 36.9-114.0 mg% per wet weight. The data indicate that Campanula flowers are promising for the production of phenolic compounds, the development of food additives and fresh consumptions a seasoning.

1 Introduction

Flowers have long been used in the cookery of different countries as ingredients that enhance the nutritional and aesthetic qualities of food. More than a hundred species of edible flowers belonging to ornamental, vegetable, and fruit crops are known [1–3]. The main component of the flowers consumed for food is water (more than 80 %), they also contain a lot of fiber, minerals, especially phosphorus and potassium, vitamins, but the content of proteins and lipids is low [4, 5]. In addition, flowers are widely used as medicinal products [6–8].

Contemporary studies have shown that the flowers are rich in natural antioxidants, such as phenolic compounds, carotenoids, and saponins. In particular, a high correlation was found between the antioxidant activity of flower extracts and the total content of phenolic substances in them [9, 10]. Phenolic acids and flavonoids—quercetin, kaempferol, apigenin, luteolin, hesperidin, rutin, myricetin—predominate, and catechins are also present. Lutein, zeaxanthin, and ß-carotene are the most common carotenoids in the flowers [6, 11, 12].

Recently, there has been an active search for new sources of nutrients and biologically active substances of natural origin, due to the growing need for safe food additives. They are necessary for the prevention and treatment of a number of chronic diseases caused by oxidative stress [5, 8, 13]. In this regard, a phytochemical study of edible flowers of wild plants, for example, *Campanula* species, is of great interest. Representatives of the genus are used in folk and traditional medicine, however, their composition has not been studied

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enough, especially that of the flowers. It is known about the consumption of green shoots and roots of some species, but flowers are mentioned very rarely [13, 14].

The aim of the study was to determine the content of selected major groups of bioactive substances in the flowers of 7 *Campanula* species.

2 Materials and methods

The study was performed at the Central Siberian Botanical Garden, SB RAS (Novosibirsk, Russia) in 2011 and 2013. Freshly collected flowers of *Campanula alliariifolia* Willd., *C. carpatica* Jacq., *C. latifolia* L., *C. persicifolia* L., *C. rapunculoides* L., *C. sarmatica* Ker-Gawl., and *C. trachelium* L. were analyzed. *C. latifolia* and *C. persicifolia* are early-summer flowering species, the rest belong to the summer group.

Weather conditions during the flowering period of *Campanula* species varied considerably over the years of the study. June 2011 turned out to be very warm and dry: the average monthly air temperature was 20.1 ˚C, exceeding the norm by 3.4 ˚C; precipitation fell 30 mm, which is half the annual average. June 2013 was cool (14.6 ˚C), but also dry (38.1 mm). In July 2011, with a lack of heat (17 ˚C), the humidity remained insufficient (46 mm). The climatic indicators of July 2013 fluctuated within the normal range: the average monthly temperature – 19.1 ˚C, precipitation – 76 mm. Due to the contrasting conditions in June, the flowering dates of early-summer species differed significantly over the years, as did the timing of the harvesting of raw materials (10.06.2011 and 17.07.2013). The mass flowering of summer species took place without noticeable deviations.

We used the generally accepted methods of phytochemical research. The amounts of phenolics, pectic substances and carotenoids were assessed spectophotometrically using SF-56 (Russia) and SF "Agilent" 8453 (USA) instruments. The method for determining catechins is based on their ability to give a crimson colour with vanillin solution in concentrated hydrochloric acid (λ = 502 nm). Their concentration in the sample was found using the conversion coefficient for (±) - catechin "Sigma". Flavonols were determined by a reaction of their complexation with aluminum chloride (λ = 415 nm), and the amounts of flavonols were calculated according to the rutin. The content of tannins (hydrolysable tanning substances) were determined by the method based on the formation of a colored complex of tannins with a 2% aqueous solution of ammonium molybdenum acid (λ = 420 nm), the calculation was made according to state standard reference samples of tannins.

Pectic substances (pectins and protopectins) were determined by noncarbazole method of obtaining a specific yellow-orange colour of uronic acids with thymol in a sulfuric acid medium (λ = 480 nm), after removing sugars from raw material. The amounts of pectins and protopectins were determined using a calibration curve constructed from galacturonic acid. The concentration of ascorbic acid was determined by titrimetric method based on its reducing properties (Tilmans' reaction). The total amounts of carotenoids were calculated taking into account the optical density of the acetone-ethanol extract at wavelengths corresponding to absorption maxima of chlorophylls a (662 nm) and b (644 nm), and carotenoids (440.5 nm). Pigment concentration was calculated according to the formulae: Ca + Cb = 5,134D662 + 20,436D644; Ccarotenoids = 4,695D440,5 – 0,268(Ca + Cb).

