



Phytochemical study of leaves and inflorescences of two genus *Sorbus* L. species native for the Ukrainian flora

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Rowan species (genus *Sorbus* L., *Rosaceae* Juss.) are widespread in the Northern Hemisphere under different climatic and ecological conditions. Recent molecular-phylogenetic studies confirmed that genus *Sorbus* L. is polyphyletic and must be divided into the segregate genera. Accordingly, the native for the Ukrainian flora species *Sorbus domestica* L. and *Sorbus torminalis* (L.) Crantz., having very distant morphological features of vegetative and generative organs, must belong to different genera. In this regard we assumed the chemotaxonomic importance of the specificity in the phenolic content and composition of two indicated rowan species. Young leaves and inflorescences of *S. domestica* and *S. torminalis* were collected in Botanical Garden of Oles Honchar DNU in May 2023. Analyses of isopropanol plant extracts revealed the higher levels of total phenolic content (2.5 times), flavonoids (1.5 times) and phenolic acids content (3.2 times), as well as ferric-reducing power (1.2 times), and total antioxidant capacity (1.7 times) in leaves of *S. domestica*, as compared to *S. torminalis* leaves. In general, *S. domestica* leaves accumulated higher total phenols, flavonoids and phenolic acids content than the inflorescences, while the opposite ratio was found for *S. torminalis*. Study results confirmed the chemotaxonomic importance of polyphenols content and composition of two rowan species. However, more detailed investigations are necessary to establish the correlation between the individual phenolic compounds and the rowan species features.

Keywords: rowans; *S. domestica*; *S. torminalis*; leaves; inflorescences; polyphenols; flavonoids; phenolic acids; antioxidant capacity; chemotaxonomy

Introduction

The genus *Sorbus* L. (*Rosaceae* Juss.) established by Linnaeus (Linnaeus, 1753) initially included only two pinnately leaved species *S. aucuparia* L. and *S. domestica* L. The different simple leaved species were added in the *Sorbus* sensu lato (*Sorbus* s.l.) by researches which based mainly on morphological characters such as the color of hairs on the buds, the number, size and shape of leaflets and the color of the fruits, combined with ploidy levels, breeding systems and geographical distribution (McAllister, 2005). Currently, the genus *Sorbus* L. include more than 250 species of trees and shrubs that grow naturally in East Asia and are widespread in the Northern Hemisphere under different climatic and ecological conditions (Sołtys et al., 2020). Not surprising, the taxonomy of *Sorbus* has been controversial due to the exceptional genetic and morphological diversity within the genus, which is the result of repeated polyploidization, homo- and heteroploidy hybridization, backcrossing and apomixis (Aldasoro et al., 1998; McAllister, 2005). Because the genus *Sorbus* L. is a polyphyletic taxon, some authors have

assigned the rank of sections, subgenera or even genera to individual groups of species within it (Robertson et al., 1991). Other taxonomists propose a broad interpretation of the genus, in which the above-mentioned taxa have the rank of sections or subgenera of the genus *Sorbus* (Aldasoro et al., 1998), referring to the fact that there is no interbreeding barrier between these genera and they are easily hybridize as among themselves.

A new approach to taxonomy of the family *Rosaceae* (Potter et al., 2007), based on the comparative results of molecular-phylogenetic and morphological studies, arranged also the genus *Sorbus* L. Plant species belonging to this genus were distributed by six taxa that received rank of genera. Studies of the nucleotide sequences of nuclear and ribosomal DNA (Li et al., 2012) confirmed the monophyletic nature of these groups and the expediency of considering them as separate genera. Recently, analyses of chloroplast genomes confirmed that *Sorbus* s. l. is polyphyletic and the six segregate genera, i.e., *Sorbus* s.s., *Aria*, *Torminalis*, *Cormus*, *Miromeles*, and *Chamaemespilus*, are monophyletic (Tang et al., 2022).

In Ukrainian flora, the rowans are represented by some native species, including *Sorbus domestica* L. and *Sorbus*

torminalis (L.) Crantz. (Dobrochaeva et al., 1987), and 35 introduced species (Melnichenko, 2008). In turn, Fedoronchuk (2017), making changes and additions to the system of Potter et al (2007), determined the position of rowan species in the new system of the *Rosaceae* genera of the flora of Ukraine. According to the new system, the species *S. domestica* L. was included in the genus *Cornus* Spach, and named *C. domestica* (L.) Spach., and the species *S. torminalis* (L.) Crantz. was assigned to the genus *Torminalis* Medik. and named *T. clusii* M. Roem. ex K.R. Robertson & Phipps. Similarly, to the great morphological diversity of rowans, the recent years studies showed also the high variability in phytochemical composition and antioxidant capacity of both vegetative and generative parts of plants of different rowan species (Olszewska & Michel, 2009; Raudonė et al., 2015; Lykholat et al., 2021). In this regard, specificity in the phenolic composition of different species within the same genus are discussed in term of their chemotaxonomic importance (Gaivelyte et al., 2013; Belemets et al, 2014). The aim of the work was to identify the features of polyphenols content and antioxidant potential of two native for the Ukrainian flora rowan species, which according to the new system should be included in separate genera.

