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CHOICE OF APPROACHES TO THE STANDARDIZATION OF THE ORIGINAL PLANT COLLECTION "OPORNOFIT"

Actuality. *Diseases of musculoskeletal system occupy 3rd place in the world in terms of prevalence. Plant remedies are used in the therapy of such diseases.*

The aim is to analyse the range of plant collections for the treatment and prevention of diseases of the musculoskeletal system with the isolation of plant raw materials which are most often included in their composition to establish the most promising groups of substances that cause pharmacological action, to confirm/cancel the prospects of their using in the development of methods for quality control of the plant collection "Opornofit species".

Material and methods. *Content analysis of available sources of information. The component composition of organic acids was determined by gas chromatography-mass spectroscopy and compounds of catechin – by high-performance liquid chromatography.*

Research results. *It was established that the composition of plant remedies and plant collections recommended for pathologies of the musculoskeletal system includes plant raw materials from 89 plant species belonging to 32 families. The most common components of the preparations are herb of Polygonum aviculare L., Hypericum perforatum L. and Thymus serpyllum L.; leaves of Urtica dioica L. and Rubus fruticosus L.; flowers of Crataegus sanquinea Pall. and Matricaria recutita L.; fruits of Rosa majalis Herrm. and Crataegus sanquinea Pall.; roots of Comarum palustre L. and Arctium lappa L. Analysis of the chemical composition of these types of plant raw materials showed that the main factors of pharmacological activity are phenolic compounds and organic acids. Therefore, the study of the qualitative composition of organic acids and catechins in the developed plant collection "Oprnofit" as potentially important groups of biologically active substances for its standardization is relevant. The quantitative content of 8 organic acids and 4 catechins in plant collection was identified and determined., The highest content was for the citric acid from the identified organic acids which indicates the expediency of recalculating the quantitative determination of the total organic acids on it. Of the identified catechins, the highest content was fort epicatechin and epicatechin gallate, therefore these compounds can be used as marker substances for the identification of polyphenols.*

Conclusion. *As a result of the analysis of the component composition of plant remedies and plant collection which are recommended for diseases of the musculoskeletal system, the types of plant raw materials that are most often included in their composition were established. The chemical composition of these types of plant raw materials was analysed and the most promising groups of substances that determine the pharmacological action of the preparations were established. For the first time, the quantitative content of 8 organic acids and 4 catechins was identified and determined in the original plant collection "Oprnofit". Given the dominance of citric acid content (1 215,74 mg/g), it is rational to quantitatively determine the total organic acids in terms of citric acid. The highest content of epicatechin from the identified catechins (3 301,38 mg/g) makes it possible to use this substance as a marker for identification (section "Identification C" of the quality control methods). The results obtained will be used in the development of quality control methods for the plant collection "Opornofit species".*

Key words: *plant collection, musculoskeletal system, organic acids, catechins, standardization.*

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ВИБІР ПІДХОДІВ ДО СТАНДАРТИЗАЦІЇ ОРИГІНАЛЬНОГО ВІТЧИЗНЯНОГО РОСЛИННОГО ЗБОРУ «ОПОРНОФІТ»

Актуальність. *Захворюванням опорно-рухової системи належить 3-тє місце у світі за поширеністю. У терапії таких захворювань використовуються рослинні засоби.*

Мета дослідження *– проаналізувати асортимент рослинних зборів для лікування та профілактики захворювань опорно-рухового апарату, з виділенням рослинної сировини, що найчастіше входить до їхнього складу, встановити найперспективніші групи речовин, які зумовлюють фармакологічну дію, для підтвердження/скасування перспективності їх використання під час розроблення методів контролю якості рослинного збору "Oporнofit species".*

Матеріал і методи. *Контент-аналіз доступних джерел інформації. Компонентний склад органічних кислот визначали методом газової хромато-мас-спектроскопії, сполук катехінової природи – методом високоефективної рідинної хроматографії.*

