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Nutrients content and composition in different morphological parts of Cornelian cherry (*Cornus mas* L.)

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The aim of this study, focused on the nutritional value of different morphological parts: leaves, flowers, fruits and seeds of *Cornus mas* L., was to determine the contents of essential nutrients, fatty acid and amino acid profiles, and the content of selected elements. The most importantly, it was concluded that the contents of studied nutrients differed significantly ($p < 0.05$) depending on the morphological part of plant. Protein content (2.27–10.58%) was generally higher than in many wild or cultivated fruits, while flowers were distinguished by the highest content (10.58%), as compared with other studied parts of this plant. *Cornus mas* contained a substancial amount of lipids (3.34–5.23%, except fruits). Leaves proved to be extremely rich in carotenoids, mainly β-carotene (88.5 mg.kg^{-1}) compared with the rest of the plant. The application of GC enabled detecting 14 fatty acids in lipid fraction extracted from *Cornus mas* samples, belonging to all groups. SFAs were represented by palmitic acid (C16:0) 10.87–32.20 g.100 g^{-1} of oil. Among MUFAs oleic acid (C18:1 *9c*) 3.25–19.61 g.100 g^{-1} of oil dominated, with the highest content in fruits. Lipid fraction was extremely rich in PUFAs: 32.52–61.86 g.100 g^{-1} of oil. The major PUFA was linoleic acid (C18:2 *9c12c*): 7.93 (in leaves) – 60.18 g.100 g^{-1} of oil (in seeds); second most abundant was α-linolenic acid (C18:3 *9c12c15c*), especially in leaves and flowers (24.59–30.22 g.100 g^{-1} of oil, respectively). *Cornus mas* samples may represent a novel dietary source of valuable α-linolenic acid from n-3 PUFAs family. In total, 18 amino acids were detected in *Cornus mas* samples, while 9 of them belonged to essential ones. Flowers were distinguished by the highest content of amino acids with the highest amounts of leucine (6.1 g.kg^{-1}), lysine (6.2 g.kg^{-1}), aspartic (10.7 g.kg^{-1}) and glutamic (10.7 g.kg^{-1}) acids. Calcium was the most abundant element in all samples (2647–25687 mg.kg^{-1} of dry weight, except fruits. Nutrients content and composition suggest that *Cornus mas* may become an inexpensive novel plant source of functional foods, and as new ingredient in human diet, especially with regard to underappreciated leaves and flowers.

Keywords: *Cornus mas*, fruits, leaves, seeds, flowers, fatty acids, amino acids, elements

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Introduction

Recently, nutrition gained much attention due to an extremely important role in prevention of many diseases. Thus, healthy diet and lifestyle as well as usage of underutilized and little-known edible medicinal plants has become popular (Monka et al., 2014; Ivanišová et al., 2017; Klymenko et al., 2017, 2019; Grygorieva et al., 2018a, 2018b; Horčinová Sedláčková et al., 2018; Bayram and Ozturkcan, 2020). A good example may be noticeable increased interest in the *Cornus mas*, which can be explained by an abundance of many bioactive components (flavonoids, phenolic acids, anthocyanins, iridoids, tannins), carbohydrates, fatty acids, vitamins (vitamin C) and minerals.

The Cornelian cherry (*Cornus mas* L.), also known as dogwood, belongs to Cornaceae family. Plants take a form of a large shrub or small tree mostly grown in natural conditions in Balkan and Apennine peninsulas, central Europe, and southwest Asia (Blagojević et al., 2021; Dinda et al., 2016; Szczepaniak et al., 2019;), while is cultivated in many countries like Ukraine, Slovakia, Poland, Georgia, Armenia, Czech Republic, Turkey, Serbia, and Austria (Kucharska et al., 2015). *Cornus mas* is best-known for its attractive red-purple or, less frequently, yellow or pink fruits, possessing astringent taste (Szczepaniak et al., 2019; Kucharska et al., 2015). Regarding its traditional use and prospective uses in food and beverage production (Blagojević et al., 2021; Dinda et al., 2016), fruits are recognized food ingredient in traditional cusines of several countries, such as Poland, Ukraine, Serbia, Romania, Torkey, Iran, and Czech Republic. Fruits may be consumed fresh or processed, in form of jam, gel, marmalade, compote, soup with rice, fruit yoghurt, puree, tea, sweets, jelly, marinated, candied fruits, syrup, juice, alcoholic beverages – liquolr, wine, beer (Blagojević et al., 2021; Kucharska et al., 2015; Brindza et al., 2007; Stankovic et al., 2014; Klymenko et al., 2019). Generally, Cornelian cherry presents a very promising functional fruit due to its powerful biological potential.

