Effect of variety on content of bioactive phenolic compounds in common elder (Sambucus nigra L.)

Naděžda Vrchotová, Eva Dadáková, Aleš Matějíček, Jan Tříška and Jiří Kaplan

Laboratory of Metabolomics and Isotopic Analyses, Global Change Research Centre, Academy of Sciences of the Czech Republic, České Budějovice, Czech Republic; Faculty of Agriculture, Department of Applied Chemistry, University of South Bohemia, České Budějovice, Czech Republic; Gene Pool Department, Research and Breeding Institute of Pomology Holovousy Ltd., Hořice, Czech Republic

ABSTRACT
The inflorescence of common elder (Sambucus nigra L., Adoxaceae) is known to be rich in phenolic compounds. The content of five selected phenolic compounds (rutin, chlorogenic acid, isoquercitrin, isorhamnetin-3-O-rutinoside and dicaffeoylquinic acid) was determined in methanolic extracts from flowers and floral stems by HPLC in samples obtained from 20 varieties of S. nigra cultivated in Czech Republic. In all samples, there were determined rutin (11–54 mg/g), chlorogenic acid (23–46 mg/g), isoquercitrin (0.6–18 mg/g), isorhamnetin-3-O-rutinoside (3–10 mg/g), calculated on air-dried material. The content of dicaffeoylquinic acid was 0–13 mg/g of air-dried material. The amount of the analysed compounds in floral stems was lower than the flowers. The results are a unique set of information on the content of main phenolics in the inflorescence of cultured elderberry varieties.

1. Introduction
Common elder (Sambucus nigra L.) prefers edge of forest, vicinity of ways and buildings and ruderal territory. Common elder has been a traditional medicinal plant since the Middle Ages. The inflorescence and fruit of common elder are incorporated into European pharmacopoeia. Common elder seems to be a valuable plant usable as a rich source of bioactive phenols (Zakay-Rones et al. 2004).
The material from common elder (inflorescence, fruit) is also used in the production of food. Intensively fragrant inflorescence serves as raw material for the production of beverages. In Middle Europe, short time fermented lemonade is prepared in households. Syrup flavoured with elderflower is produced and sold all over Europe. These products can also be sources of flavonoids in the case of careful preparation methods. Elderberries are rich in organic acids and anthocyanins, and they are used for the production of juice, fruit syrup and jams. The anthocyanins from elderberries are very intensive food colourants (Veberic et al. 2009) and they have strong antioxidant potential (Mandrone et al. 2014).

Raw material for industrial processing is obtained from wild plants. The breeding of cultivated variety is extended because of material quality and regular yield.

The aim of our study was to compare the content of significant phenolic compounds (rutin, isoquercitrin, chlorogenic acid, isorhamnetin-3-O-rutinoside, 3, 5-dicafeoylquinic acid) in inflorescences of 20 varieties of common elder cultivated in the Czech Republic.

2. Results and discussion

In this study, the samples of inflorescence and floral stems from 20 varieties of elderberry were analysed. Studies dealing with the inflorescence and floral stems are still few in number; much more work is focused on the contents of the substance in fruits of elderberry. Christensen and his colleagues (Christensen et al. 2008) analysed compounds in inflorescence of 16 varieties, four of them were also in our experimental group (‘Haschberg’, ‘Sambu’, ‘Samdal’, ‘Sampo’).

From our set of 20 varieties, three varieties were ornamental (‘Aurea’, ‘Black Beauty’ and ‘Madona’) and the rest were fruit varieties (‘Albida’, ‘Allesö’, ‘Bohatka’, ‘Dana’, ‘Heidegg 13’, ‘Haschberg’, ‘Körsör’, ‘Mammut’, ‘Pregarten’, ‘Riese aus Voßloch’, ‘Sambo’, ‘Sambu’, ‘Samdal’, ‘Sampo’, ‘Samyl’, ‘Tulbing’ and ‘Weihenstephan’). In the sampling site, three bushes of each variety were planted (Matějíček et al. 2015).

The inflorescence of common elder is a very rich source of flavonoids and phenolic acids. The chromatogram of the extract from flower is shown in Figure S1. The main flavonoid in elderflowers is rutin. The content of rutin in elderflower growing in the wild exceeds 20 mg/g per air-dried material (ADM). Thus, this material is one of the richest plant sources of rutin together with buckwheat (Fagopyrum) (Kalinova & Dadakova 2006, Christensen et al., 2010), amaranth (Amaranthus) (Kalinova & Dadakova 2009) and Japanese pagoda tree (Sophora japonica) (Paniwnyk et al. 2001). According to one of our previous studies, rutin is stable during drying at room temperature, but the rutin content decreases by about a quarter during one year of storage (Dadakova et al. 2011). A smaller amount of rutin can also be found in branches and leaves of common elderberry (Vespalcová et al. 2011).