Результати дослідження. *Встановлено, що до складу рослинних зборів та фіточаїв, які рекомендуються у разі наявності патологій опорно-рухової системи, входить сировина 89 видів рослин, що належать до 32 родин. Найчастіше компонентами зборів є трава Polygonum aviculare L., Hypericum perforatum L. та Thymus serpyllum L.; листя Urtica dioica L. і Rubus fruticosus L.; квітки Crataegus sanquinea Pall. і Matricaria recutita L.; плоди Rosa majalis Herrm. та Crataegus sanquinea Pall.; корені Comarum palustre L. і Arctium lappa L. Аналіз хімічного складу цих видів сировини показав, що основними чинниками фармакологічної активності є фенольні сполуки й органічні кислоти. Тому дослідження якісного складу органічних кислот і катехінів у розробленому рослинному зборі «Опорнофіт», як потенційно важливих груп біологічно активних речовин для його стандартизації, є актуальним. У зборі ідентифіковано та визначено кількісний вміст 8 органічних кислот і 4 катехінів. З ідентифікованих органічних кислот найвищий вміст притаманний лимонній, що свідчить про доцільність проведення перерахунку кількісного визначення суми органічних кислот на неї. З ідентифікованих катехінів найвищий вміст притаманний епікатехіну й епікатехінгалату, тому ці сполуки можна використовувати як речовини-маркери для ідентифікації поліфенолів.*

Висновок. *У результаті проведеного аналізу компонентного складу рослинних зборів і фіточаїв, які рекомендуються в разі наявності захворювань опорно-рухової системи, установлено види рослинної сировини, що найчастіше входять до їхнього складу. Проаналізовано хімічний склад цих видів сировини та встановлено найперспективніші групи речовин, що зумовлюють фармакологічну дію зборів. Уперше в оригінальному рослинному зборі «Опорнофіт» ідентифіковано та визначено кількісний вміст 8 органічних кислот і 4 катехінів. Зважаючи на домінування за вмістом лимонної кислоти (1 215,74 мкг/г), раціонально кількісне визначення суми органічних кислот проводити в перерахунку на лимонну кислоту. Найвищий вміст епікатехіну з ідентифікованих катехінів (3 301,38 мкг/г) дає можливість використовувати цю речовину як маркер для ідентифікації (розділ «Ідентифікація С» проєкту методів контролю якості). Отримані результати будуть застосовані в розробленні методів контролю якості рослинного збору "Oporнofit species".*

Ключові слова: *рослинний збір, опорно-рухова система, органічні кислоти, катехіни, стандартизація.*

Introduction. Plant collections (PC) and plant teas occupy a certain place in phytotherapy. Analysis of the available range of these products showed that the largest number of PC and plant teas on the market are for the prevention and treatment of diseases of the respiratory, digestive, cardiovascular, nervous and genitourinary systems and for increasing immunity (Kompendium, 2025). At the same time, manufacturers use medicinal plant raw materials (MPRM) of both pharmacopoeial and non-pharmacopoeial kind, often do not indicate the ratio of components and do not provide standardization parameters both in terms of product labeling and in terms of active substances.

Today diseases of musculoskeletal system occupy 3rd place in the world in terms of prevalence (Salieieva, 2023). These diseases often lead to limited mobility of the patient and are accompanied by severe pain and swelling (Lazko, 2021; Aloshyna, 2022). Given the predominantly symptomatic treatment, pharmacotherapy suggests using nonsteroidal anti-inflammatory drugs, glucocorticosteroids, analgesics and muscle relaxants and plant medicines (PM) (ointment "Zhyvokost" by PrJSC Pharmaceutical Factory "Viola", "Tincture of Zhyvokost" by LLC DKP "Pharmaceutical Factory", "Capsicum tincture" by PrJSC Pharmaceutical Factory "Viola" etc.) and MPRM in the form of infusions, decoctions, compresses, baths etc. (Derzhavnyi reiestr likarskykh zasobiv, 2025).

MPRM and products based on it exhibit a wide range of biological activity (anti-inflammatory, analgesic, antimicrobial, antioxidant, diuretic, desensitizing) and normalize metabolism due to the diverse content of different groups of biologically active substances (BAS): polyphenols (phenolcarboxylic acids, flavonoids, tannins), organic acids, carbohydrates, minerals, vitamins (Baloch, 2021; Mechshanova, 2023; Savych, 2023: Salas-Arias, 2024). PM and MPRM in the therapy of diseases of the musculoskeletal system are used as long-term adjuvants with anti-inflammatory, analgesic, anti-edematous, desensitizing effects.