Cornus mas represents valuable source of vitamin C and phenolic compounds possessing strong activity. The *Cornus mas* fruits are rich in ascorbic acid 101–193 mg.100 g^{-1} of fresh fruits, anthocyanins 223–292 mg cyanidin-3-O-glucoside equivalent.100 g^{-1}, and phenolics 281–704 mg GAE.100 g^{-1}. Interestingly, leaves of *C. mas* contain a lot of phenolics (11.7%) compared with fruits (9.1%). Moreover, anthocyanins are not detectable in leaves, unlike in fruits – anthocyanins are important and responsible for unique colour and properties of fruits (Dinda et al., 2016; Milenkovic-Andjelkovic et al., 2015). Flowers are also rich in phenolics and flavonoids (42–188 mg GAE.100 g^{-1} and 50–56 mg Routine.g^{-1}, respectively) (Stankovic et al., 2014). One of the most valuable sources of both iridoids and anthocyanins are *C. mas* fruits. The presence of iridoids (monoterpenoid compound group), mainly loganic acid, cornuside, loganin, sweroside, are characteristic for *C. mas* fruits because they rarely occur in fruits (can be found in some berries species, exotic fruits, like noni (Yamabe et al., 2007; Kucharska et al., 2015; Kucharska et al., 2017; Klymenko et al., 2021). In addition to iridoids and anthocyanins, *Cornus mas* fruits contain also other flavonoids (e.g., flavonols), phenolic acids, terpenoids (ursolic acid), carotenoids and organic acids (Danielewski et al., 2021). Significant amounts of flavonoids, anthocyanins, and iridoids were identified in fruits and leaves of *C. mas*. These compounds are linked with strong radical scavenging potential and antitumour properties.

It should be highlighted that bioactive compounds which possess beneficial properties are not only located in fruits, but also in other morphological parts of the plant like leaves, flowers, seeds, or bark. Interestingly, most parts of *Cornus mas* plant have been used in folk medicine since ancient times (Klymenko et al., 2021; Kazimierski et al., 2019). Previous studies have shown that *Cornus mas* therapeutic effects include: antioxidant, antimicrobial, antidiabetic, antiatherosclerosis, antiobesity, antiglaucoma; cytoprotective, neuroprotective, cardioprotective, liverprotective, renalprotective; hypolipidemia and hypotensive properties (Bayram and Ozturkcan, 2020).

The spectrophotometric analysis of different plant parts (leaf, flower, and fruit) of cornelian cherry indicated that all plant parts of *C. mas* are extrimely rich in phenolic compounds and flavonoids. While antioxidant activity of extracts assayed by DPPH test and expressed as IC_{50} values range from 518.47 to 11.06 μg.ml^{-1} (Stankovic et al., 2014). Furthermore, studies of Celep et al. (2013) on *in vitro* and *in vivo* antioxidant activity properties of cornelian cherry leaves clearly demonstrated that the consumption of *C. mas* leaves, rich in antioxidant polyphenolics, might increase total antioxidant capacity of the body. These results evidenced the use of plant parts of *Cornus mas* in agriculture, food industry and pharmacy, as well as can be regarded as promising natural plant sources of high antioxidant value.

Although the composition and properties of *Cornus mas* fruits has been well-studied, the nutritional value of different morphological parts of plant: leaves, flowers, fruits, and seeds remain to be thoroughly studied. Thus, the aim of this study was to determine the contents of most essential nutrients, profiles of fatty and amino acids, content of selected elements, and the content of β-carotene, vitamin A and E of leaves, flowers, fruits, and seeds of *Cornus mas*.

Material and methodology

Sampling

Fruits, leaves, flowers, and seeds of *Cornus mas* (Figure 1) were collected in 2020 from the trees growing in the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv, Ukraine).

Chemicals and reagents

All the chemicals and reagents were of analytical grade and were purchased from Sigma-Aldrich (Steinheim, Germany), Merck (Darmstadt, Germany) and CentralChem (Slovakia).

Analysis of proximate composition

Dry matter, ash, and protein content were determined according to CSN-EN 12145 procedures (1997). Total lipid content was determined according to ISO 659 (1998).