Materials and methods

Leaves and inflorescences of the plants of *Sorbus domestica* L. and *Sorbus torminalis* (L.) Crantz, representing the native rowan species in Ukrainian flora, were used for a comparative study of the secondary metabolites' accumulation and antioxidant potential. Both the inflorescences and young leaves were collected in the first part of May 2023 on the territory Botanical Garden of Oles Honchar Dnipro National University (48 ° 26'7 "N 35 ° 2'34" E, Dnipro city, Ukraine). The plant material was air-dried at the room temperature before plant extracts preparing.

The names of rowan species are given in accordance with the "The World Flora Online Plant List" (WFO) for the genus *Sorbus* L., as it is currently the most comprehensive and authoritative list of the world's plants, maintained by the world's taxonomic community as a free and open access resource. The WFO plant list contains the accepted Latin name of the species with references to all synonyms by which the species has been known.

Morphological features of the studied rowan species are significantly different: plants of *S. domestica* have odd-pinnate, saw-toothed leaves, a gynoeceum of 5 carpels, an inferior ovary; plants of *S. torminalis* have simple lobed or dissected leaves, sometimes one pair of blades is completely separated, a gynoeceum with 2 carpels (Dobrochaeva et al., 1987; Robertson et al., 1991; Melnychenko, 2008). Here, indicated differences are illustrated by leaves and inflorescences of *Sorbus domestica* L. and *Sorbus torminalis* (L.) Crantz collected in the Botanical Garden (Fig. 1).

The extracts of rowan leaves and inflorescences containing the phenolic compounds were prepared using 80% isopropanol. The method of Singleton et al. (1999) was used for the total phenolic content (TPC) measurement with Folin – Ciocalteu reagent; the results were calculated with calibration graph prepared on the solutions of Gallic Acid (GA), and expressed in GA equivalents (mg GAE/g DW). Total flavonoids content (TFC) was determined by aluminum chloride spectrophotometric method (Pękal & Pyrzynska, 2014) and expressed as Rutin equivalents (mg RE/g DW). Phenolic acids content (PAC) in leaves and in inflorescences was determined by spectrophotometric method (Gawron-Gzella et al., 2012) with Arnov's reagent at 490 nm; the results were calculated with a calibration graph and expressed in Gallic Acid equivalents (mg GAE/g DW). Ferric-reducing antioxidant power (FRAP) of the plant extracts was evaluated using potassium ferricyanide method (Pulido et al., 2000) and expressed in Ascorbic Acid equivalents (mg AAE/g DW). Evaluation of total antioxidant capacity (TAC) of leaves and inflorescences was carry out in accordance with Prieto et al (2000) using the reagent solution (0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate); the results were calculated using a calibration graph prepared on the Ascorbic Acid solutions, and expressed in Ascorbic Acid equivalents (mg AAE/g DW).

All determinations were carried out in triplicate; the results were statistically processed and presented as mean $\pm$ standard deviation ($M \pm SD$). The research results were processed by the method of variation statistics using the Statistica 7.0 software package. The significance of the differences between the obtained data was assessed using the Student's t-test with a confidence level of $P \leq 0.05$.

Results and discussion

Analysis of the young leaf isopropanol extracts of two species of the genus *Sorbus* L., assigned to the segregated rowan genera in the new system, revealed notable differences in total phenolic content, flavonoid and phenolic acids content, as well as the antioxidant activity (Table 1).

Young leaves of *S. domestica*, as compared to *S. torminalis* leaves, had the higher levels of all investigated indicators, including total phenolic content (2.5 times), flavonoid content (1.5 times), phenolic acids content (3.2 times), ferric-reducing power (1.2 times), and total antioxidant capacity (1.7 times). Differences between two rowan species were also in the proportion of main studied phenolic compounds. Share of flavonoids 34.8% versus 57.1%, and share of phenolic acids 27.2% versus 21% were revealed, respectively, in *S. domestica* and *S. torminalis* leaves.

Ferric-reducing power accounted for 43.9% of the total antioxidant capacity in leaves of *S. domestica* compared to 65.6% in *S. torminalis* leaves. So, the phenolic complex of young leaves of *S. torminalis* was comparatively richer in



Fig. 1. Leaves and inflorescences of *S. domestica* L. (A) and *Sorbus torminalis* (L.) Crantz (B) collected in the Botanical Garden of Oles Honchar Dnipro National University

Table 1

Phenolic composition and antioxidant capacity of leaves of rowan plants (M ± SD, n=3)

Indicator	Plant species name in WFO	
	<i>S. domestica</i> L.	<i>S. torminalis</i> (L.) Crantz
Total phenolic content, mg GAE/g DW	31.42 ± 0.35	12.62 ± 0.39*
Total flavonoids content, mg RE/g DW	10.93 ± 0.12	7.20 ± 0.12*
Phenolic acids content, mg GAE/g DW	8.56 ± 0.13	2.65 ± 0.17*
Ferric reducing/antioxidant power, mg AAE/g DW	17.11 ± 0.95	14.68 ± 0.35*
Total antioxidant capacity, mg AAE/g DW	38.97 ± 1.21	22.39 ± 0.73*

Note: asterisk (*) means the significant differences in a row, $P < 0.05$

flavonoids, while leaves of *S. domestica* richer in phenolic acids, which reflected the features of the secondary metabolism of studied rowan species.

