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THE STUDY OF FATTY ACID COMPOSITION IN *RUMEX PATIENTIA* L. × *RUMEX TIANSCHANICUS* LOSINSK

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Introduction. *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. is a multifunctional plant valued for its use as forage, food, vegetable, and medicinal resource. It provides a rich source of plant-derived nutrients, including high-quality protein, essential macro- and micronutrients, vitamins, organic acids, lipids, amino acids, and carotenoids. Therefore, an in-depth phytochemical study of all organs of this plant is relevant. The aim of our study was to conduct a comparative analysis of the content of fatty acids in the leaves, flowers, roots, and seeds of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk.

Materials and methods. The material for the research was the leaves, roots, seeds and flowers of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. Identification and quantitative content of fatty acids in the studied medicinal plant raw materials was carried out by gas chromatography / mass spectrometry (GC/ MS) of fatty acid methyl esters using the Agilent 6890N/5973inert gas chromatography-mass spectrometry system (Agilent technologies, USA).

Results. Some 15 fatty acids have been identified in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. roots, leaves, flowers, and seeds, and their quantitative content has been determined by gas chromatography. Accordingly, in all samples of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk., unsaturated fatty acids dominated. Oleic acid was the dominant unsaturated fatty acid in the flowers and seeds, while *α*-linolenic acid was predominant in the roots. The highest content of oleic acid (7947.51 μg/g) was found in the seeds, while that of linoleic acid (1507.01 μg/g) was found in the flowers.

Conclusion. The performed study on the fatty acid composition of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. did not reveal any substantial differences in qualitative composition and quantitative content of fatty acids across different plant parts. The results have shown that unsaturated fatty acids prevailed in the roots, leaves, flowers, and seeds.

Keywords: *Rumex patientia* L. × *Rumex tianschanicus* Losinsk., fatty acids, gas chromatography/mass spectrometry.

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ДОСЛІДЖЕННЯ ЖИРНОКИСЛОТНОГО СКЛАДУ У *RUMEX PATIENTIA* L. × *RUMEX TIANSCHANICUS* LOSINSK
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Метою дослідження було встановлення якісного складу та кількісного вмісту жирних кислот у *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. (щавнату) методом газової хромато-мас-спектрометрії (ГХ/МС).

Об'єктами досліджень були квітки та листки щавнату, заготовлені у фазі початку цвітіння, корені – восени після відмирання надземної частини, а насіння – у фазі повної стиглості на дослідних ділянках Національного ботанічного саду імені М. М. Гришка НАН України у 2023 році. Методом ГХ/МС встановлювали якісний склад і визначали кількісний вміст індивідуальних жирних кислот.

У досліджуваній сировині щавнату було ідентифіковано 15 жирних кислот. У всіх зразках *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. переважали ненасичені жирні кислоти. Олеїнова кислота була домінуючою у квітах та насінні, α-ліноленова – переважала в коренях. Найвищий вміст олеїнової кислоти (7947,51 мкг/г) було виявлено в насінні, лінолевої (1507,01 мкг/г) – у квітах.

Ключові слова: *Rumex patientia* L. × *Rumex tianschanicus* Losinsk., жирні олії, газова хромато-мас-спектрометрія.

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Стаття поширюється на умовах ліцензії

Introduction

Preservation and enrichment of genetic resources in useful plants, as well as increasing the biotic diversity of cultural phytocenoses through introduction and selection, are among the main tasks of botanical gardens. Comprehensive introduction and breeding studies should be conducted primarily with species that are of high national and economic value [1; 2]. These include species of the genus *Rumex* L. [3].

Plants from the Rumex genus have traditionally been used as astringents in the treatment of skin conditions. In veterinary practice, aqueous extracts derived from the fruits and roots of certain Rumex species have demonstrated anti-inflammatory and wound-healing properties [4; 5]. The rich diversity of biologically active compounds found in various Rumex species and their therapeutic effects underscore the importance of continued scientific investigation. In many Rumex types, the polyphenolic profile predominantly includes anthraquinones, flavonoids and their glycosidic forms, as well as tannins [6; 7].