Analysis of sugars

Sample preparation: cornelian cherry samples of 1 g with 10 mL of water/ethanol (4 : 1) were vigorously mixed (vertical shake table; GFL, Germany). After 60 min of extraction, the mixture was centrifuged at 6000 rpm for 4 min (EBA 21, Hettich, Germany). The supernatant was filtered through the filter paper with 0.45 mm pore size (Labicom, Czech Republic) and filled up to 50 mL in a volumetric flask with water.

An HPLC analysis of sugars (fructose, maltose, sucrose, lactose) was performed using a Agilent 1260 Infinity instrument (Agilent Technologies, Santa Clara, USA) coupled to a evaporative light scattering (ELSD) detector. Separation of sugars was conducted on a Prevail Carbohydrates ES column (250 × 4.6 mm). Acetonitrile/water (75 : 25, v/v) was used as the mobile phase. The identification of sugars was made by comparison the relative retention times of sample peaks with standards (Sigma-Aldrich, Steinheim, Germany). The contents of sugars were expressed as $g.kg^{-1}$ of dry sample.

β-carotene content

β-carotene from *Cornus mas* samples was extracted by the Sarker and Oba (2019). Briefly, 1 g of dry sample was ground in a mortar and pestle with 10 mL of 80% acetone. After removing the supernatant in a volumetric flask, the extract was centrifuged at 10000 × g for 4 min. The final volume was brought up to 20 mL. The absorbance was measured spectrophotometrically at 480 and 510 nm (UV-VIS spectrophotometer, Jenway Model 6405, England). The content of β-carotene was computed from the following equation: β-carotene = 7.6 (Abs. at 480) – 1.49(Abs. at 510) × final volume/1000. The results were expressed as mg $β\text{-carotene.kg}^{-1}$ of dry sample.

Analysis of fatty acid composition

Lipid fraction extracted from each morphological part of *Cornus mas* was determined as follows: the samples were prepared according to official methods Ce 2-66 (1997) to convert triacylglycerols into methyl esters of fatty acid (FAMEs). The FAMEs were analyzed by gas chromatography using an Agilet 6890N instrument (Agilent Technologies, Santa Clara, USA) equipped with flame ionization detector (FID; 250 °C; constant flow, hydrogen 40 $mL.min^{-1}$, air 450 $mL.min^{-1}$), a capillary column DB-23 (60 m × 0.25 mm, film thickness 0.25 µm, Agilent Technologies, Santa Clara, CA, USA). A detailed description of the chromatography

Figure 1 *Cornus mas* L.
1 – leave; 2 – flower; 3 – fruits; 4 – seed

conditions is presented in the work Szabóová et al. (2020). Standards of a C4-C24 FAME mixture (Supelco, Bellefonte, PA, USA) were applied to identify FAME peaks. The evaluation was carried out by the ChemStation 10.1 software. The contents of FAs were expressed as g.100 g^{-1} of lipids.

Analysis of amino acid profile

Amino acid (AA) profile was determined by ion-exchange chromatography using an AAA-400 Amino Acid Analyzer (Ingos, Czech Republic) and post-column derivatization with ninhydrin and a VIS detector, as described elsewhere (Zhurba et al., 2021). Separation was provided on a glass column (length 350 mm, inner diameter 3.7 mm) filled with a strong cation exchanger in the LG ANB sodium cycle (Laboratory of Spolchemie) with average particles size of 12 µM and 8% porosity. The column was heated within the range of 35–95 °C, with the elution of AAs at 74 °C. A double-channel VIS detector with the inner cell volume of 5 µL was set to 440 and 570 nm. A solution of ninhydrin was prepared in 75% v/v methyl cellosolve and in 2% v/v 4 M acetic buffer (pH 5.5). $SnCl_2$ was used as a reducing agent. Solution of ninhydrin was stored in an inert atmosphere (N_2) without access of light at 4 °C. The flow rate was 0.25 mL.min^{-1}, and the reactor temperature was 120 °C. Individual amino acids values were expressed as g.kg^{-1} of dry sample.

Elemental analysis

The contents of macroelements, microelements and trace metals were determined by the inductively coupled plasma optical emission spectroscopy (ICP-OES) according to Divis et al. (2015) by using an ICP-OES instrument (Ultima 2, Horiba Scientific, France). Samples were prepared for analysis after microwave digestion (Milestone 1200, Milestone, Italy), 0.25 g of sample was decomposed in a mixture of nitric acid (6 mL) (Analytika Praha Ltd, Czech Republic) and hydrochloric acid (2 mL) (Analytika Praha Ltd, Czech Republic). After the decomposition sample was filtered through filter paper (0.45 mm pore size) and filled up to 25 mL in a volumetric flask with pure water.

