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STUDY OF THE PHARMACOGNOSTIC CHARACTERISTICS OF *MACLURA POMIFERA*

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Abstract. The article presents the results of studies aimed at developing a technology for obtaining biologically active compounds from the leaves and fruits of *Maclura pomifera*. The relevance of the study is based on the need to identify and quantitatively evaluate biologically active substances in medicinal plant raw materials, as they determine the plant's pharmacological properties and its potential applications in pharmaceutical practice. During the study, key pharmacognostic parameters such as moisture content, total ash, and extractive matter were determined. It was found that using an 80% hydroalcoholic solvent provided a higher yield of extractive substances compared to a 50% solution. Quantitative analysis revealed that the leaves and fruits contain significant amounts of flavonoids and coumarins, as well as saponins, tannins, alkaloids, and small amounts of free organic acids. Elemental analysis indicated that the main macroelements are potassium, calcium, and magnesium, while the levels of heavy metals comply with regulatory standards. Additionally, an amino acid analysis was performed. Comparative analysis showed that the fruits of *Maclura pomifera* have higher amounts and a greater diversity of amino acids compared to the leaves. These results confirm that *Maclura pomifera* is a promising source of biologically active compounds.

Keywords: *Maclura pomifera*, medicinal plant raw materials, biologically

active complexes, pharmacognostic parameters, flavonoids, elemental composition, phytopreparations

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MACLURA POMIFERA ӨСІМДІГІНІҢ ФАРМАКОГНОСТИКАЛЫҚ СИПАТТАМАЛАРЫН ЗЕРТТЕУ

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Аннотация. Мақалада *Maclura pomifera* өсімдігінің жапырақтары мен жемістерінен биологиялық белсенді кешендерді алу технологиясын әзірлеуге бағытталған зерттеулердің нәтижелері ұсынылған. Зерттеудің өзектілігі дәрілік өсімдік шикізатындағы биологиялық белсенді заттарды анықтау және сандық бағалау қажеттілігімен негізделеді, өйткені олар өсімдіктің фармакологиялық қасиеттерін және фармацевтикалық тәжірибеде қолдану перспективаларын айқындайды. Зерттеу барысында ылғалдылық, жалпы күлділік және экстрактивті заттар мөлшері сияқты негізгі фармакогностикалық көрсеткіштер анықталды. Экстрагент ретінде 80%-дық су-спирт ерітіндісін қолдану 50%-дық ерітіндімен салыстырғанда экстрактивті заттардың жоғары шығымын қамтамасыз ететіні анықталды. Сандық талдау нәтижесінде жапырақтар мен жемістер құрамында флавоноидтар мен кумариндердің едәуір мөлшері, сондай-ақ сапониндер, тері илегіш заттар, алкалоидтар және бос органикалық қышқылдардың аз мөлшерде кездесетіні анықталды. Элементтік талдау деректері бойынша негізгі

макроэлементтерге калий, кальций және магний жатады, ал ауыр металдардың мөлшері нормативтік талаптарға сәйкес келеді. Сонымен қатар амин қышқылдарына да талдау жүргізіліп, салыстырмалы талдаудан маклюра жемістерінің құрамында аминқышқылдарының мөлшері мен алуан түрлілігі жағынан жоғары екенін анықталды. Алынған нәтижелер Maclura pomifera өсімдігінің биологиялық белсенді қосылыстардың перспективалы көзі екенін дәлелдейді.

Түйін сөздер: *Maclura pomifera,* дәрілік өсімдік шикізаты, биологиялық белсенді кешендер, фармакогностикалық көрсеткіштер, флавоноидтар, элементтік құрам, фитопрепараттар

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ИЗУЧЕНИЕ ФАРМАКОГНОСТИЧЕСКИХ ХАРАКТЕРИСТИК *MACLURA POMIFERA*

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Аннотация. В статье представлены результаты исследований, направленных на разработку технологии получения биологически активных комплексов из листьев и плодов *Maclura pomifera*. Актуальность исследования обусловлена необходимостью идентификации и количественной оценки биологически активных веществ лекарственного растительного сырья, поскольку именно они определяют фармакологические свойства растения и перспективы его применения в фармацевтической практике. В ходе исследования определены основные фармакогностические показатели, включая влажность, общую зольность и содержание экстрактивных веществ. Установлено, что использование 80%-ного водно-спиртового экстрагента обеспечивает более высокий выход экстрактивных веществ по сравнению с 50%-ным раствором этанола. Результаты количественного анализа показали, что листья и плоды содержат значительные количества флавоноидов и кумаринов, а также сапонинов, дубильных веществ, алкалоидов и небольшое количество свободных органических кислот. Согласно данным элементного анализа, основными макроэлементами являются калий, кальций

