

Evaluation of bark phytochemical composition of the genus *Sorbus* plants as a source of biologically active compounds

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Phytocompounds have attracted considerable scientific interest due to their promising healing properties, including antioxidant and anti-inflammatory effects. Plants of the genus *Sorbus* L. are well known in traditional medicine, but the constituents responsible for the pharmacological activity of herbal preparations have not yet been sufficiently identified. In this work, the composition of non-phenolic phytocomponents in the bark of natural for Ukraine *Sorbus* plants was investigated. Using gas chromatography-mass spectrometry (GC-MS), 33, 39, and 36 phytocompounds belonging to alkanes, aldehydes, alcohols, fatty acids and their esters, ketones, terpenoids and nitrogen-containing compounds were identified in extracts of the bark of *Sorbus domestica* L., *S. aucuparia* L., and *S. torminalis* (L.) Crantz., respectively. The largest classes of compounds were alkanes in the bark of *S. domestica*, and terpenoids in the bark of *S. aucuparia* and *S. torminalis*. Extracts of *S. aucuparia* were dominated by tetracyclic terpenoid ethyl isoallocholate (12.44% of the total), while the pentacyclic terpenoids lupeol (15.71%) and alpha-amyrin (7.41%) were predominant in *S. torminalis* and *S. domestica* extracts, respectively. Many of the compounds identified in *Sorbus* bark extracts are well known for their biological activities, including antimicrobial, anti-inflammatory, anti-cancer, hepatoprotective and anti-arthritis effects. The study results indicate that the bark of the genus *Sorbus* plants is a promising source of phytocompounds with significant bioactive potential.

Keywords: *S. domestica*; *S. aucuparia*; *S. torminalis*; bark; non-phenolic compounds; terpenoids; biological activity.

Introduction

The complex of phytocompounds extracted from plant raw materials has long been and still is a rich starting material for the development of medicinal products. Scientific studies of recent decades have made it possible to establish the relationship between the biological activity of plant extracts, including their pharmacological effects, and the phytochemical composition of plants (Reshi et al., 2023). In particular, the important role of polyphenols in inhibiting many diseases has been shown due to their unique molecular structure, which allows them to stop oxidative chain reactions in the cell. The powerful antioxidant capacity of polyphenols is the basis for most of the pharmacological effects of health protection (Proestos, & Varzakas, 2017). Phenolic compounds can contribute to the prevention and/or treatment of such metabolic pathologies as cancer, obesity, diabetes or cardiovascular diseases (Di Sotto, & Di Giacomo, 2023), therefore, the peculiarities of their composition in various plants are actively investigated. The biological activity of other groups of secondary metabolites, including terpenoids, nitrogen-

containing and sulfur-containing compounds, remains less studied, as well as their accumulation in plant tissues.

A large number of plant species are known in ethnomedicine as a source of various compounds that can prevent or alleviate the course of a number of diseases. Such plants include representatives of the genus *Sorbus* L. (family Rosaceae), which accounts for more than 250 species and hybrids, widely distributed in the temperate regions of the Northern Hemisphere (Soltys et al., 2020). In particular, the species *S. aucuparia*, *S. domestica* and *S. torminalis* grow naturally on the territory of Ukraine, and the species *S. aria* and some hybrids were introduced and are cultivated in different regions of the country (Fedoronchuk, 2017).

The genus *Sorbus* plants are well known in the ethnopharmacology of Europe and the world, in particular, preparations made from them served as means for the treatment of bacterial and viral diseases (Sarv et al., 2020). In traditional Turkish medicine, preparations from *S. aucuparia* leaves were used for gastrointestinal problems or prostatitis (Kültür, 2007), and *S. domestica* leaves were used to treat burns, cough, and urolithiasis (Akkol et al., 2020). The bark of *S. decora* and

S. americana plants was used by aboriginal peoples of Canada to treat diabetes (Bailie et al., 2016). A decoction of the *S. aucuparia* bark was used in Lithuania as a means for washing wounds (Pranskuniene et al., 2019), and for the treatment of cancer diseases in Estonia (Sak et al., 2014). Today, the fruits of Sorbus plants are included in the pharmacopoeias of various countries as multivitamin components (Arvinte et al., 2023).

Despite numerous studies, the phytochemicals of Sorbus plants, responsible for the pharmacological activity of herbal preparations, have not yet been fully identified. The vast majority of research on the biological activity of the genus Sorbus plants is devoted to the contribution of polyphenols to its provision (Lykholat et al., 2021; Orsavová et al., 2023), while the role of other compounds is less defined and involves some individual species. For example, a variety of terpenoids have been found in *S. aucuparia* plants, including acyclic triterpenes, triterpene alcohols, as well as triterpene acids (Sarv et al., 2020; Sołtys et al., 2020).