Considering to prevalence of pathologies of the musculoskeletal system, the importance of PC, which can be used in the long-term treatment of these diseases, and the possibility of obtaining various dosage forms from them (tinctures, liquid, thick and dry extracts, granules, capsules, tablets, ointments), it was relevant to monitor the range of MPRM in PC available on the domestic pharmaceutical market, analyze their chemical composition, and find out by which groups of BAS it is appropriate to standardize them.

This is also relevant because we developed the composition of the original PC "Opornofit". This PC includes plant raw materials of both pharmacopoeial (*Arctium* root (*Arctium lappa* L., *Arctium minus* (Hill) Bernh., *Arctium tomentosum* Mill.), rhizomes with roots of *Sanguisorba officinalis* L. and herb of *Bidens tripartita* L.) and non-pharmacopoeial (Rose root (*Rosa majalis* Herrm., *Rosa canina* L.) and rhizomes with roots of *Rumex confertus* Willd.) kind, which are used in traditional and evidence-based medicine as an anti-inflammatory, analgesic, diuretic, choleretic, antioxidant, antimicrobial agent and contributes to the normalization of metabolism (Khvorost, 2025, p. 170–178).

In the series of PC "Opornofit" we have established the quantitative content of the main groups of BAS and a number of commodity indicators of PC (fig. 1) (Oproshanska, 2024; Khvorost, 2025). Therefore, from the point of view of developing a project of quality control methods for PC "Opornofit species" the study of the component composition of organic acids and catechins as possibly promising groups of BAS for the standardization of PC "Opornofit" is relevant.

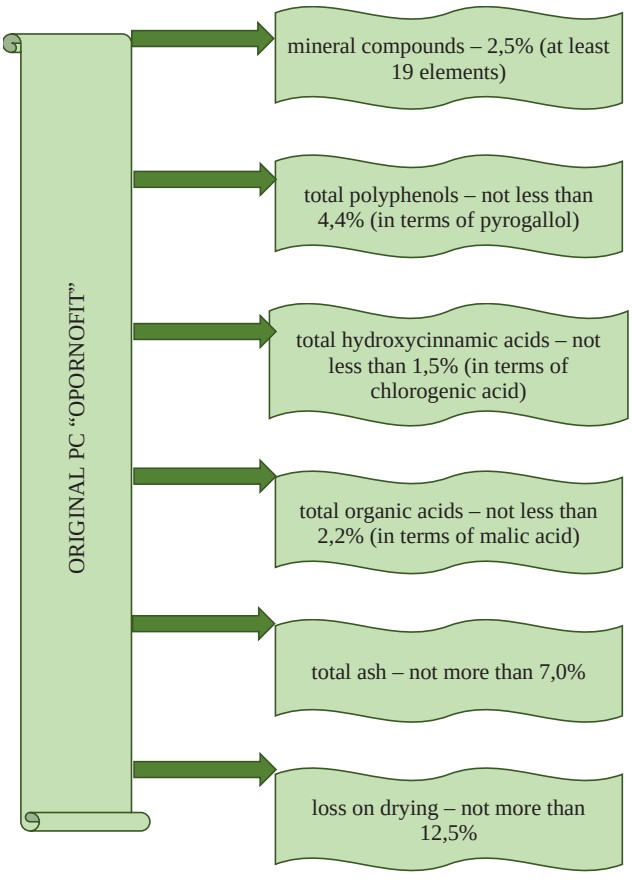

Fig. 1. Qualitative composition of PC "Opornofit"

The aim is to analyze the range of PC for the treatment and prevention of diseases of the musculoskeletal system

with the release of MPRM, which is most often included in their composition, to establish the most promising groups of BAS that determine the pharmacological effect, to confirm/cancel the prospects of their use in the development of quality control methods for PC "Opornofit species".

We chose the following experimental design (fig. 2).

