Bioactive compounds of guelder rose and pro-health potential

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In Poland, the guelder rose (*Viburnum opulus* L.) occurs in its natural state or, due to its decorative value, is planted in home gardens. Although various parts of the plant are used in folk medicine, the scientific research conducted so far has focused mainly on the composition and biological activity of the fruit. The pro-health properties of guelder rose fruit are mainly attributed to the presence of phenolic compounds, which contribute to a significant reduction in the risk of developing civilization diseases, including obesity and type 2 diabetes. An important strategy in the treatment of these diseases is the inhibition of the digestion of lipids and carbohydrates and, consequently, the reduction of the amount of free fatty acids and glucose absorbed from the gastrointestinal tract.

The paper presents a research hypothesis that the components of the bark and flowers of the guelder rose, similarly to fruit phytochemicals, exhibit antidiabetic and antiobesity activities, which have not been confirmed in the literature. In order to verify the above assumption, the biological properties of the extracted components of various parts of the guelder rose were examined, including the determination of the antioxidant potential, the ability to inhibit the activity of glycolytic and lipolytic enzymes and the formation of advanced glycation end products, as well as the binding of bile salts. An important aspect of the work was the use of various model measurement systems and confirmation of the obtained results in a simulated three-stage digestion process of potato starch and rapeseed oil. It was also important to determine the qualitative and quantitative composition of extracts using the UPLC-PDA-Q/ TOF-MS method in order to link the demonstrated biological properties with extracts composition.

In the first stage of the research, dried fruits, bark and flowers of guelder rose were characterized in terms of their basic chemical composition and the content of phenolic compounds and vitamin C using gravimetric, titration, spectrophotometric and chromatographic methods. The results obtained during the experiments showed variation in the content of macronutrients, total phenolic compounds, flavonoids, flavanols, proanthocyanidins, flavonols and hydroxycinnamic acids.

The second stage of the work involved the extraction of plant material with the use of water, 70% ethanol and 70% acetone, followed by purification of crude ethanol and acetone extracts by solid phase extraction. The content of phenolic compounds was the criterion for the quality of the obtained extracts. It was shown that the most effective extraction solvent was 70% acetone and the purification process caused a significant increase in the

concentration of phenolic compounds in fruit extracts. The phenolic profile determined by the UPLC-PDA-Q/TOF-MS method did not depend on the type of extractant. Twenty tree, twenty five and seventeen phenolic compounds were identified in fruit, flower and bark extracts, respectively. The fruit extracts contained hydroxycinnamic acids, flavanols, flavonols and flavalignans, while flavonols were not present in the bark extracts, and the flower extracts did not contain flavanols and flavalignans. Moreover, the dominant phenolic compound in fruits and flowers was chlorogenic acid, and in the bark (+)-catechin.

In the next part of the work, research was undertaken to determine the antidiabetic, antiobesity and antioxidant activity of extracts *in vitro*. The antidiabetic potential was determined as the effectiveness of inhibition of porcine pancreatic α-amylase activity in the presence of potato and rice starch, rat intestinal α-glucosidase in a maltose or sucrose model and the formation of protein glycation end products using the BSA-fructose and BSA-glucose systems. The antiobesity activity was determined as the effectiveness of inhibition of porcine pancreatic lipase in an emulsion of glycerol trioleate and binding of bile salts. Whereas, the antioxidant potential was determined as the ability to scavenge $ABTS^{\bullet+}$, $ROO^{\bullet}$ and $O_2^{\bullet-}$ radicals and reduce iron(III) ions. The crude extracts were characterized by a lower biological activity than the purified extracts due to the lower content of phenolic compounds and the presence of non-phenolic components. The highest inhibitory activity against glycolytic enzymes and lipase, as well as glycation end products in BSA-fructose model, was demonstrated by purified acetone extract from guelder rose fruit. However, its activity was lower than that of acarbose and orlistat - drugs used in the treatment of diabetes or obesity. The components of the purified fruit extract, such as acarbose, inhibited the activity of α-amylase in a competitive manner and the activity of α-glucosidase through mixed inhibition, and also showed the ability to enhance the activity of acarbose. Probably, the proanthocyanidins are responsible for the antiamylase activity while chloregonic acid for the antiglucosidase and antiglycation activities of the guelder rose fruit. Inhibition of the lipolysis process by the components of *V. opulus* fruit was associated with the reduction of pancreatic lipase activity by extractable compounds through competitive inhibition and as a result of bile salts binding by dietary fiber components.

The tests carried out under the conditions of simulated *in vitro* digestion confirmed the antidiabetic and antiobesity properties of fruit and bark extracts and only the antidiabetic effect of flower extracts. The above abilities have also been demonstrated for ground fruit,

bark and flowers subjected to the digestive process. In addition, the decrease of phenolics content and the presence of new compounds such as quinic acid, neochlorogenic acid, caffeoylquinic acid and vanillic acid have been observed after the digestion process. After the digestion process, the highest retention of the total phenolics was determined for fruit extracts and for hydroxycinnamic acids among the analysed groups of phenolic compounds.

To sum up, the results of the present research increase knowledge in the field of the composition of *V. opulus* bark and flowers, as well as the antidiabetic, antiobesity and antioxidant potential of fruit, bark and flower components. Research indicates guelder rose fruit as a potential source of bioactive ingredients for functional food design and dietary supplements intended for people with obesity and type 2 diabetes.