Statistic analysis

The results were subjected to one-way ANOVA followed by Tukey-Kramer test, when the differences between mean values were considered significant at $p < 0.05$. The variability of all parameters was evaluated by descriptive statistics. The results were presented as means with standard error (SE). The PAST 2.17 software was used.

Results and discussion

The results revealed a significant ($p < 0.05$) variation in the nutrient contents of different morphological parts of cornelian cherry (Table 1). The protein content of *Cornus mas* (2.27–10.58%) was generally higher than in many wild or cultivated fruits (e.g., strawberry, cherry), up to 1% (de Souza et al., 2014) and higher than in seedless red fleshy part of berries (red arils) of *Taxus baccata* L., 1.79–3.80% (Tabaszewska et al., 2021). It should be pointed out that *Cornus mas* flowers were distinguished by the highest content of

Table 1 Proximate composition of *Cornus mas* L. (means ± SE)

Component	Leaves	Flowers	Fruits	Seeds
Proteins (%)	8.66 ±0.10	10.58 ±0.05	4.50 ±0.02	2.27 ±0.04
Lipids (%)	3.38 ±0.08	5.23 ±0.02	1.49 ±0.02	3.34 ±0.03
SFAs (g.100 g^{-1} oil)	46.10 ±0.12	26.33 ±1.50	36.78 ±1.68	13.56 ±0.09
MUFAs (g.100 g^{-1} oil)	10.22 ±0.09	4.87 ±0.09	15.21 ±1.02	22.13 ±1.07
PUFAs (g.100 g^{-1} oil)	27.80 ±1.10	48.45 ±1.65	32.12 ±1.40	62.19 ±1.55
Fructose (g.kg^{-1})	33.28 ±1.33	26.60 ±0.89	68.33 ±1.78	3.21 ±0.04
Maltose (g.kg^{-1})	<0.5	<0.5	<0.5	<0.5
Sucrose (g.kg^{-1})	<0.5	4.12 ±0.04	<0.5	<0.5
Lactose (g.kg^{-1})	<0.5	<0.5	<0.5	<0.5
Dry matter (%)	92.10 ±2.18	91.87 ±2.23	84.38 ±1.89	90.86 ±2.09
Ash (%)	8.86 ±0.15	5.21 ±0.01	2.11 ±0.02	0.98 ±0.01
Vitamin A (retinyl acetate) (mg.kg^{-1})	<0.1	<0.1	<0.1	<0.1
β-carotene (mg.kg^{-1})	88.45 ±1.30	25.68 ±0.76	4.87 ±0.05	2.08 ±0.02
Vitamin E (α-tocopherol) (mg.kg^{-1})	228.0 ±2.58	198 ±1.68	49.43 ±1.12	22.19 ±0.78

proteins (10.58%), as compared with other studied parts of this plant. *Cornus mas* contained a substancial amount of lipids, reaching from 3.34 to 5.23% (except fruits). Surprisingly, flowers had also the highest amount of lipids (5.23%) in relation to other parts of plant. Obtained results are in agreement with previous studies, which indicated that fruits and leaves may be regarded as important source of lipids (Tabaszewska et al., 2021; Zhurba et al., 2021).

Among sugars, *Cornus mas* plant were characterized by the highest content of fructose. As expected, fruits were the most abundant in simple sugars, mainly fructose (68.33 $g.kg^{-1}$), followed by leaves and flowers. Perova et al. (2014) and Bijelic et al. (2011) stated that in fruits glucose (2.5–7.0%) is present as major carbohydrate component, followed by fructose and sucrose. Studies of Wind et al. (2010) proved that monosaccharides may accumulate in leaves of plants that grow under unfavorable and stress conditions. Contrary, seeds contained only about 3.21 $g.kg^{-1}$. Literature data indicated that fructose and glucose were predominant among reducing sugars in *Cornus mas*, reaching 3.69 and 5.39%, respectively (Szczepaniak et al., 2019). Generally, other sugars (maltose, sucrose, and lactose) were detected in trace amounts (<0.5 $g.kg^{-1}$). The moisture content has an impact on physical properties of fruits. *Cornus mas* samples had rather low moisture content (7.9–9.14%), except for fruits – 15.62%.