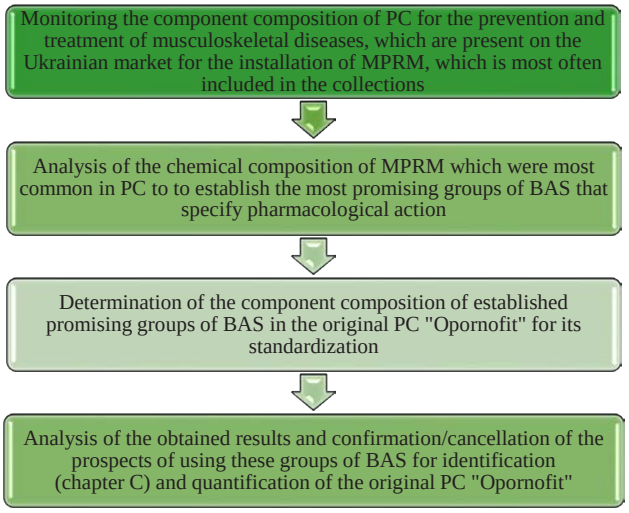

Fig. 2. Stages of the study

Materials and methods. Content analysis of available sources of information about PC for the prevention and treatment of musculoskeletal diseases with subsequent interpretation of the results. For the research, we used PC "Opornofit", which was manufactured in the laboratory of the Department of Pharmacognosy and Nutrition of the National University of Pharmacy. The plant raw materials were harvested during the corresponding growing seasons in 2022 in the Kharkiv and Vinnytsia regions.

The component composition of organic acids was determined by gas chromatography-mass spectroscopy (GC/MS) on the gas chromatography-mass spectrometry system *Agilent 6890N/5973inert (Agilent technologies, USA)* according to a known method (Agius, 2018; Budniak, 2024).

The component composition of catechin compounds was determined by high-performance liquid chromatography (HPLC) on the *Agilent Technologies 1200 chromatograph (Agilent technologies, USA)* according to a known method (Li, 2019, p. 29–38).

Research results and their discussion. Regarding the range of collections and plant teas recommended for use in pathologies of the musculoskeletal system, it is quite narrow (up to 10% of the total number of collections).

The composition of herbal medicines includes 12 types of plant raw materials (fig. 3). Most often, the plant raw material is the above-ground part of plants: herb and leaves and something less are underground organs (roots and rhizomes).

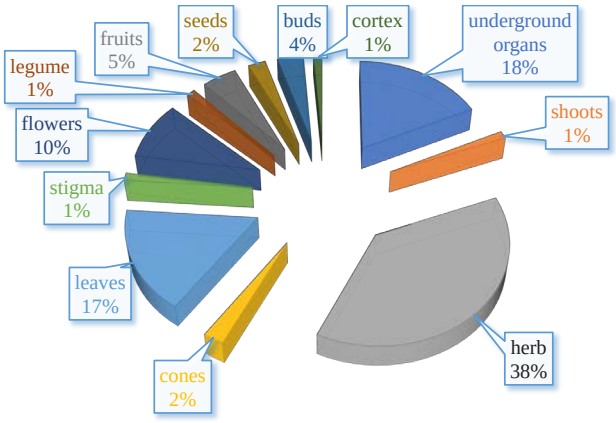

Fig. 3. Types of MPRM which are the part of PC

The component composition of the analyzed collections is represented by plant raw materials of 89 plant species belonging to 32 families, with 19 families represented by only one plant species. The names of families that have several plant species as sources of plant raw materials are given in fig. 4.

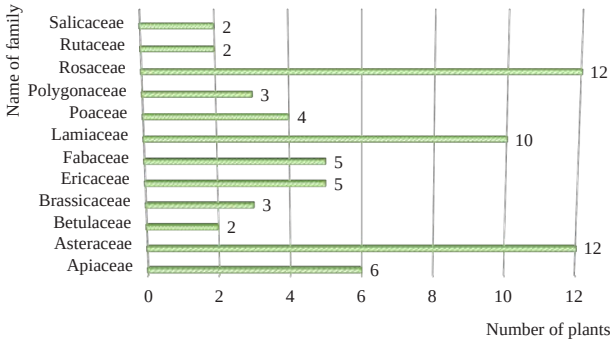

Fig. 4. Names of families to which belong plants as source of MPRM

The number of components in the PC varies from 3 to 28 (fig. 5). Most often, these are seven-component PC.