Variability of total phenolic content from 12.6 mg GAE/g (*S. torminalis* leaves) to 31.4 mg GAE/g (*S. domestica* leaves) is consistent with the data of Gaivelyte et al (2013) about ranging the total content of identified phenolic compounds from 7.18 to 35.74 mg GAE /g in leaf samples of introduced rowan plants. In the methanolic leaf extracts of three rowan species the total content of phenolics was determined in range 30.4–76.1 mg GAE/g (Tahirovic et al., 2019).

Differences between our results and reported data could be due to genetic factors, environmental conditions, leaf maturity as well as the solvent extraction activity. Zymone et al. (2022)

noted the phenolic content in the inflorescences and leaves of various *Sorbus* genotypes strongly depends on geographic, climatic, and edaphic conditions.

This study identified less notable differences in both phenolic compounds content and antioxidant activity of the inflorescence isopropanol extracts of two compared native rowan species (Table 2).

Total phenolic content, flavonoid content, ferric-reducing power, and total antioxidant capacity were higher in the *S. domestica* inflorescences (respectively, by 19.9%, 36.6%, 8.5%, and 13.9%) than in *S. torminalis* once. However, phenolic acids content was by 25.5% higher in the *S. torminalis* inflorescences. Differences in the flavonoids share in the total phenolic content and FRAP/TAC proportion in the

Table 2

Polyphenolic composition and antioxidant capacity of inflorescences of rowan plants (M ± SD, n=3)

Indicator	Plant species name in WFO	
	<i>S. domestica</i> L.	<i>S. torminalis</i> (L.) Crantz
Total phenolic content, mg GAE/g DW	21.78 ± 0.70	18.16 ± 0.23*
Total flavonoids content, mg RE/g DW	6.76 ± 0.17	4.95 ± 0.09*
Phenolic acids content, mg GAE/g DW	5.54 ± 0.10	6.95 ± 0.04
Ferric reducing/antioxidant power, mg AAE/g DW	21.51 ± 1.50	19.83 ± 0.98
Total antioxidant capacity, mg AAE/g DW	38.74 ± 0.69	34.01 ± 0.87*

Note: asterisk (*) means the significant differences in a row, $P < 0.05$

inflorescences of *S. domestica* and *S. torminalis* were not notable (respectively, 31% versus 27.3%, and 55.6% versus 58.3%). Olszewska (2011) reported the methanolic extracts from *S. torminalis* inflorescences and leaves exhibited lower antioxidant potentials than those of model antioxidant *Sorbus* species, namely *Sorbus aucuparia* L.

Study results showed the species features of both the phenolic compounds proportions and antioxidant activity in the young leaves and inflorescences. Leaves of *S. domestica* accumulated higher total phenols, flavonoids and phenolic acids content, while had lower FRAP and equal TAC level as compared to the inflorescences. At the same time, in leaves of *S. torminalis* all determined indicators were significantly lower than in the inflorescences. Our findings are in accordance with Olszewska and Michel (2009) that the antioxidant activities of *S. aucuparia*, *S. aria*, and *S. intermedia* inflorescences were higher compared to the leaves. In contrast, data of Zymone et al. (2022) showed the total phenolic contents in inflorescences and leaves of various *Sorbus* L. genotypes were comparable. Given the complexity and variability of the individual phenolics composition between plant materials, more detailed investigations are needed.

Conclusion

Phytochemical investigation of isopropanol extracts derived from young leaves and inflorescences of two native for Ukraine rowan species having prominent morphological features was carry out. The results of the experiment have revealed statistically significant differences in the secondary metabolites accumulation and antioxidant potential between of *Sorbus domestica* L. and *Sorbus torminalis* (L.) Crantz. The highest total phenolic content, flavonoids, and phenolic acids content were detected in leaves of *S. domestica*. The greatest ferric reducing/antioxidant power was in the *S. domestica* inflorescences, while the total antioxidant capacity was almost equally high in both leaves and inflorescences of *S. domestica*. As for the *S. torminalis*, the inflorescences of this species exceeded leaves in all parameters, except for the content of flavonoids, which was higher in leaves. Generally, rowans young leaves and inflorescences represent a significant source of phytochemicals, particularly total phenolic compounds, flavonoids, and phenolic acids, resulting in the notable levels of antioxidant activity. At the same time, study results confirmed the hypothesis about the chemotaxonomic

importance of polyphenols content and composition. In this regard, more detailed investigations on the individual phenolic compounds and their antioxidant properties are necessary.

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