и магний, при этом содержание тяжёлых металлов соответствует нормативным требованиям. Дополнительно был проведён анализ аминокислотного состава. Сравнительный анализ показал, что плоды маклюры характеризуются более высоким содержанием и большим разнообразием аминокислот по сравнению с листьями. Полученные результаты подтверждают, что *Maclura pomifera* является перспективным источником биологически активных соединений и может рассматриваться в качестве ценного сырья для создания фитопрепаратов.

Ключевые слова: *Maclura pomifera*, лекарственное растительное сырьё, биологически активные соединения, фармакогностические показатели, флавоноиды, элементный состав, фитопрепараты

Introduction. Currently, about 15–20% of herbal medicinal products are manufactured at domestic pharmaceutical enterprises, while the majority of medicines are imported from abroad. This leads to an increase in the cost of pharmaceutical products and a greater dependence of the pharmaceutical market on synthetic drugs (WHO, 2013). At the same time, synthetic medicines are often characterized by insufficient biocompatibility and difficulties in elimination from the body, which reduces their effectiveness from the perspective of public health protection and economic feasibility. In this regard, the study of medicinal plants traditionally used in folk medicine, as well as the development of technologies for obtaining biologically active complexes based on them, are relevant tasks of modern pharmaceutical science and industry (Heinrich et al., 2018). The development of organic chemistry and the pharmaceutical industry is closely associated with the study of natural compounds isolated from plant raw materials. Medicinal plants represent a valuable source of biologically active substances possessing a wide spectrum of pharmacological activity, including anti-inflammatory, antioxidant, and antimicrobial effects. In this context, plant raw material of *Maclura pomifera* is of particular interest, as it is distinguished by a rich chemical composition and promising prospects for practical application (Evans, 2009).

Maclura pomifera belongs to plants containing a complex of phenolic compounds, flavonoids, coumarins, and other biologically active substances that determine its pharmacological potential. Despite the availability of certain information on the chemical composition of this plant, issues related to raw material standardization, quantitative assessment of biologically active compounds, and the development of rational technology for their extraction remain insufficiently studied. This determines the relevance of conducting pharmacognostic and phytochemical studies of the leaves and fruits of *Maclura pomifera* (Heinrich et al., 2018).

The study of the chemical composition of *Maclura pomifera* plant raw material, including the determination of pharmacognostic parameters, quantitative evaluation of the main groups of biologically active substances, and analysis of the elemental composition, is a necessary stage for substantiating the possibility of its application in pharmaceutical practice. The development of technology for obtaining biologically active complexes based on this plant creates prerequisites for expanding the range of domestically produced herbal medicines and reducing dependence on synthetic drugs

(Kang et al., 2006). The data obtained during the study are considered as a basis for the further use of *Maclura pomifera* in the development of dosage forms of various types, including liquid, solid, and semi-solid forms, as well as for the implementation of the results into pharmaceutical technology and phytopharmaceutics.

Literary review

Maclura pomifera (Raf.) Schneid., commonly known as Osage orange, is a woody plant species of North American origin belonging to the family Moraceae. The species is known by various common names, including Adam's apple, Osage orange, hedge apple, horse apple, and monkey ball. Its native range includes the present-day states of Texas, Oklahoma, and Missouri (USA), where the Osage people traditionally used its durable wood for bow making, while the milky latex was employed as a natural dye. The scientific name of the genus was given in honor of the American geologist and president of the Academy of Natural Sciences of Philadelphia, William Maclure (Gubanov et al., 2003).

Under the climatic conditions of Kazakhstan, *M. pomifera* has been successfully introduced and is currently cultivated in the Turkestan region, particularly within the territory of the Sairam-Ugam State National Natural Park, as well as in the dendrological park of Shymkent city, demonstrating good adaptation to local environmental conditions (Abdulina et al., 1999).