Edible grass (*Rumex patientia* L. × *Rumex tianschanicus* Losinsk.) is a perennial plant developed in China through conventional breeding methods. This newly introduced type of sour grass, known as "edible grass", was obtained by hybridizing the Rumex K-1 cultivar with the wild species *Rumex patientia* L. On October 13, 2021, it was officially recognized as a novel food ingredient by the National Health Commission of China [8].

Rumex patientia L. × *Rumex tianschanicus* Losinsk. is a multifunctional plant valued as forage, food, vegetable, and medicinal resource. Additionally, it serves as a significant bioenergy crop, with its biomass utilized in the production of bio-oil, bioethanol, biogas, and solid biofuels [9]. Edible grass is known for its pleasant taste and suitability for dietary use [10]. It provides a rich source of plant-derived nutrients, including high-quality protein, essential macro- and micronutrients, vitamins, organic acids, lipids, amino acids, carotenoids, and fatty acids, along with a notable energy value. Among its most beneficial components are the elevated levels of ascorbic acid and carotene found in the leaves.

Despite its potential, limited research has been conducted on the biologically active compounds found in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk., and its fatty acid profile has yet to be examined. As a result, investigating the fatty acid composition of this edible grass hybrid holds significant practical value.

The aim of the study. The study aimed to establish qualitative composition and determine the quantitative content of individual fatty acids in the edible grass using the gas chromatography/mass spectrometry (GC/MS) method.

Materials and Methods

Plant materials. The study objects included flowers and leaves of *Rumex patientia* L. × *Rumex tianshanicus* Losinsk. collected at the beginning of flowering, roots harvested in autumn after withering of the aerial part, and seeds obtained at full maturity. The plant material was collected in 2023 at the research plots of the Cultural Flora Department at the M. M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv). The plant materials were dried in a warm-air convection dryer at a temperature of 40 °C and stored in paper bags in a dry place [11].

Chemicals and standards. Fatty acids were identified by the reference standard mixture FAME (Supelco, Belle fonte, PA, USA). The internal standard nonadecanoic acid (≥ 98% purity) used for metabolite quantification was purchased from Sigma-Aldrich (St. Louis, MO).

GC/MS determination of fatty acids (Protocol No. 403 of January 16, 2024). GC/MS analysis of fatty acids was performed using gas chromatograph Agilent 6890N with mass detector 5973 inert (Agilent Technologies, USA). Samples were analyzed on a silica capillary column HP-5MS (30 m × 0.25 mm × 0.25 mkm, Agilent Technologies, USA). The interface was operated at 250 and 380 °C respectively. The initially set up oven temperature at 60 °C for 4 min, then at the rate of 4 °C/min raised to 250 °C and kept at this point for 6 min and maintained at a final temperature for 7 min. The carrier gas was used helium at a constant flow rate of 1.0 ml/min. The sample with a volume of 1 µl was injected in a splitless mode using a 7683 series Agilent Technologies injector. Detection was performed in scan mode in the range (38–400 m/z).

Sample preparation with pre-column derivatization. Samples of herbal raw materials were ground into a powder by laboratory mill and about 0.5 g (accurately mass) were selected and placed into a glass vial. Then 3.3 ml of reacting mixture (methanol: toluene: sulfuric acid (44:20:2 v/v)) with 1.7 ml of internal standard solution (nonadecanoic acid in heptane solution) was added. The obtained samples were stood at 80 °C for 2 hours, refrigerated and centrifuged for 10 minutes at 5000 rpm. It was taken 0.5 ml of the upper heptane phase, which contains methyl esters of fatty acids [12–14].

The compositions of the product obtained were identified by comparison of their mass-spectrums with data obtained from the National Institute Standard and Technology (NIST 2008) database. The quantitative content of fatty acids was done using the internal standard of nonadecanoic acid in heptane solution added to the sample.

Research results and their discussion

In the present study, 15 fatty acids were identified and quantified, utilizing GC/MS analyses (Table 1). The chromatographic fatty acid profiles of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. raw materials are revealed in Figures 1-4, respectively. The results of the qualitative composition study and quantitative content determination of fatty acids of the raw material are shown in Table 1.

The analysis demonstrated that unsaturated fatty acids predominated across all samples of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. Saturated fatty acids accounted for approximately one-quarter of the total identified fatty acids in the leaves, while in the roots, seeds, and flowers, their proportion reached approximately one-third. The seeds showed the highest concentration of unsaturated fatty acids among all the plant parts examined.