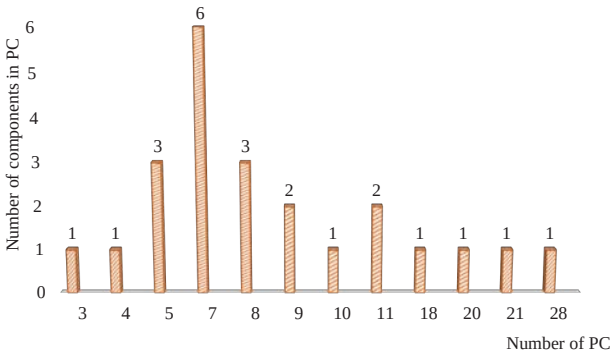

Fig. 5. Number of components included in the composition of PC

On the fig. 6 shows the types of MPRM that are most often included in the PC. So, the most common MPRM in the collection were: herb – *Polygonum aviculare* L., *Hypericum perforatum* L. *and Thymus serpyllum* L.; leaves – *Urtica dioica* L. *and Rubus fruticosus* L.; flowers – *Crataegus sanquinea* Pall. And *Matricaria recutita* L.; fruits *Rosa majalis* Herrm. and *Crataegus sanquinea Pall.;* roots *Comarum palustre* L. and *Arctium lappa* L.

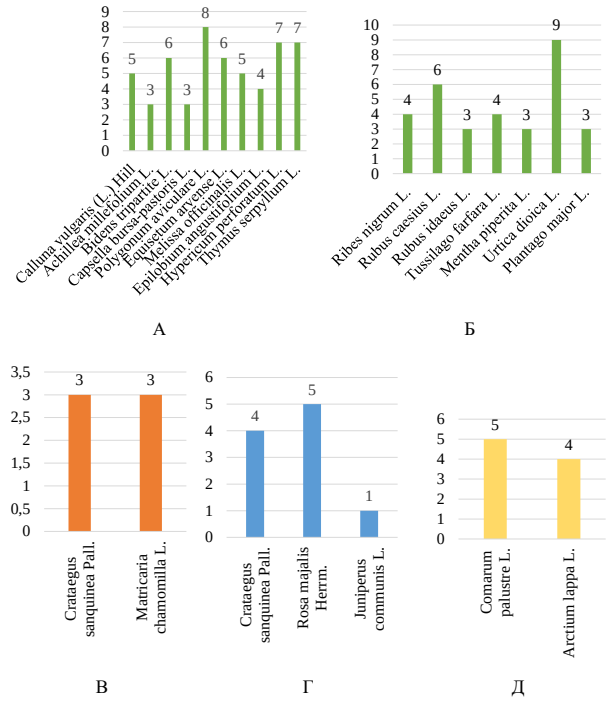

Fig. 6. Morphological groups of plant raw materials in the PC, which are most often found: A – herb; B – leaves; C – flowers; D – fruits; D – roots

Analysis of the chemical composition of these types of MPRM demonstrated that phenolic compounds and organic acids are one of the main factors in the inherent pharmacological activity of the PC. Therefore, the next stage of the work is the study of the qualitative composition of organic acids and catechins in the PC "Opornofit" as potentially important groups of BAS for its standardization.

The results of studying the component composition of organic acids of the PC "Opornofit" are shown in fig. 7 (GC/MS chromatogram) and fig. 8 (quantitative content of components).

In total, no less than 8 compounds were identified, the total content of which was 3 487,37 μg/g. Of the identified organic acids, citric acid is found in the largest amount (its part is almost 35% of the total organic acids). 26% of the total organic acids is accounted for by oxalic acid and a slightly smaller content is inherent in malonic acid (17% of the total organic acids). The smallest amount of the identified acids in the collection is α-ketoglutaric acid – a fairly common plant component, which was found in a minor amount of 6,97 μg/g (0,2% of the total organic acids) in the PC "Opornofit". Fumaric acid is also found in a small amount, its content is 11,73 μg/g (0,3% of the total organic acids).

The results of studying of the component composition of catechins of the PC "Opornofit" are shown in fig. 9 (HPLC chromatogram) and fig. 10 (quantitative content of components).

Epicatechin was found in the largest amount in the collection – 3 301,38 μg/g (40% of the total catechins) from the identified catechins. The content of epicatechin gallate was more than 1.4 times lower than the content of epicatechin and was equal to 2 302,86 μg/g, which