The plant is a dioecious deciduous tree reaching 15–20 m in height, characterized by a short, massive trunk covered with dark brown, deeply furrowed bark. The crown is dense and spreading, while the branches bear sharp thorns. The leaves are alternate, ovate, thick, and glossy, measuring 8–13 cm in length. The upper leaf surface is dark green, whereas the lower surface is lighter in color. During autumn, the foliage turns bright yellow, enhancing the ornamental value of the plant (Komarov et al., 1936).

Flowering occurs from May to mid-June. The flowers are small and unisexual: male flowers are arranged in catkin-like inflorescences, whereas female flowers form spherical capitulate inflorescences. Pollination is predominantly wind-mediated, although insects may occasionally participate (Sokolov et al., 1954). Although *M. pomifera* is generally dioecious, favorable environmental conditions may result in the development of both male and female flowers on the same tree, thereby increasing the likelihood of fruit production.

The fruits mature between September and October. They are large, spherical syncarps reaching up to 15 cm in diameter, with a rough orange-green surface resembling that of an orange. The interior contains a milky latex and a sticky white pulp characterized by a distinct fresh cucumber-like aroma. The fruits are not edible and may exhibit toxic properties when ingested. Furthermore, the latex can cause skin irritation; therefore, harvesting should be carried out using appropriate protective equipment (Bobrov et al., 1949).

Despite its toxicity, *M. pomifera* has been widely used in traditional medicine. Alcoholic tinctures, extracts, and ointments prepared from the fruits, leaves, bark, and young shoots are traditionally applied for the treatment of inflammatory and degenerative joint disorders, osteochondrosis, intervertebral hernias, and metabolic disturbances.

The species exhibits remarkable ecological plasticity and resistance to extreme

climatic conditions. It tolerates temperatures as low as −15 °C and as high as +38 °C and prefers sunny, well-drained habitats. Fruiting generally begins at 5–6 years of age without the need for growth stimulants. Owing to its dense crown and distinctive fruits, *M. pomifera* is widely utilized in landscape architecture as a hedge plant and as an ornamental focal element in park and garden compositions (Kurkin et al., 2004).

Therefore, *Maclura pomifera* represents not only an ornamental and utilitarian species but also a promising pharmacological resource. Its rich phytochemical composition, adaptability to diverse environmental conditions, and pronounced biological potential make it an attractive subject for further phytochemical, pharmacological, and biomedical investigations aimed at the discovery and development of natural bioactive compounds.

Materials and Methods

Plant Material

The study was performed using the leaves and fruits of *Maclura pomifera* (Raf.) Schneid. collected during the active vegetation period in the Turkestan region of Kazakhstan. Botanical identification of the plant material was carried out according to standard taxonomic descriptions and floristic references. The collected samples were cleaned from mechanical impurities, washed with distilled water when necessary, and dried under natural ventilation conditions at room temperature (22–25 °C) until constant weight was achieved. The dried material was ground using a laboratory mill and passed through a sieve to obtain a homogeneous powder suitable for analytical procedures. The prepared samples were stored in airtight containers protected from light and moisture until further analysis.

Chemicals and Reagents

All chemicals and reagents used in the study were of analytical grade. Ethyl alcohol solutions (50% and 80%) were employed for extraction procedures. Ninhydrin reagent was used for the qualitative and quantitative determination of amino acids. Glycine served as the reference standard for calibration during spectrophotometric amino acid analysis. Hydrogen peroxide and nitric acid were used during ash analysis and sample preparation procedures. Solvents for chromatographic analysis included n-propanol, ethyl acetate, pyridine, acetic acid, and purified water. All reagents complied with the requirements of the State Pharmacopoeia of the Republic of Kazakhstan and were used without further purification.

Analytical Methods

The quality assessment of medicinal plant raw material was carried out according to the requirements of the State Pharmacopoeia of the Republic of Kazakhstan (XI edition). Pharmacognostic parameters including moisture content, total ash, and extractive substances were determined.

The content of biologically active substances (flavonoids, coumarins, saponins, tannins, alkaloids, and free organic acids) was evaluated using standard pharmacognostic and spectrophotometric methods.