Palmitic acid was the predominant saturated fatty acid identified across all *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. samples, with concentrations ranging from 1858.77 µg/g in the seeds to 970.08 µg/g in the roots (Table 1).

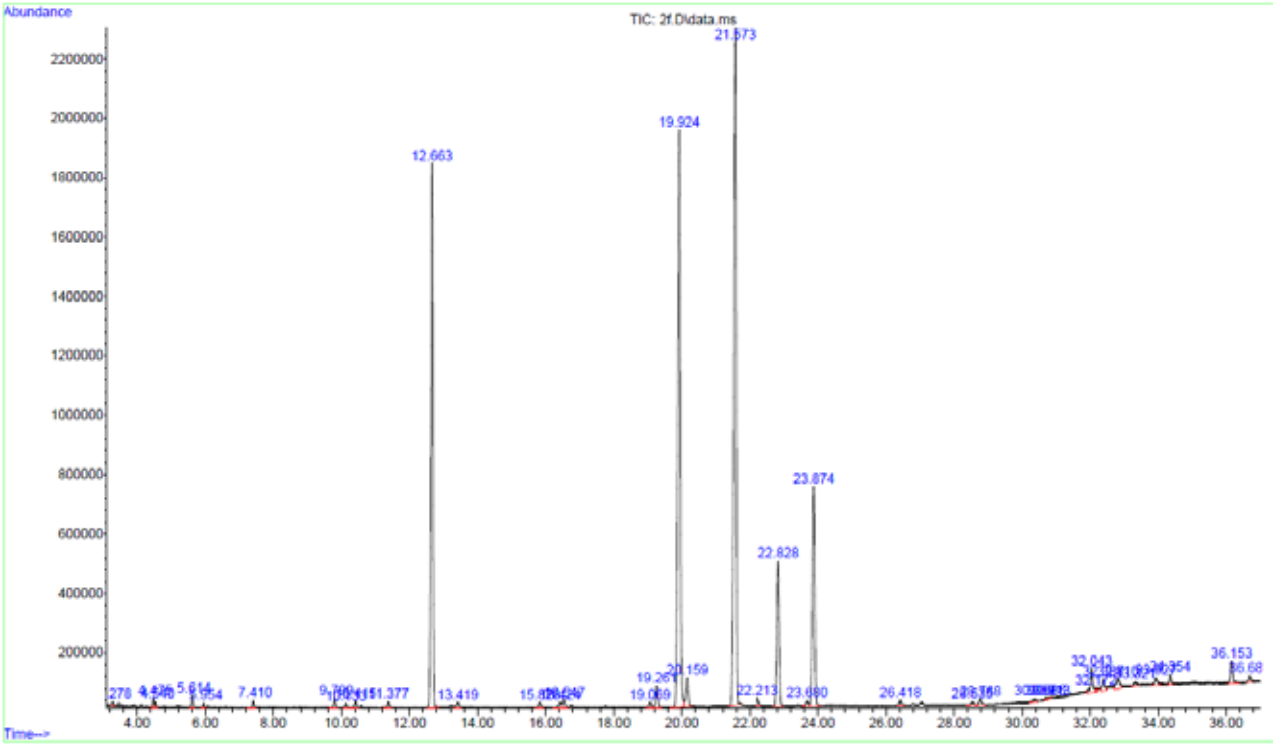

Fig. 1. Chromatographic profile of fatty acid methyl esters in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. roots