Cornus mas leaves proved to be extremely rich in carotenoids, mainly β-carotene (88.5 $mg.kg^{-1}$) compared with the rest of the plant (Table 1). For comparison, carrots which are known for high amount of β-carotene, contained about 140 $mg.kg^{-1}$ (Anjum et al., 2008). For example, pawpaw (*Asimina triloba*) contains β-carotene in seeds, pulp, and peel at the levels of 4.8, 6.6 and 12.7 $mg.kg^{-1}$, respectively. Results obtained by the other authors, clearly shows that β-carotene accumulated in peel 2-fold more than in pulp and 3-fold more than in seeds (Grygorieva et al., 2021).

The application of GC (gas chromatography) enabled detecting 14 FAs in lipid fraction extracted from *Cornus mas* samples: leaves, flowers, fruits and seeds, belonging to all groups (Table 1 and 2). The results of FA composition, saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) of the studied samples are shown in Table 2. It should be highlighted that the contents of many of them differed significantly ($p < 0.05$) depending on the morphological part of plant.

SFAs were represented mainly by palmitic acid (C16:0) 10.87–32.20 $g.100\ g^{-1}$ of oil and stearic acid (C18:0) 1.48–4.12 $g.100\ g^{-1}$ of oil. The content of other SFAs can be regarded as low. *Cornus mas* leaves and fruits

Table 2 Fatty acid composition ($g.100\ g^{-1}$ of oil) of lipids of *Cornus mas* L. (means ±SE)

Fatty acid	Leaves	Flowers	Fruits	Seeds
SFAs	**41.33**	**27.51**	**35.98**	**17.30**
C12:0	0.27 ±0.02	0.20 ±0.03	0.48 ±0.03	<0.1
C14:0	2.22±0.05	1.48 ±0.02	2.26 ±0.03	0.10 ±0.02
C16:0	32.20 ±1.34	19.87 ±1.12	29.07 ±1.18	10.87 ±0.33
C17:0	0.39 ±0.02	0.26 ±0.02	0.38 ±0.03	0.12 ±0.03
C18:0	4.12 ±0.07	1.86 ±0.06	1.48 ±0.03	3.74 ±0.08
C20:0	1.33 ±0.02	1.83 ±0.06	0.50 ±0.02	1.34 ±0.03
C22:0	0.44 ±0.02	1.06 ±0.02	0.94 ±0.01	0.65 ±0.01
C24:0	0.36 ±0.01	0.95 ±0.02	0.87 ±0.02	0.38 ±0.01
MUFAs	**12.29**	**4.61**	**20.18**	**12.31**
C16:1	0.84 ±0.04	0.18 ±0.003	<0.1	2.37 ±0.04
C18:1	10.57 ±1.01	3.25 ±0.06	19.61 ±1.37	9.28 ±0.78
C20:1	0.78 ±0.03	0.86 ±0.02	0.37 ±0.03	0.56 ±0.02
C22:1	<0.1	0.32 ±0.01	<0.1	<0.1
PUFAs	**32.52**	**50.30**	**39.48**	**61.86**
C18:2	7.93 ±0.56	20.08 ±1.29	32.27 ±1.87	60.18 ±1.48
C18:3	24.59 ±1.05	30.22 ±1.65	7.21 ±1.06	1.68 ±0.07

Note: Saturated fatty acids – SFAs; monounsaturated fatty acids – MUFAs; polyunsaturated fatty acids – PUFAs were distinguished by the highest amounts of C16:0. Red arils of *Taxus baccata* L. also contained substantial amounts of C16:0 acid (an average 22.5 g.100 g^{-1} of FA) (Tabaszewska et al., 2021). Studies of Zhurba et al. (2021) on FA profile of *Schisandra chinensis* leaves proved that its also characterized by the high content of C16:0 (about 44.60 g.100 g^{-1} of oil).

Among MUFAs oleic acid (C18:1 *9c*) 3.25–19.61 g.100 g^{-1} of oil undoubtedly dominated in *Cornus mas* samples, with the highest content in fruits. It shoud be noted that flowers contained only 3.25 g.100 g^{-1} of oil. The difference between the contents of MUFAs in leaves and seeds was irrelevant. Generally, other MUFAs were identified in rather small quantities in all studied samples.