Qualitative and quantitative determination of amino acids was carried out using ninhydrin-based colorimetric methods, supported by chromatographic identification techniques.

Experimental Procedures

Determination of Moisture Content

Moisture content was determined as the loss in mass after drying to constant weight. Plant material was ground to approximately 10 mm particle size and thoroughly mixed. Samples weighing 3–5 g were placed in previously dried weighing bottles and dried at 100–105 °C until constant weight was achieved. Constant weight was considered reached when the difference between two consecutive weighings did not exceed 0.01 g after cooling in a desiccator.

Determination of Total Ash

The total ash content was determined according to the procedures described in the State Pharmacopoeia of the Republic of Kazakhstan (XI edition). Approximately 2–3 g of accurately weighed powdered plant material was placed in a previously ignited and weighed porcelain crucible. The sample was gradually heated over a low flame until complete carbonization and then transferred to a muffle furnace maintained at 500–550 °C. Incineration was continued until a light gray or white residue indicating complete combustion of organic matter was obtained.

The crucibles were cooled in a desiccator and weighed. If carbon particles remained, the residue was moistened with a small volume of hydrogen peroxide or nitric acid solution and reheated until complete ashing. The process of heating, cooling, and weighing was repeated until constant weight was achieved.

Determination of Extractive Substances

The content of extractive substances was determined using 50% and 80% aqueous ethanol solutions as extraction solvents in order to evaluate the extraction efficiency of biologically active compounds from *Maclura pomifera* leaves and fruits. Approximately 5.0 g of air-dried and powdered plant material was accurately weighed and transferred into a conical flask. The sample was extracted with the appropriate solvent at a raw material-to-solvent ratio of 1:10. Extraction was performed under continuous stirring at room temperature for 24 h. The resulting extracts were filtered through filter paper to remove insoluble plant residues.

An accurately measured aliquot of each filtrate was transferred into a pre-weighed evaporating dish and evaporated to dryness in a water bath. The residue was subsequently dried in a drying oven at 100–105 °C to constant weight, cooled in a desiccator, and weighed.

Quantitative Determination of Biologically Active Substances

The quantitative content of biologically active compounds was evaluated using standard pharmacognostic and spectrophotometric methods. The analyzed groups of compounds included flavonoids, coumarins, tannins, alkaloids, saponins, and free organic acids.

Flavonoids were quantified spectrophotometrically based on the formation of colored complexes with specific reagents and expressed as a percentage of dry plant material.

Coumarins were determined using extraction and spectrophotometric measurement techniques based on their characteristic absorption spectra.

Tannins were quantified using established pharmacopoeial procedures involving complex formation reactions.

Alkaloids were isolated through acid-base extraction and subsequently quantified using gravimetric and spectrophotometric approaches.

Saponins were determined according to their ability to form stable foam and through quantitative extraction methods.

The content of free organic acids was evaluated by titrimetric procedures and expressed as a percentage of absolutely dry raw material.

Determination of Elemental Composition

The macro- and microelement composition of *Maclura pomifera* leaves and fruits was investigated to assess their nutritional, pharmacological, and toxicological significance. The samples were subjected to acid digestion prior to instrumental analysis.

The concentrations of sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), and lead (Pb) were determined using atomic absorption spectrometry. Calibration curves were constructed using certified standard solutions. The results were expressed in μg/mL and compared with established safety standards for medicinal plant materials.

Qualitative Determination of Amino Acids

The presence of amino acids was initially confirmed using the ninhydrin reaction. One milliliter of the test solution was mixed with an equal volume of freshly prepared 0.2% ninhydrin solution and heated in a water bath for 5–10 min. The appearance of a violet-red coloration indicated the presence of free amino acids.

Chromatographic Identification of Amino Acids

Thin-layer chromatography (TLC) and paper chromatography were used to identify individual amino acids. Silufol UV-254 plates were developed using the solvent systems n-propanol–water (7:3) and ethyl acetate–pyridine–acetic acid–water (30:20:6:11). Standard amino acids including alanine, glycine, and leucine were used as reference compounds. Detection was performed using 0.2% aqueous ninhydrin solution followed by heating.