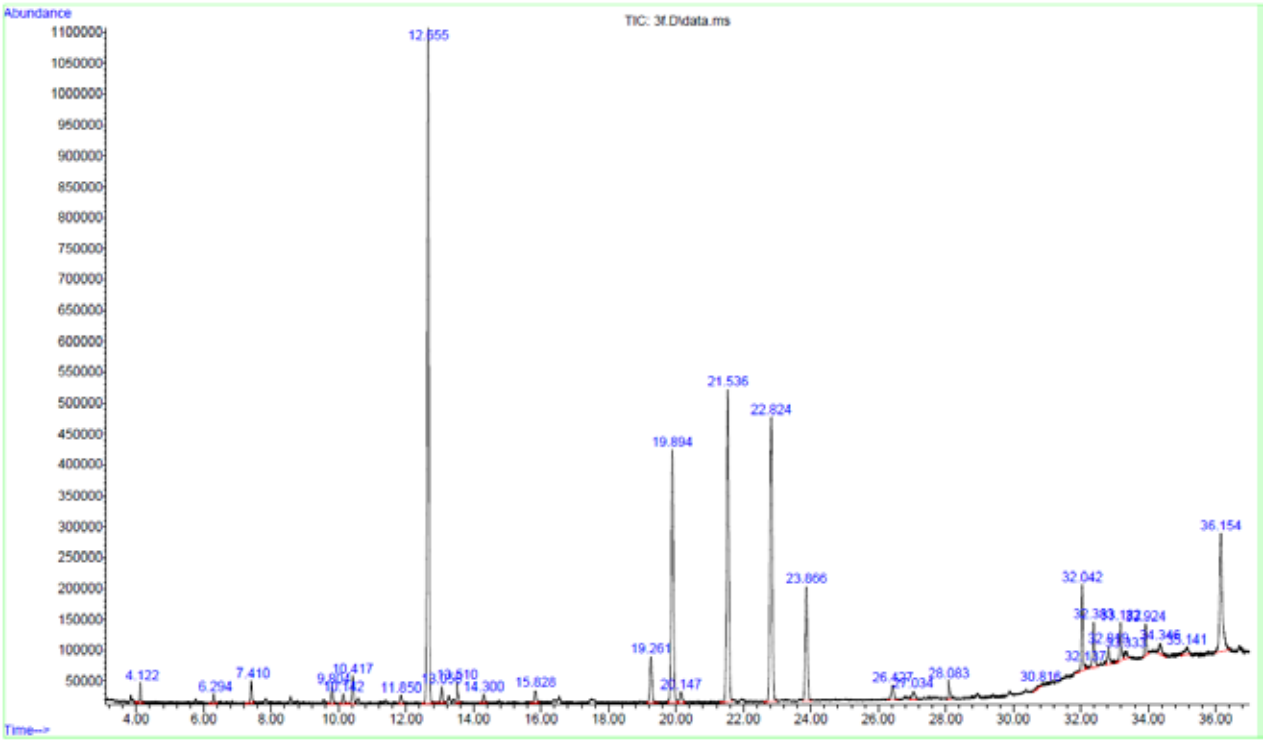

Fig. 2. Chromatographic profile of fatty acid methyl esters in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. flowers