The detection of nitrogen-containing compounds in Sorbus plants is few, in particular, the insignificant content of phenylamides (derivatives of spermidine) was found in *S. aucuparia* inflorescences (Olszewska et al., 2019). Sarv et al. (2020) reported the specific for *S. aucuparia* seeds cyanogenic glycoside prunazine, as well as parasorbic acid in the fruits, which are toxic compounds, but the latter is transformed into non-toxic sorbic acid at low temperature. The component composition of the bark metabolites of the Sorbus genus plants remains understudied at the moment, therefore the aim of the work was to characterize the value of this plant resource in terms of the composition and content of biologically active phytochemicals.

Research materials and methods

We studied the bark of natural for Ukraine plant species *Sorbus domestica* L., *S. aucuparia* L., and *S. torminalis* (L.) Crantz, from the collection of the botanical garden of Oles Honchar Dnipro National University. Bark from one-year shoots of plants was collected in May 2024, dried, ground, and extracts in 80% isopropanol (1:10, weight: volume) were prepared. To identify non-phenolic metabolites, an aliquot of the original extract was extracted three times with chloroform, the combined fractions were dried at 40° C on a rotary evaporator (IKA® RV 10, Germany) and stored at 4 ° C until gas chromatography – mass-spectrometry (GC-MS) analysis.

GC-MS analysis was performed using Shimadzu GCMS-QP 2020 EI (Japan), equipped with a Rxi®-5ms column with a stationary phase of 5% diphenyl/95% dimethyl-polysiloxane. The column temperature increased from 100°C to 300°C with a programmed gradient; flow rate of helium carrier gas 28.2 ml/min; sample volume 1 µl. The identification of separated compounds was carried out by comparing the obtained mass spectra with the database of the electronic library Mass Spectrum Library 2014 for GC-MS (O2125401310). The content of compounds was expressed as a percentage of the total sum of peak areas in the sample.

All analyzes were performed in triplicate; the results were statistically processed by the method of analysis of variance (ANOVA). Data obtained were expressed as mean ± standard deviation ($\bar{x} \pm SD$), and differences between means were considered statistically significant at $P < 0.05$.

Results and discussion

Using GC-MS analysis, 33 compounds were identified in *S. domestica* bark extracts, 39 compounds in *S. aucuparia* bark extracts, and 36 compounds in *S. torminalis* bark extracts, which represented, respectively, 95.8%, 96.4%, and 98.9% of total content of components in the extracts. The content of the main chemical classes to which the identified phytochemicals belong varied significantly in the bark extracts of the studied plants (Table 1).

The composition of alcohols in the bark extracts of *S. aucuparia* and *S. torminalis* plants was dominated by 3,13-octadecenediol (1.16% and 1.82% of total, respectively), while 13-heptadecynol was the main alcohol in *S. domestica* bark extracts.

Among the aldehydes, heptadecanal had the largest share in bark extracts of *S. domestica* and *S. torminalis*, when *S. aucuparia* bark extracts contained almost equal amounts of heptadecanal, pentadecanal and 2-tridecanal.

The composition of main alkanes in the extracts of *S. aucuparia* and *S. torminalis* were represented by tetradecane and pentadecane, as opposed to bark extract *S. domestica*, dominated by tetradecane and heptadecane.

Fatty acids in the bark extracts of *S. domestica*, *S. aucuparia* and *S. torminalis* were represented only by 3-hydroxydodecanoic acid.

Fatty acid esters in the studied bark extracts had the greatest variety of compounds, among which octadecyloxyethyl stearate, dodecylhexyl oxalate, tridecyl methoxyacetate, and 9-octadecenoic acid (2-phenyl-1,3-dioxolan-4-yl) methyl ester were common for the bark extracts of *S. domestica* and *S. torminalis*, while only 6,9,12-octadecatrienoic acid, phenylmethyl ester was common for all plant species. In addition, the bark extracts of *S. domestica*, *S. aucuparia* and *S. torminalis* had a high content of phthalic acid esters (respectively, 18.76%, 10.88% and 12.5% of the total content of compounds), among which dibutyl phthalate dominated in all species.

Nitrogen-containing compounds were represented by various pteridine derivatives in the bark extracts of all plant species, N-methyl-1-adamantaneacetamide in *S. aucuparia* and *S. torminalis* bark extracts, and 2-cyclopropyl-2-nitro-1-phenylethanol as the most nitrogen-containing component in the bark extract of *S. aucuparia* (1.53% of total amount).