Quantitative Determination of Amino Acids

The quantitative content of amino acids in the studied extracts was determined by the colorimetric (biuret) method using ninhydrin reagent. For analysis, a sample of the dry extract (accurate weight) was dissolved in 20 mL of purified water and kept at room temperature for 24 hours with periodic stirring. After filtration, the resulting extract was used for analysis. To 10 mL of the test solution, 10 mL of 0.2% ninhydrin reagent was added, and the mixture was heated in a water bath at a temperature of (80 ± 5) °C for 15 minutes. After cooling, the optical density of the solution was measured using a spectrophotometer at a wavelength of 540 nm. A control solution was prepared by mixing the ninhydrin reagent with purified water. The quantitative content of amino acids was determined using a calibration curve constructed with a standard glycine solution. The obtained results were expressed as milligrams of amino acids per 1 g of dry extract by formula.

$$X = \frac{C \cdot 50 \cdot 25 \cdot 100 \cdot 100}{m \cdot 10 \cdot (100 - W)}$$

Results

Pharmacognostic Characteristics of Maclura pomifera Raw Material. The pharmacognostic characteristics of *Maclura pomifera* leaves and fruits are presented in Table 1. Evaluation of moisture content, total ash, and extractive values is an essential stage in assessing the quality, purity, and storage stability of medicinal plant raw materials.

The moisture content of the investigated samples ranged from 4.97% in fruits to 6.39% in leaves. These values are within the permissible limits established for medicinal plant materials and indicate satisfactory storage stability. The lower moisture content observed in the fruits suggests a reduced susceptibility to microbiological spoilage and biochemical degradation during storage compared with the leaves.

Total ash content, which reflects the overall mineral composition and the possible presence of inorganic impurities, amounted to 8.70% in leaves and 5.33% in fruits. The higher ash content in the leaves may be associated with greater accumulation of mineral elements in photosynthetically active tissues. At the same time, the obtained values indicate the absence of excessive contamination by foreign inorganic matter and confirm the acceptable quality of the studied raw material.

The determination of extractive substances demonstrated a significant influence of solvent concentration on extraction efficiency. Extraction using 80% ethanol provided substantially higher yields of extractive substances compared with 50% ethanol in both plant organs. In the leaves, the extractive value increased from 13.86% to 29.33%, whereas in the fruits it increased from 14.94% to 18.41%.

Among all investigated samples, the highest extraction yield was obtained from the leaves using 80% ethanol (29.33%). This result suggests that a considerable proportion of biologically active compounds present in *Maclura pomifera* leaves exhibits higher solubility in hydroalcoholic mixtures with increased ethanol concentration. Therefore, 80% ethanol can be considered a more effective extraction solvent for recovering bioactive constituents from this species.

Overall, the obtained pharmacognostic parameters confirm the good quality of *Maclura pomifera* raw material and demonstrate the suitability of hydroalcoholic extraction, particularly with 80% ethanol, for the efficient isolation of biologically active compounds from both leaves and fruits.

Table 1 – Pharmacognostic Indicators of *Maclura pomifera* Raw Material Calculated on an Absolutely Dry

Name of raw material	Moisture content, %	Total ash, %	Extractive substances, % (50%)	Extractive substances, % (80%)
Leaves of *M.pomifera*	6,391	8,7	13,86	29,33
Fruits of M. pomifera	4,968	5,33	14,94	18,41

Content of Biologically Active Substances. The quantitative content of biologically active substances in the leaves and fruits of *Maclura pomifera* is presented in Table 2 and illustrated in Figures 1–2. The phytochemical analysis revealed the presence of several groups of secondary metabolites, including flavonoids, coumarins, saponins, tannins,

alkaloids, and free organic acids, which are known to contribute to the biological and pharmacological activities of medicinal plants.

Among the identified compounds, flavonoids represented one of the dominant groups in both plant organs. Their content reached 3.3% in the leaves and 3.2% in the fruits, indicating a relatively uniform distribution within the plant. The high concentration of flavonoids suggests that *Maclura pomifera* may serve as a valuable source of natural antioxidant compounds. Flavonoids are widely recognized for their antioxidant, anti-inflammatory, antimicrobial, and membrane-protective properties, which significantly enhance the therapeutic potential of medicinal plant materials.