The total content of PUFAs in *Cornus mas* lipids varied from 32.52–61.86 g.100 g^{-1} of oil. It should be highlighted that the lipid fraction of *Cornus mas* was extremely rich in PUFAs, even though only two acids from this group were identified. The major PUFA was linoleic acid from n-6 family (C18:2 *9c12c*) which content ranged from 7.93 (in leaves) up to 60.18 g.100 g^{-1} of oil (in seeds), it was the most abundant in the lipid fraction of seeds. In studies of Brindza et al. (2009) also linoleic acid was the most abundant FA in seeds (and barks) of *C. mas*. It should be noted that FAs composition of seeds of *Asimina triloba* (L.) Dunal, with regard to the linoleic acid content, was similarly high. However, with the substantial presence of oleic acid – 40.13 g.100 g^{-1} of oil (Grygorieva et al., 2021). The α-linolenic acid (C18:3 *9c12c15c*) was the second important PUFA, especially in leaves and flowers samples (24.59–30.22 g.100 g^{-1} of oil respectively). The *Cornus mas* may be perceived as a valuable source of α-linolenic acid belonging to the n-3 family (Rutkowska et al., 2012). Also, worth mentioning is that the differences in FAs contents resulted from the lipid content (Table 1 and 2).

In studies of Krivoruchko (2014) seven FAs of high content are reported for fruits and leaves of *Cornus mas*. In the fruits, the most abundant was linoleic (2.8 g.kg^{-1}), followed by oleic acid (2.47 g.kg^{-1}). Contrary, in leaves, the most abundant was 2,4-heptadienoic (2.38 g.kg^{-1}), and palmitic acid (2.24 g.kg^{-1}).

It is well-known that edible plant oils are the primary sources of essential unsaturated FAs form n-3 and n-6 families. Recently, was observed an increase in the number of studies aimed to support the specific health benefits of plant-derived omega-3 fatty acids, mainly α-linolenic, and the importance of searching for its new sustainable plant sources. The α-linolenic acid plays a significant role in the prevention and treatment of a variety of cardiovascular disorders, including heart attacks and stroke, as well as to have a positive impact on both function and behavior of the central nervous system (Mikołajczak et al., 2020; Tabaszewska et al., 2021).

Based on obtained results of FA composition, *Cornus mas* may represent relevant plant dietary source of valuable n-3 PUFAs (α-linolenic acid) in human diet.