The result was taken as an average of three measurements for each indicator calculated per absolute dry weight of raw material, except for ascorbic acid.

3 Results and discussion

The biological activity of plants is primarily due to various phenolic compounds, including catechins, flavonols, and tannins. It was found that the content of catechins in *Campanula* flowers is insignificant, at the level of 0.06–0.15 % (Table 1). The amount of flavonols varies considerably, from low values of 0.31–0.59 % in *C. latifolia* to relatively high values – over 3% in *C. alliariifolia*. For most species, the indicator ranges from 1.2–1.7 %. The tannin content is 3.31–6.47 %, with higher values for *C. sarmatica* and *C. rapunculoides*. No definite dynamics of the accumulation of phenolic substances was revealed over the years of the study. However, in the early-summer flowering species *C. latifolia* and *C. persicifolia* under the arid conditions of 2011, the synthesis of flavonols and tannins was reduced. In general, the content of phenolics is characterized by less interspecific variability than other groups of secondary metabolites, with the highest total values for *C. alliariifolia* and *C. sarmatica* (above 7 %), and the lowest for *C. latifolia* and *C. persicifolia*.

Table 1. Total content of phenolic substances in *Campanula* flowers (% per absolute dry weight)

Name	Catechins	Flavonols	Tannins
C. alliariifolia	0.15±0.002 0.14±0.001	3.11±0.07 3.17±0.05	4.63±0.12 3.74±0.10
C. carpatica	0.10±0.001 0.08±0.001	1.68±0.03 1.33±0.02	5.66±0.16 3.63±0.11
C. latifolia	0.07±0.001 0.13±0.001	0.59±0.01 0.31±0.01	4.52±0.11 3.83±0.12
C. persicifolia	0.09±0.001 0.11±0.002	1.42±0.01 1.32±0.01	4.11±0.17 3.96±0.09
C. rapunculoides	0.11±0.001 0.11±0.001	0.91±0.02 1.07±0.02	3.93±0.09 6.47±0.19
C. sarmatica	0.08±0.01 0.10±0.001	1.52±0.01 1.72±0.01	5.65±0.15 5.74±0.18
C. trachelium	0.15±0.001 0.06±0.001	1.74±0.02 1.17±0.02	3.31±0.10 6.28±0.19

Note. Above the line are the data of 2011, below the line those of 2013.

Vitamin activity of *Campanula* flowers is due to the content of ascorbic acid and carotenoids. It was found that the species significantly differ in the content of ascorbic acid. Meanwhile, its amount is rather high—50–100 mg% per wet weight—so that fresh *Campanula* flowers can serve as an additional source of this vitamin (Fig. 1). Fluctuations in the indicator over the years can be significant, as in *C. rapunculoides*, reflecting the specific reaction to a complex of environmental conditions. In most species, the dry conditions of 2011 have increased amounts of ascorbic acid in flowers, while the range of interspecific variation of the indicator over the years is not so significant. Perhaps this is due to the influence of the June drought in both seasons of the study.

The content of carotenoids in *Campanula* flowers varies from 0.66 % to 16.4 % (Fig. 2). The minimum value is obtained for *C. alliariifolia*, a species with white flowers. In intensely colored, blue and violet flowers, there are more of them – in flowers of *C. rapunculoides*, *C. latifolia*, *and C. persicifolia*. However, the values for *Campanula* flowers are inferior to those for other edible flowers [12].