A pronounced difference was observed in the accumulation of coumarins between the investigated plant organs. The highest coumarin content was detected in the fruits (3.12%), whereas the leaves contained only 0.28%. Thus, the concentration of coumarins in the fruits was more than ten times higher than that in the leaves. This finding indicates that the fruits may represent a particularly rich source of coumarin derivatives, which are known for their anti-inflammatory, vasoprotective, anticoagulant, and antimicrobial activities.

Saponins were also present in considerable amounts in both plant organs. The highest concentration was observed in the fruits (3.35%), while the leaves contained 2.81%. The elevated saponin content in fruits may contribute to enhanced biological activity, as these compounds are characterized by expectorant, immunomodulatory, antimicrobial, and surface-active properties. In addition, saponins can improve the bioavailability of other biologically active compounds by increasing membrane permeability.

Tannins were detected in both samples, with a higher concentration in the leaves (0.5773%) compared with the fruits (0.3062%). The predominance of tannins in leaves may be associated with their protective function against environmental stress factors, pathogens, and herbivores. Due to their astringent, antioxidant, and antimicrobial properties, tannins are considered important pharmacologically active constituents of medicinal plants.

A significant difference was also observed in alkaloid content. The leaves contained 2.59% alkaloids, whereas only trace amounts were detected in the fruits (0.022%). The relatively high alkaloid concentration in leaves indicates their potential pharmacological significance, as alkaloids are known to exhibit a broad spectrum of biological activities, including analgesic, antimicrobial, anti-inflammatory, and neuroactive effects.

Free organic acids were found in comparatively low concentrations in both plant organs. Their content amounted to 0.093% in leaves and 0.077% in fruits. Despite their relatively low abundance, organic acids play an important role in plant metabolism and may contribute to the antioxidant activity and stability of plant extracts.

Overall, the obtained results demonstrate that both leaves and fruits of *Maclura pomifera* are rich sources of biologically active compounds. However, the distribution of individual metabolite groups differs considerably between plant organs. Fruits are characterized by elevated concentrations of coumarins and saponins, whereas leaves contain higher levels of alkaloids and tannins. Such differences should be taken into account when selecting plant material for the development of phytopharmaceutical preparations and biologically active extracts with specific therapeutic properties.

Table 2 – Content of Biologically Active Substances in *Maclura pomifera* Raw Material, %

Biologically active substances	Leaves, %	Fruits, %
Flavonoids	3,3	3,2
Free organic acids	0,093	0,077
Coumarins	0,28	3,12
Tannins	0,5773	0,3062
Alkaloids	2,59	0,022
Saponins	2,81	3,35

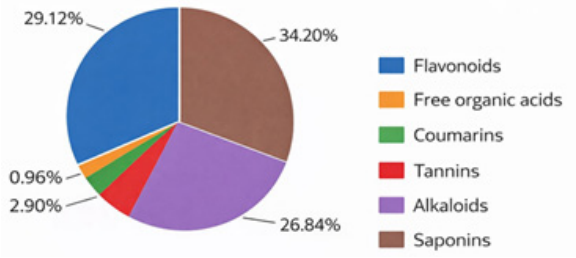

Figure 1 – Content of Biologically Active Substances in the Leaves of Maclura pomifera, %

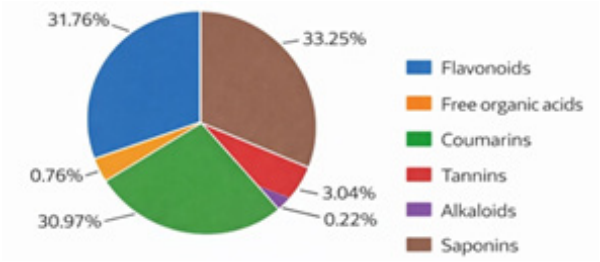

Figure 2 – Content of Biologically Active Substances in the Fruits of *Maclura pomifera,* %

Elemental Composition. The macro- and microelement composition of Maclura pomifera is shown in Table 3. Potassium, calcium, and magnesium were identified as the dominant macroelements. The highest calcium concentration was observed in leaves (1550.52 µg/mL), whereas potassium predominated in fruits (1417.48 µg/mL). Trace elements including Mn, Fe, Zn, Cu, and Ni were detected in both organs. Toxic elements such as Cd and Pb were present only in low concentrations.