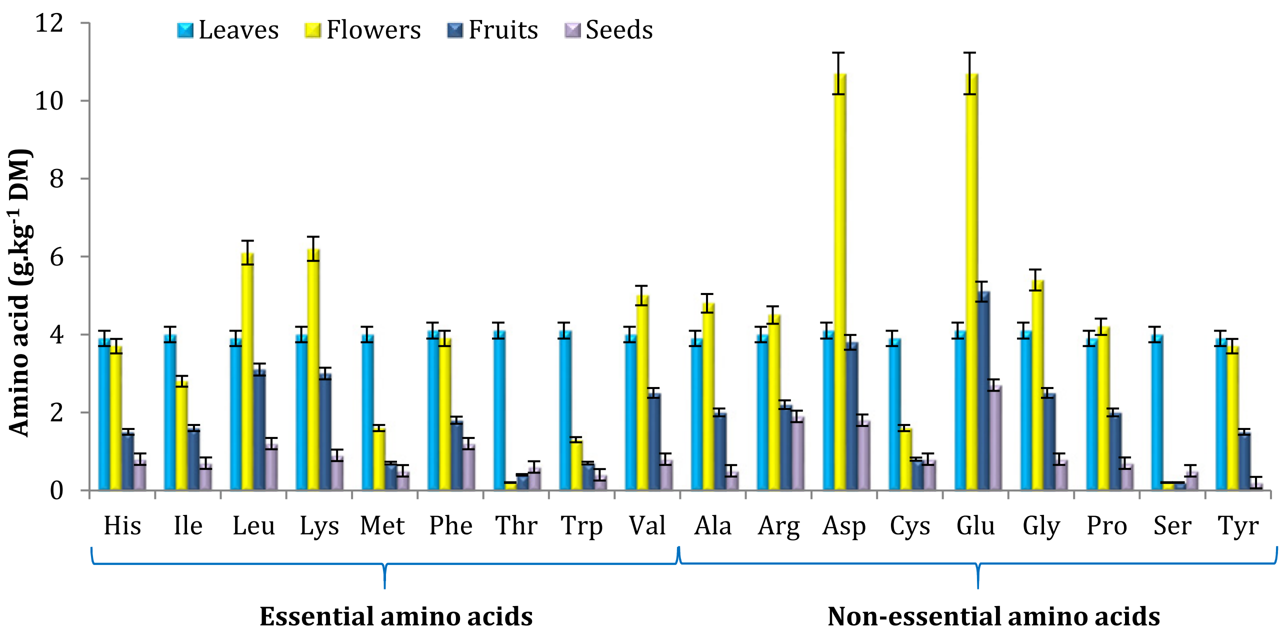

Figure 2 Amino acid composition (g.kg^{-1} of dry matter; DM) of *Cornus mas* L. leaves, flowers, fruits, and seeds

For nutritional reasons, it is important to search for long-chain PUFAs, especially those from the n-3 family.

In total eighteen amino acids were detected in *Cornus mas* samples, nine of them belonged to essential amino acids and also nine to non-essential ones (Figure 2). It should be highlighted that the contents of most of them differed significantly ($p < 0.05$) depending on the morphological part of plant.

The content of amino acids in leaves, flowers, fruits, and seeds was at the level of 72.0, 76.6, 35.4, and 17.0 $g.kg^{-1}$ of dry matter, respectively; while content of total essential amino acids was 36.1, 30.8, 15.3, and 7.1 $g.kg^{-1}$ of dry matter (amounted 50.1, 40.2, 43.2 and 41.8%, respectively) and 35.9, 45.8, 20.1 and 9.9 $g.kg^{-1}$ of dry matter (49.9, 59.8, 56.8 and 58.2%, respectively) for total non-essential amino acids.

It is important to emphasise that flowers of *Cornus mas* were distinguished by the highest content of amino acids in total. Furthermore, flowers contained the highest amounts for some amino acids, such as: leucine (6.1 $g.kg^{-1}$) and lysine (6.2), aspartic (10.7) and glutamic (10.7) acids (Figure 2). Predominating shares of lysine and leucine (from essential amino acids) were also found in other fruits, plants (Hegazy et al., 2019), as well as for glutamic acid (Guo et al., 2015). *Cornus mas* seeds has been shown to have the lowest content of amino acids compared with the other morphological parts of plant.

In the study of Zhurba et al. (2021) on the composition of *Schisandra chinensis* (Turcz.) Baill. leaves glutamic acid resulted to be the major component of non-essential amino acids (25 $g.kg^{-1}$ of dry matter), followed by aspartic acid (16.2 $g.kg^{-1}$) and leucine (14.2 $g.kg^{-1}$). This proves that *Cornus mas* leaves are not abundant in amino acids.

The contents of macroelements: K, P, Ca, S, Mg, Na, microelements: Zn, Fe, Cu, Mn, Cr, Se, and metals: Al, As, Cd, Ni, Hg, Pb in studied *Cornus mas* samples are presented in Table 3. It should be marked that the contents of most of them differed significantly ($p < 0.05$) depending on the morphological part of plant.

Calcium (Ca) was the most abundant element in *Cornus mas* samples (2647–25687 $mg.kg^{-1}$ of dry weight, except fruits (1644 $mg.kg^{-1}$ of dry weight), followed by K, P, Mg and S. Interestingly, *Cornus mas* fruits were rich in potassium (9545 $mg.kg^{-1}$ of dry weight)

Table 3 Elements composition of *Cornus mas* L. leaves, flowers, fruits, and seeds ($mg.kg^{-1}$ of dry weight; mean ± SE)

Element	Leaves	Flowers	Fruits	Seeds
		Macroelements		
K	9190 ±366	10351 ±398	9545 ±289	844 ±68
P	3615 ±265	2390 ±199	929 ±54	977 ±62
Ca	25687 ±878	18856 ±812	1644 ±112	2647 ±217
S	2245 ±189	1917 ±128	1080 ±118	462 ±56
Mg	3004 ±212	1613 ±131	395 ±46	432 ±49
Na	7.0 ±0.8	40 ±1.7	8.0 ±0.8	9 ±0.6
		Microelements		
Zn	30.0 ±1.3	37 ±1.1	5 ±0.2	24 ±1.1
Fe	54.0 ±1.2	29 ±0.9	42 ±1.2	82 ±1.5
Cu	5.0 ±0.3	13 ±0.9	6 ±0.1	6 ±0.1
Mn	12.5 ±1.1	7.9 ±1.3	2.9 ±0.05	2.3 ±0.04
Cr	0.68 ±0.08	0.38 ±0.02	0.40 ±0.01	0.47 ±0.02
Se	<0.2	0.48 ±0.02	<0.2	<0.2
		Metals		
Al	14.6 ±1.5	16.1 ±1.2	6.1 ±0.1	2.6 ±0.02
As	<0.3	<0.3	<0.3	<0.3
Cd	0.013 ±0.002	0.073 ±0.001	<0.01	<0.01
Ni	0.60 ±0.04	0.29 ±0.02	0.23 ±0.01	0.39 ±0.91
Hg	0.026 ±0.001	0.013 ±0.001	0.007 ±0.0001	0.004 ±0.0001
Pb	0.25 ±0.016	1.64 ±0.04	0.27 ±0.012	1.51 ±0.02