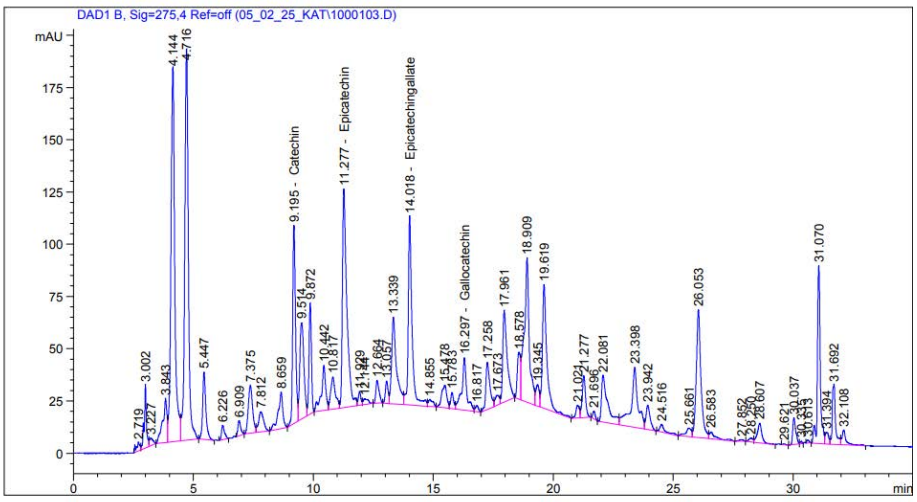

Fig. 7. GC/MS chromatogram of organic acids of the PC "Opornofit" (sample)

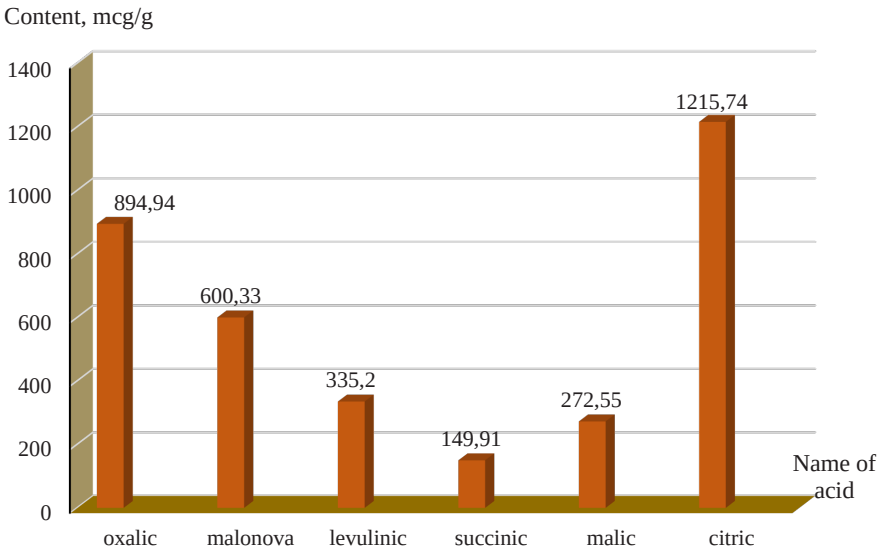

Fig. 8. Component composition of organic acids of the PC "Opornofit"