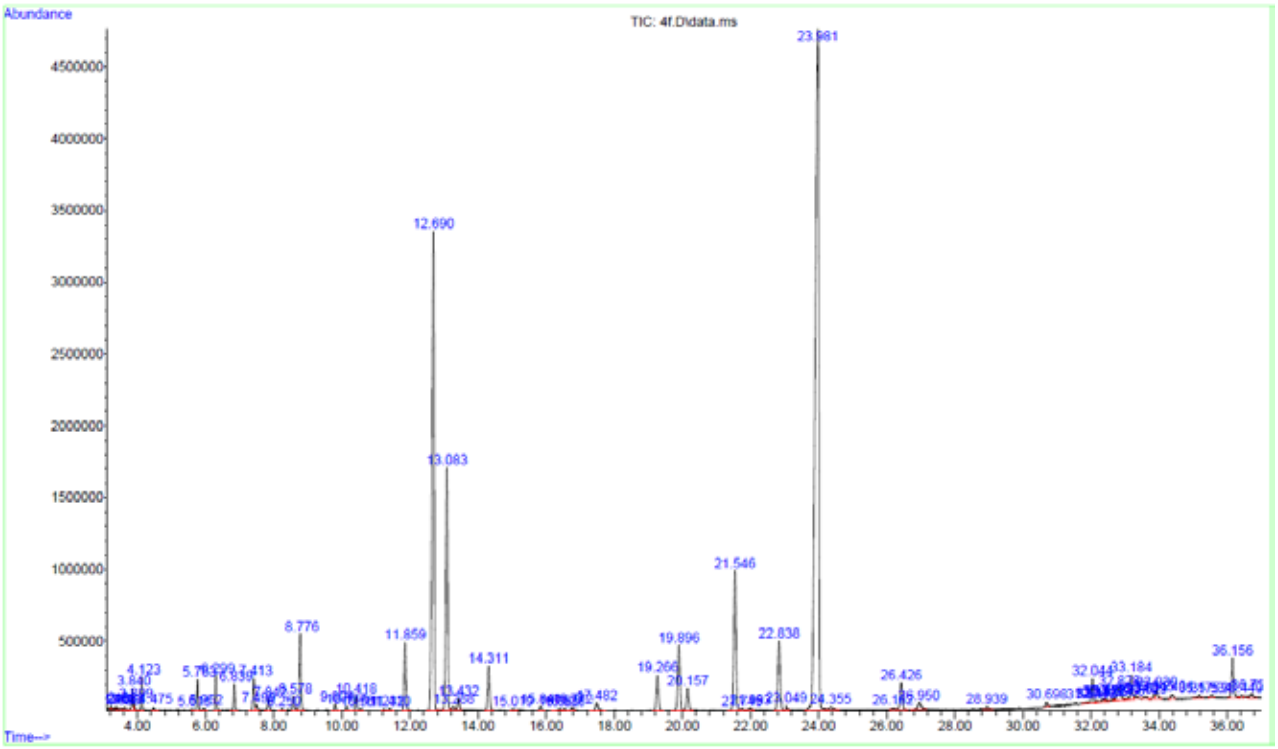

Fig. 3. Chromatographic profile of fatty acid methyl esters in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. leaves

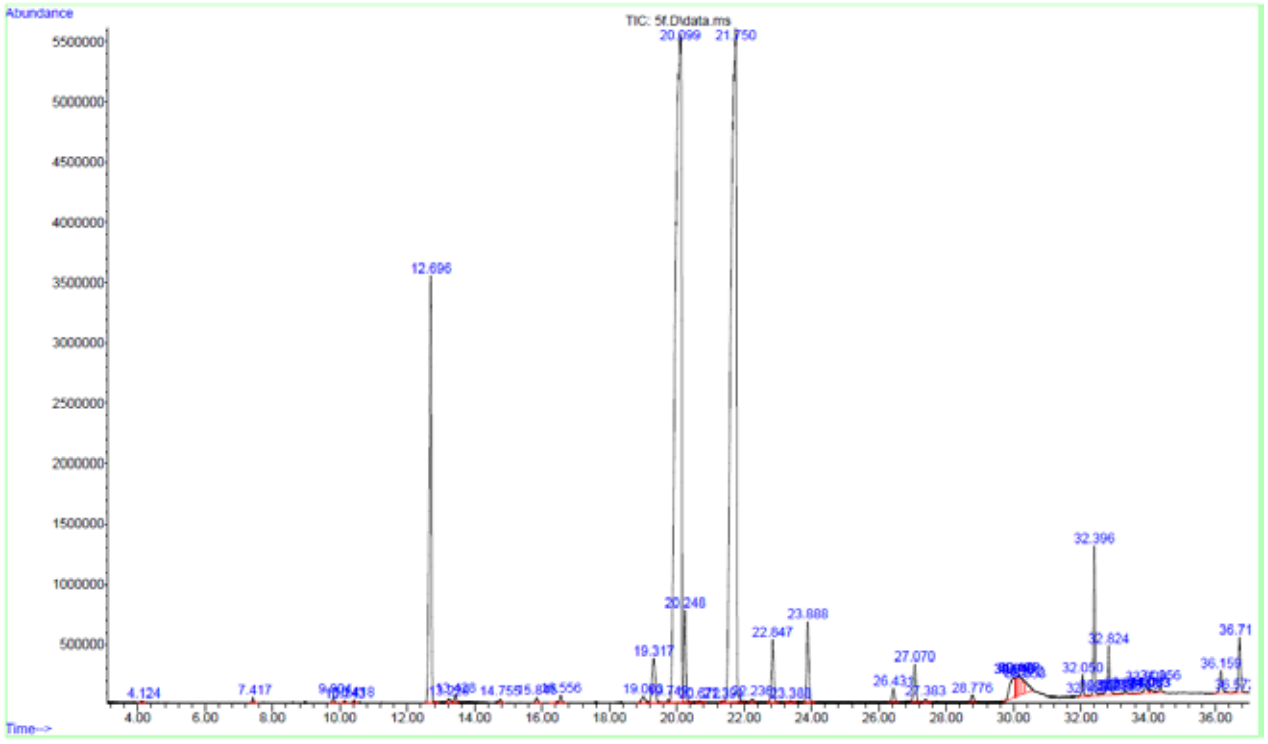

Fig. 4. Chromatographic profile of fatty acid methyl esters in *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. seeds