The total amount and the diversity of terpenoids prevailed in *S. aucuparia* bark extracts, where tetracyclic triterpenoid ethyl isoallocholate dominated (12.44% of the total), while pentacyclic triterpenoids lupeol (15.71% of the total) and alpha-amyrin (7.41% of the total) prevailed in the bark extracts of *S. torminalis* and *S. domestica* respectively (Fig. 1A, 1B, and 1C).

Table 1
The main chemical classes of the phytochemicals from bark extracts of the Sorbus plants

Chemical class of the compounds	Content of the compounds in the extracts, % of total		
	<i>S. domestica</i>	<i>S. aucuparia</i>	<i>S. torminalis</i>
Alcohols	7.25 ± 0.23	1.44 ± 0.06	2.85 ± 0.10
Aldehydes	8.89 ± 0.31	6.06 ± 0.34	5.24 ± 0.16
Alkanes	39.58 ± 0.42	14.44 ± 0.51	22.85 ± 0.26
Esters	26.96 ± 1.13	18.92 ± 0.87	20.71 ± 0.83
Fatty acids	5.37 ± 0.15	2.96 ± 0.11	1.69 ± 0.06
Terpenoids	11.11 ± 0.67	48.89 ± 1.74	36.10 ± 0.93
Nitrogen-containing	0.81 ± 0.06	2.21 ± 0.08	2.34 ± 0.18