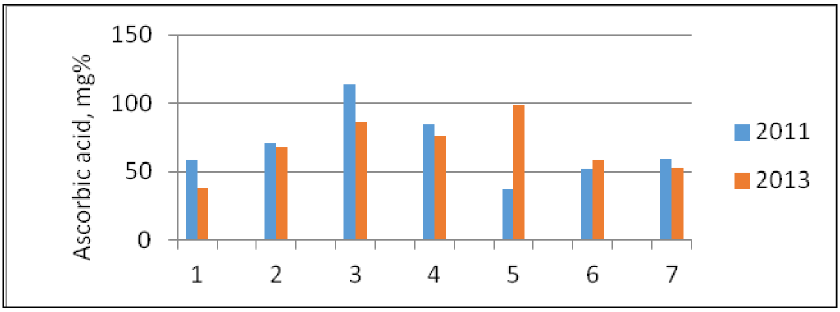

Fig. 1. The content of ascorbic acid (wet weight) in *Campanula* flowers: 1 – *C. alliariifolia*, 2 – *C. carpatica*, 3 – *C. latifolia*, 4 – *C. persicifolia*, 5 – *C. rapunculoides*, 6 – *C. sarmatica*, 7 – *C. trachelium*.

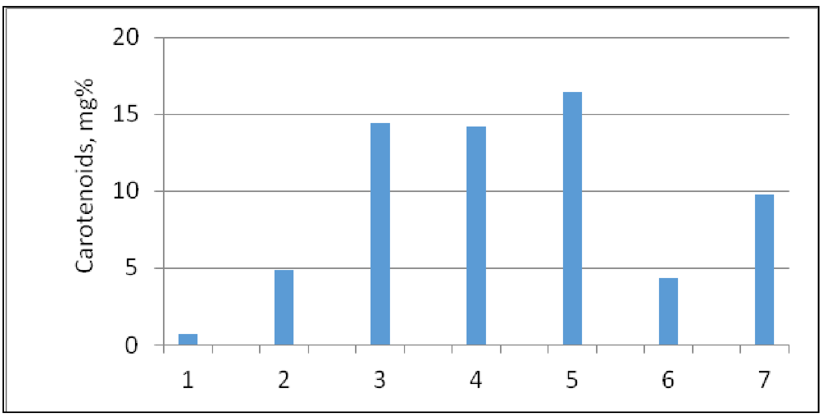

Fig. 2. Total carotenoid content (absolute dry weight) in *Campanula* flowers. Names – see Fig. 1.

The nutritional value of flowers is also provided by the content of pectic substances, which serve as dietary fiber (prebiotics) necessary for the health of the human immune system [15]. In plants, these substances play a role of structural components, and protopectins predominate in actively growing tissues. In *Campanula* flowers the amounts of pectic substances varies within 3.10–15.57 % (Fig. 3).

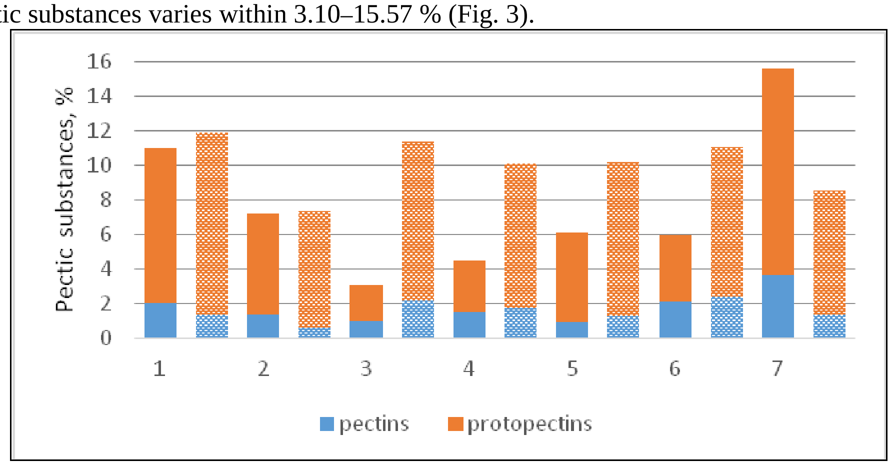

Fig. 3. The content of pectic substances (absolute dry weight) in *Campanula* flowers. Names – see Fig. 1. Columns with solid fill correspond to the values for 2011, columns with patterned fill those for 2013.

Under more favorable conditions for plant growth in 2013 their content, as a rule, was higher.

4 Conclusion

The flowers of *Campanula* species cultivated in the forest-steppe of Western Siberia are characterized by relatively high total content of phenolic compounds (up to 7.89 %), pectic substances (up to 15.57 %), and ascorbic acid (up to 114.0 mg%). The findings testify to the prospects of using them as a source for obtaining bioactive substances of natural origin and fresh consumption as a food supplement.

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