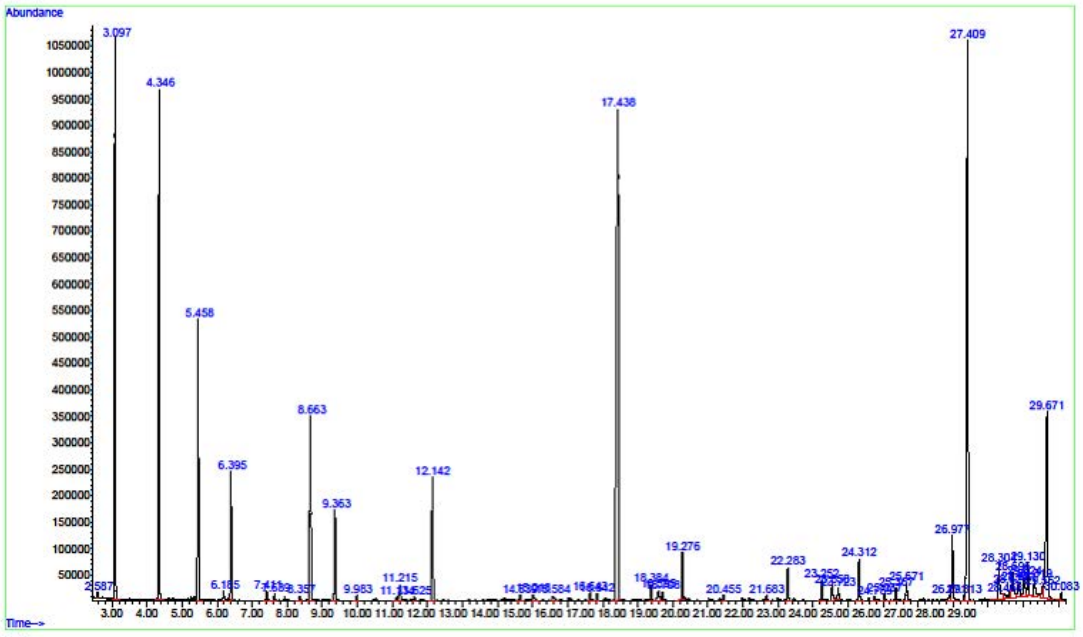

Fig. 9. HPLC chromatogram of catechins of the PC "Opornofit" (sample)

is 28% of the total catechins. The content of catechin is lower than the content of epicatechin and epicatechin gallate by almost 1,9 times and 1,3 times, respectively. The smallest amount was halocatechin (10% of the total catechins). It is known that catechins exhibit strong antioxidant properties (Musial, 2020, p. 1744).

Epicatechin, which is contained in the largest amount in the collection "Opornofit", has a positive effect on skeletal muscles – on the differentiation of myoblasts and promotes mitochondrial biogenesis and angiogenesis, which prevents the loss of muscle mass. In skeletal muscles, epicatechin suppresses the expression of atrogenes and, in combination with physical activity, improves muscle function (German, 2024, p. 326). Of course, the presence of epicatechin and other compounds of catechin nature determines the pharmacological activity of the PC "Opornofit" and has a positive effect on the formation of skeletal muscles in

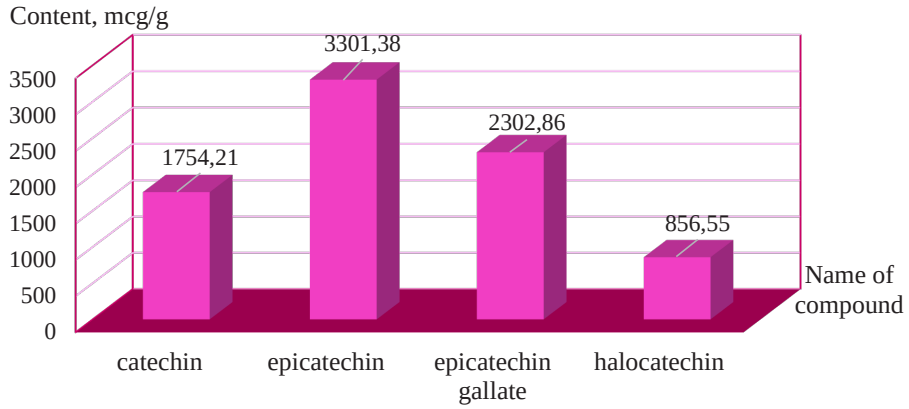

Fig. 10. Component composition of catechins of the PC "Opornofit"

potential consumers with diseases of the musculoskeletal system.

Therefore, considering to the component composition of organic acids in PC, it is advisable to determine the quantitative content of total organic acids in the collection in terms of citric acid. Taking into account the quantitative content of identified catechins and polyphenolic compounds, in chapter C of the quality control methods for PC "Opornofit species" it is rational to identify polyphenolic compounds, using epicatechin, epicatechin gallate or catechin as marker substances.

Conclusions. As a result of the analysis of the component composition of PC and plant teas which are recommended for treatment of diseases of the musculoskeletal system, were established the species of plant raw materials that are most often included in their composition. The chemical composition of these species of plant raw materials was analyzed and the most promising groups of substances that determine the pharmacological action of the preparations were established. For the first time, the quantitative content of 8 organic acids and 4 catechins was identified and determined in the original PC "Opornofit". Considering to the dominance content of citric acid (1 215,74 μg/g), it is rational to determine quantitative content of total organic acids in terms of citric acid. The highest content of epicatechin from the identified catechins (3 301,38 μg/g) makes it possible to use this substance as a marker for identification (chapter "Identification C" of the quality control methods). The results obtained will be used in the development of quality control methods for PC "Opornofit species".

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Khvorost O. – idea, collection and analysis of literature, research design, conclusions, summary, correction of the article;
Skrebtsova K. – collection and analysis of literature, participation in writing the article.

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