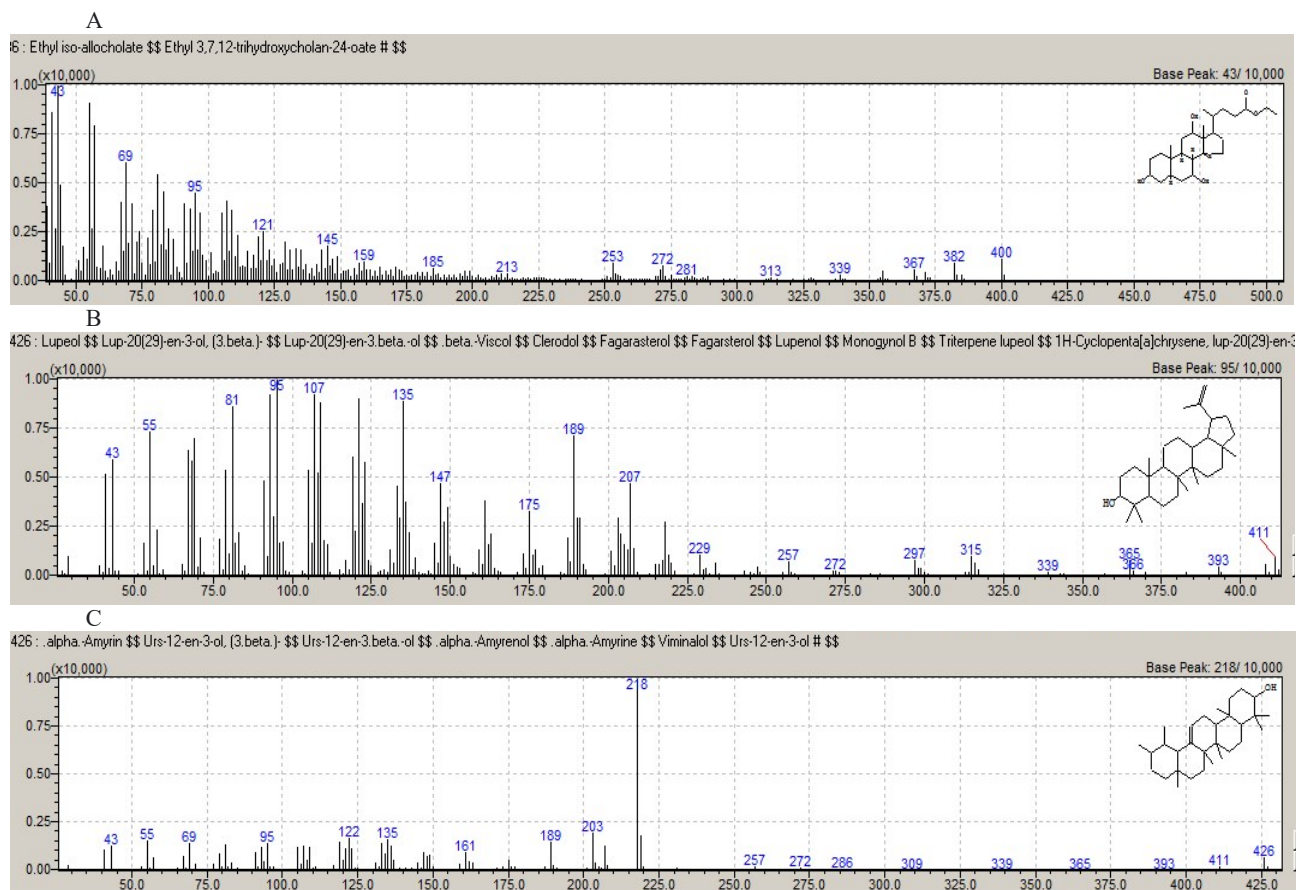


Fig. 1. Mass spectra of main triterpenoids identified by GC-MS assay in the bark extracts of *S. aucuparia*, *S. torminalis* and *S. domestica*: A – ethyl isoallocholate, B – lupeol, C – alpha-amyryn

Ethyl isoallocholate was also found as a minor component in the bark extracts of *S. domestica* (2.45% of total) and *S. torminalis* (1.2% of total). In addition, *S. aucuparia* and *S. torminalis* bark extracts, in contrast to *S. domestica* extracts, contained several steroids, among which cholest-22-ene-21-ol-3,5-dehydro-6-methoxy pivalate was the common compound for these two species.

Some phytochemicals identified in the bark extracts of *S. domestica*, *S. aucuparia* and *S. torminalis* are known for their significant biological activity. Among the terpenoids, ethyl-isoallocholate is known due to anti-inflammatory activity (Sosa et al., 2021). Lupeol possesses an extensive range of pharmacological activities such as anticancer, antioxidant, anti-inflammatory, and antimicrobial activities (Liu et al., 2021). Terpenoid alpha-amyryn exhibited antimicrobial activities against bacteria and fungi, including methicillin-resistant human pathogen *Staphylococcus aureus* (Chung et al., 2013).

Cycloartenol acetate (Fig. 2A), the second largest tetracyclic triterpenoid in *S. aucuparia* bark extracts (8.2% of total), showed moderate cytotoxic activity against breast cancer cell lines (Radi et al., 2023). Tetracyclic triterpenoid beta-sitosterol acetate (Fig. 2B) identified in *S. aucuparia* extracts (5.62% of the total), seems to have antifungal and antibacterial activities (Madureira et al., 2003). Sesquiterpenoid hexahydrofarnesyl acetone, identified as a minor component in bark extracts of *S. domestica* and *S. aucuparia*, endowed with anti-inflammatory, cytotoxic, and antibacterial activities (Xu et al., 2022). Pentadecanal, founded in *S. aucuparia* bark extracts, showed anti-biofilm activity against *Staphylococcus epidermidis* (Casillo et al., 2017).

Phthalic acid esters, identified in the bark extracts of all studied *Sorbus* plants, in particular dibutyl phthalate (Fig. 2C), was found to be bioactive metabolites and showed wide spectrum of antibacterial activity (Bhimba et al., 2012).

In addition, bioactivity of 6,9,12-octadecatrienoic acid, phenylmethyl ester, common compound for all bark extracts,

includes anti-inflammatory, cancer preventive, hepatoprotective, antiarthritic, antihistaminic, and anti-coronary effects (Dr. Duke's, 2016). Ketone 3-(hydroxyphenyl-methyl)-2,3-dimethyl-octan-4-one, founded in *S. aucuparia* bark extracts, was reported (Rahman et al., 2023) as showed good pharmacokinetics and drug-able properties without toxicity, along with antioxidant, anti-inflammatory, and antibacterial activities.

Conclusion

The phytochemical profiling of the bark extracts of *Sorbus domestica* L., *S. aucuparia* L., and *S. torminalis* (L.) Crantz was carry out by GC-MS assay. The non-phenolic phytochemicals were represented by alkanes (39.6%, 14.4% and 22.9% of the total, respectively in *S. domestica*, *S. aucuparia*, and *S. torminalis* bark extracts), aldehydes (8.9%, 6.1%, and 5.4%), alcohols (7.3%, 1.4%, and 2.9%), fatty acids (5.4%, 3.0%, and 1.7%) and their esters (27.0%, 18.9%, and 20.7%), ketones (0%, 5.1%, and 1.9%), terpenoids (11.1%, 48.9%, and 36.1%), and nitrogen-containing compounds (0.8%, 2.2%, and 2.3% of the total). Extracts of *S. aucuparia* were dominated by tetracyclic terpenoid ethyl isoallocholate (12.44% of the total), while the pentacyclic terpenoids lupeol (15.71% of the total) and alpha-amyryn (7.41% of the total) were predominant in *S. torminalis* and *S. domestica* extracts, respectively. Many of the compounds identified in *Sorbus* bark extracts are well known for their biological activities, including antimicrobial, anti-inflammatory, anti-cancer, hepatoprotective and anti-arthritis effects. Our findings suggest the accumulation of great diversity of nonphenolic phytoconstituents in the bark of *Sorbus* plants. The known biological activities of the compounds, identified in the bark extracts of *Sorbus* plants, include wide range of the health-promoting properties. That is why, the bark of *S. domestica*, *S. aucuparia* and *S. torminalis*