We found that the content of rutin in the flowers of selected cultivars varies from 11 to 54 mg/g ADM (Table S1). The highest content was in the variety ‘Weihenstephan’ (54 mg/g AMD). Content of rutin in the varieties ‘Sambo’ and ‘Samdal’ (ca. 22 mg/g AMD) was approximately the same as described by Christensen et al. (2008). For variety ‘Haschberg’, the rutin content was approximately twice as large (ca. 50 mg/g AMD) and for ‘Sampo’, twice less (ca. 18 mg/g AMD) than described by Christensen et al. (2008). Also, values of the other substances differ from the results of Christensen et al. (2008). It is interesting that the rutin content in flowers in six varieties is greater than 30 mg/g ADM, which is more than we have seen in long-term studies in wild growing elder. Amount of substances depends, of course, on the date of collection, location, weather and also on the process of extracts preparation.
In flowers, chlorogenic acid content varies between 23 and 46 mg/g AMD, isoquercitrin content varies between 0.7 and 18 mg/g AMD; isorhamnetin-3-O-rutinoside between 3 and 10 mg/g AMD and the content of 3,5-dicaffeoylquinic acid does not exceed 14 mg/g AMD (Table S1). The quantity of selected compounds in the floral stems is substantially lower than in the flowers (Table S1, S2, Figure S2). The differences between sum of analysed compounds in flowers and floral stems were statistically significant (the test for differences of means of paired samples, \( p < 0.01 \)).

PCA analysis of the flavonoid content in the flowers proves that Aurea, one of the ornamental varieties, is very different from all the others (Figure S3). The other varieties do not show any significant relationship.

The flowers of ‘Riese aus Voßloch’, ‘Sampo’, ‘Sambu’ and ‘Körsör’ contain the highest amounts of phenolic acids, varieties ‘Weihenstephan’, ‘Tulbing’ and ‘Haschberg’ are rich in rutin and isorhamnetin-3-O-rutinoside. Variety ‘Aurea’ is different in content of substances in the flower stems from the others, but ‘Tulbing’ and ‘Körsör’ are the most different varieties, when we compare the amounts of substances in the stems (Figure S4). Correlation between the content of individual compounds in flowers and floral stems was not found.

The limit of detection and quantification is shown in Table S3.

It is interesting, that sensory testing of fruits showed that ‘Dana’, ‘Bohatka’, ‘Samdal’, ‘Weihenstephan’ and ‘Haschberg’ were the best and ‘Aurea’ and ‘Albida’ were among the worst (Matějíček et al. 2013).

3. Conclusion

Growing and breeding of diverse varieties of common elder are the way to get high-quality material for food and pharmaceutical use. Preparations with elderflowers are known to be effective in healing of the common cold, flu and cough. According to scientific literature, flavonoids of common elder have the ability to be strong antioxidants. The natural sources of bioactive compounds are believed to be more suitable than synthetic drugs because of a better absorption and recovery of the compounds. The material originating from common elder is rich in bioactive compounds with predominant flavonoids and phenolic acids.

According to our study, the flowers of common elder from cultivated varieties contain much more phenolic compounds than material from wild common elder. The flower stems are also a source of polyphenols, especially rutin and chlorogenic acid.

Supplementary material

Experimental details of this article, Tables S1–S3 and Figures S1–S4 are available online.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Grant Agency of the University of South Bohemia [grant number GAJU 112/2016/Z]; the Ministry of Education, Youth and Sports of CR within the National Sustainability Program I (NPU I) [grant number LO1415] and by the Ministry of Education, Youth and Sports of CR under Infrastructure project CZ.1.05/2.1.00/03.0116.
References

Christensen LP, Kaack K, Fretté XC. 2008. Selection of elderberry (Sambucus nigra L.) genotypes best suited for the preparation of elderflower extracts rich in flavonoids and phenolic acids. Eur Food Res Technol. 227:293–305.

Christensen KB, Kaemper M, Loges R, Fretté XC, Christensen LP, Grevsen K. 2010. Effect of nitrogen fertilization, harvest time, and species on the concentration of polyphenols in aerial parts and seeds of normal and tartary buckwheat (Fagopyrum sp.). Europ J Hort Sci. 75:153–164.

Dadáková E, Vrchotová N, Chmelová Š, Šerá B. 2011. The stability of rutin and chlorogenic acid during the processing of black elder (Sambucus nigra) inflorescence. Acta Alim. 40:327–334.

Kalinová J, Dadáková E. 2006. Varietal and year variation of rutin content in common buckwheat (Fagopyrum esculentum Moench). Cereal Res Commun. 34:1315–1321.

Kalinova J, Dadakova E. 2009. Rutin and total quercetin content in amaranth (Amaranthus spp.). Plant Foods Hum Nutr. 64:68–74.

Mandrone M, Lorenzi B, Maggio A, La Mantia T, Scordino M, Bruno M, Poli F. 2014. Polyphenols pattern and correlation with antioxidant activities of berries extract from four different populations of Sicilian Sambucus nigra L. Nat Prod Res. 28:1246–1253.

Matějíček A, Kaplan J, Matějíčková J. 2013. Methodology for the development of cultural varieties of elderberry. Holovousy: Research and Breeding Institute of Pomology Holovousy Ltd.

Matějíček A, Kaplan J, Matějíčková J. 2015. Performance of elderberry cultivars growing in the Czech Republic. Acta Hort (ISHS). 1061:209–213.

Paniwnyk L, Beaufoy E, Lorimer JP, Mason TJ. 2001. The extraction of rutin from flower buds of Sophora japonica. Ultrason Sonochem. 8:299–301.

Veberic R, Jakopic J, Stampar F, Schmitzer V. 2009. European elderberry (Sambucus nigra L.) rich in sugars, organic acids, anthocyanins and selected polyphenols. Food Chem. 114:511–515.

Vespalcová M, Grušlichová H, Matějíček A, Kaplan J. 2011. Elderberry as a source of important flavonoid rutin. Vědecké práce ovocnářské. 22:243–251 (In Czech.).

Zakay-Rones Z, Thom E, Wollan T, Wadstein J. 2004. Randomized study of the efficacy and safety of oral elderberry extract in the treatment of influenza A and B virus infections. J International Med Res. 32:132–140.