Table 1

The qualitative composition and quantitative content of fatty acids of Rumex patientia L. × *Rumex tianshanicus* Losinsk. raw material

Fatty acid name	Retention time	Fatty acids content of Rumex patientia L. × *Rumex tianshanicus* Losinsk., μg/g			
		Flowers	Leaves	Roots	Seed
Myristic acid	7.4	28.37	70.41	n/d	18.99
Pentadecanoic acid	9.8	n/d	11.95	n/d	n/d
Palmitic acid	12.65	1119.10	1824.54	970.08	1858.77
Palmitoleic acid*	14.31	n/d	155.40	n/d	n/d
Margaric acid	15.84	n/d	n/d	n/d	24.42
Stearic acid	19.26	44.66	90.74	138.34	295.39
Oleic acid*	19.89	1321.46	509.37	260.92	7947.51
Linoleic acid*	21.53	1507.01	608.63	553.95	13.21
Nonadecanoic acid	22.82	Internal standart			
α-Linolenic acid*	23.87	461.76	233.69	4291.10	363.01
Arachidic acid	26.42	n/d	36.16	114.91	62.34
11-Octadecenoic acid*	27.07	n/d	n/d	n/d	171.60
Behenic acid	32.04	50.99	112.23	59.81	61.61
Hexacosanoic acid	32.82	n/d	n/d	n/d	220.51
Tricosanoic acid	33.93	n/d	n/d	6.73	n/d
Lignoceric acid	36.16	n/d	289.48	149.65	115.20

Note: * – unsaturated fatty acids.

The seeds contained the highest concentration of stearic acid at 295.39 μg/g. In comparison, lower levels were observed in the roots (138.34 μg/g), leaves (90.74 μg/g), and flowers (44.66 μg/g). Additionally, the experiment revealed that the leaves, roots, and seeds of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. accumulated notable amounts of lignoceric acid (Table 1).

In all examined organs of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk., consistently high levels of unsaturated fatty acids were observed. Oleic acid was the dominant unsaturated fatty acid in the flowers and seeds, while *α*-linolenic acid was predominant in the roots. The seeds exhibited the highest oleic acid concentration, reaching 7947.51 μg/g.

The highest concentration of linoleic acid was detected in the flowers, amounting to 1507.01 μg/g. In comparison, its levels in the leaves, roots, and seeds were 608.63 μg/g, 553.95 μg/g, and 13.21 μg/g, respectively (Table 1). Additionally, the analyzed samples of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. contained minor amounts of behenic, lignoceric, myristic, and arachidic acids.

Both linoleic and linolenic acids belong to the group of essential fatty acids, which are key components of dietary oils. The most significant among them are omega-3 and omega-6 fatty acids. In human nutrition, the specific types of fatty acids consumed are often more critical than the total amount of oil intake [15; 16]. Moreover, the balance between different fatty acids plays a vital role in both nutritional quality and economic value. Omega-3 fatty acids, in particular, are essential and polyunsaturated, meaning they cannot be synthesized by the human body and must be obtained from the diet. A proper ratio of omega-3 to omega-6 is necessary for the body to metabolize them into functional derivatives. Given their recognized health benefits, omega-3 fatty acids are increasingly being included in everyday diets [17–19].

The research findings indicate that *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. is a promising plant due to the important role of fatty acids in various biological processes.

Conclusions

The performed study on the fatty acid composition of *Rumex patientia* L. × *Rumex tianschanicus* Losinsk. did not reveal any substantial differences in qualitative composition and quantitative content of fatty acids across different plant parts. The results have shown that unsaturated fatty acids prevailed in the roots, leaves, flowers, and seeds. Their concentration exceeded that of saturated fatty acids by a factor of 3 to 4, depending on the specific type of raw material.

Our findings indicated that oleic acid was the predominant fatty acid in the leaves, flowers, and seeds of the studied plant, while *α*-linolenic acid was most abundant in the roots. These results may serve as a valuable foundation for the development of pharmaceutical products derived from *Rumex patientia* L. × *Rumex tianschanicus* Losinsk.

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