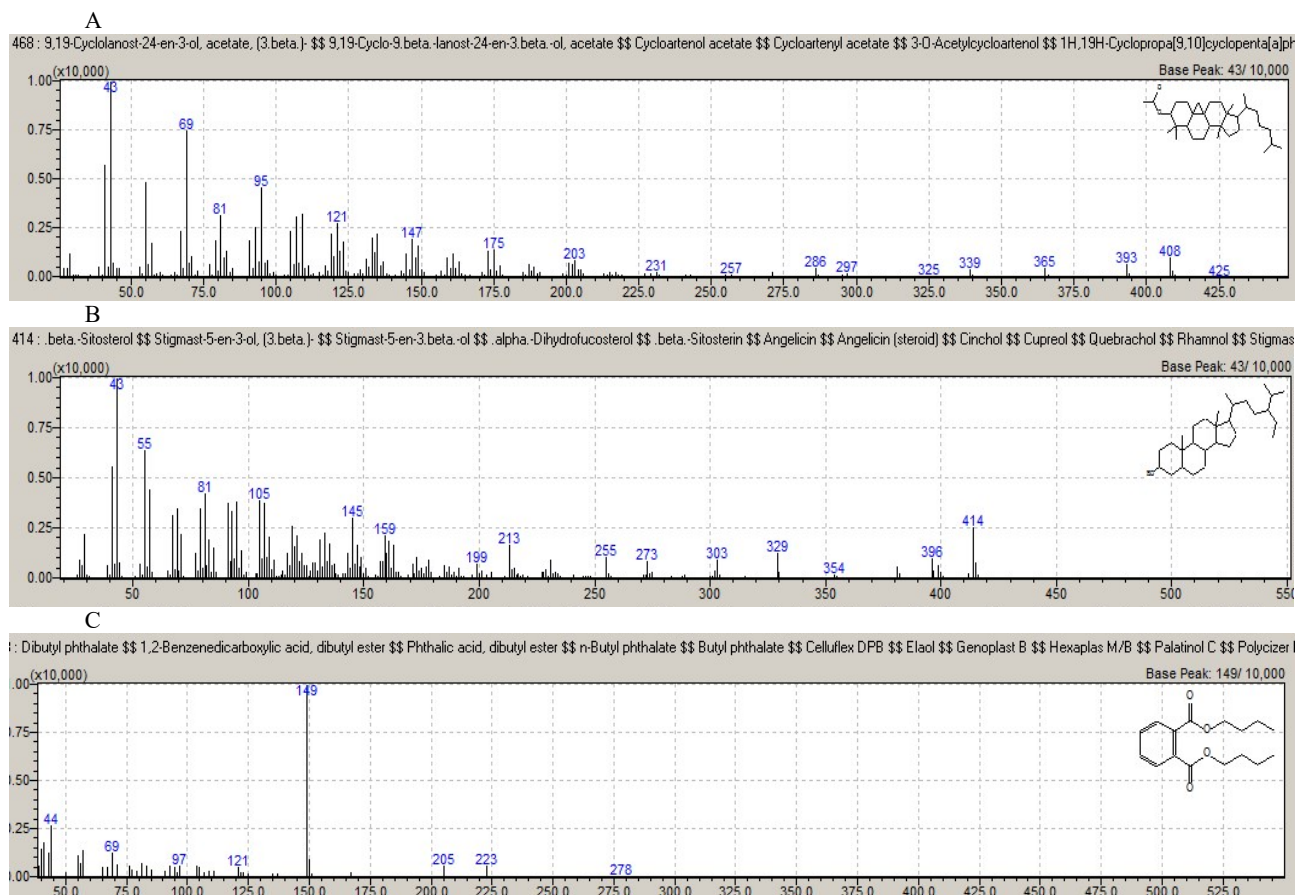


Fig. 2. Mass spectra of the bioactive phytocompounds identified in the bark extracts of *Sorbus* plants:
A – cycloartenol acetate, B – beta-sitosterol acetate, C – dibutyl phthalate

may be designated as a promising source of phytocompounds with significant bioactive potential.

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