at the level similar to other two studied samples – leaves and flowers. The content of calcium in leaves or flowers was much higher than in other cultivated fruits; like different types of berries and cherries, and also significantly higher than in wild yew berries (de Souza et al., 2014; Tabaszewska et al., 2021). Thus, not only fruits, but other parts of *Cornus mas* plant may be regarded as a valuable source of important elements in human diet.

Accordingly, literature data fruits of *Cornus mas* cultivars are rich in mineral content (Dinda et al., 2016). The concentration of minerals highly depends on cultivar, growing conditions, genotype, usig method, and technical treatments (Bayram and Ozturkcan, 2020). The mineral content in fruits from different countries are reported. For example, fruits: from Czech Republic contain K 3798–3411 $mg.kg^{-1}$ of dry fruits, Ca 656–301 $mg.kg^{-1}$, Mg 290–241 $mg.kg^{-1}$ and P 412–313 $mg.kg^{-1}$ (Dokoupil and Reznicek, 2012); from Serbia K 5609–1845 $mg.kg^{-1}$, Ca 466–27 $mg.kg^{-1}$ (Bijelic et al., 2011); from Greece K 1320–880 $mg.kg^{-1}$, Ca 30–20 $mg.kg^{-1}$ (Sotiropoulos et al., 2011).

With regard to the presence of metals, the content of aluminium (2.6–16.1 $mg.kg^{-1}$ of dry weight) strongly dominated among all detected metals in *Cornus mas* samples. The lead (Pb) was the second most abundant metal (0.25–1.64 $mg.kg^{-1}$ of dry weight). The presence of trace metals in plants may resulted not only from the natural heavy metals occurrence in the soil but also originated from the environment contamination. From food safety reasons, control of the content and the tendency to accumulate toxic trace elements in fruits and other edible parts of plants seems to be of high importance.

Conclusions

This study provided new and valuable information regarding the nutrients content and composition in different morphological parts of *Cornus mas* from Ukraine. It was concluded that the contents of nutrients differed significantly ($p < 0.05$) depending on the morphological part of plant. Protein content varied from 2.27 up to 10.58% (in flowers). Authors determined substancial share of lipids (3.34–5.23%, except fruits). As expected, fruits were the most abundant in fructose (68.33 $g.kg^{-1}$), followed by leaves and flowers. Leaves were extremely rich in carotenoids, mainly β-carotene (88.5 $mg.kg^{-1}$) compared with other parts of plant. The fatty acid profile was represented by palmitic C16:0 (10.87–32.20 g.100 g^{-1} of oil), linoleic C18:2 *9c12c* (7.93–60.18 g.100 g^{-1} of oil), and α-linolenic C18:3 *9c12c15c* (1.68–30.22 g.100 g^{-1} of oil) acids. Nine out of 18 amino acids were essential amino acids (7.1–36.1 $g.kg^{-1}$ of dry weight), with significant share of leucine, lysine, aspartic and glutamic acids in flowers. *Cornus mas* leaves and flowers may be regarded as an important source especially of calcium (18856–25687 $mg.kg^{-1}$ of dry weight), and other minerals such as K, P, S and Mg. The obtained results clearly suggest that *Cornus mas* may become an inexpensive novel plant source of functional foods and as new ingredient in human diet, especially with regard to underappreciated leaves and flowers. Accordingly, to the profile of bioactive components presented in literature data (Bayram and Ozturkcan, 2020) and findings presented in this study regarding nutrients, *Cornus mas* may contribute to a healthy diet as a "super food".

Conflicts of interest

The authors declare no conflict of interest.

Ethical statement

This article does not contain any studies that would require an ethical statement.

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