Table 3 – Macro- and Microelement Composition of *Maclura pomifera* Raw Material (µg/mL)

Element	Leaves	Fruits
Na	52,310	56,690
Ca	1550,520	386,770
K	1222,90	1417,480
Mg	476,265	168,982
Mn	11,415	3,385
Ni	0,6497	0,445
Fe	16,678	12,273
Cd	0,0571	0,0248

Zn	2,7759	2,3693
Cu	2,2112	2,8564
Pb	0,1608	0,1013

Free Amino Acid Composition. The quantitative composition of free amino acids is presented in Figures 3 and 4. The total amino acid content was 12.52 mg/g in fruits and 2.83 mg/g in leaves. In fruits, arginine (4.17 mg/g), glycine (1.61 mg/g), asparagine (1.61 mg/g), and cysteine (1.36 mg/g) were the predominant amino acids. In leaves, cysteine was the major amino acid, reaching 0.6776 mg/g.

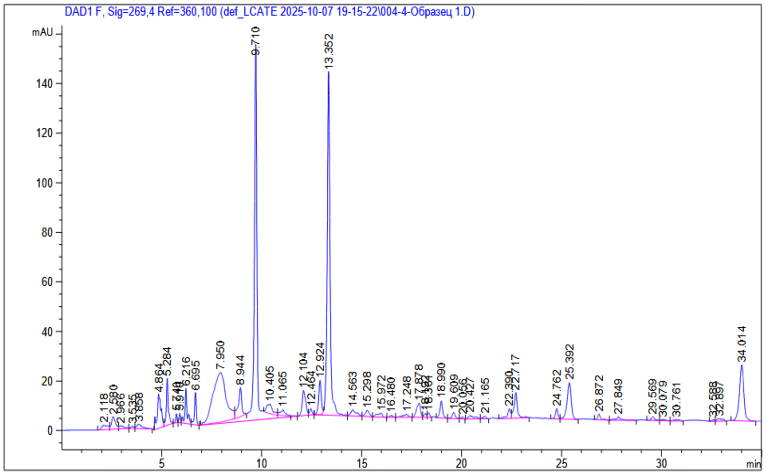

Figure 3 – Quantitative Content of Free Amino Acids in the Fruits of *Maclura pomifera*

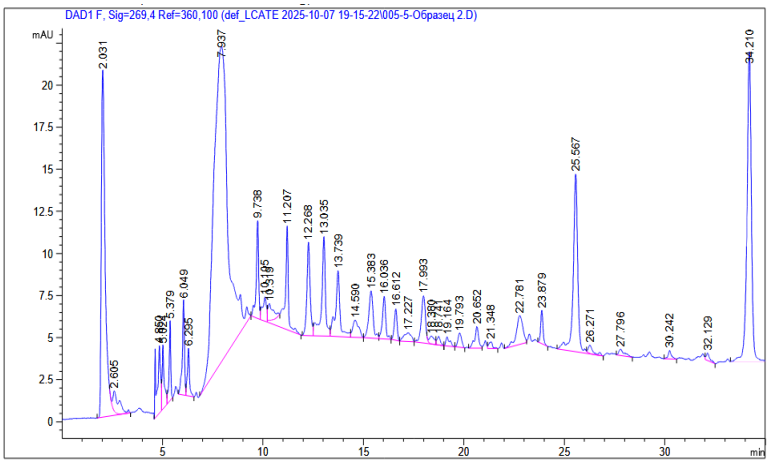

Figure 4 – Quantitative Content of Free Amino Acids in the Leaves of *Maclura pomifera*

Discussion. The obtained pharmacognostic parameters indicate good quality and stability of Maclura pomifera raw material. The low moisture content suggests a reduced risk of microbial contamination during storage, while the ash values confirm the absence

of significant inorganic impurities. The significantly higher extraction yields obtained with 80% ethanol demonstrate that hydroalcoholic mixtures with increased ethanol concentration are more efficient for recovering biologically active compounds.

The phytochemical analysis revealed that both leaves and fruits are rich in flavonoids, supporting the potential antioxidant and anti-inflammatory properties of this species. A notable difference was observed in coumarin accumulation, with fruits containing more than ten times higher concentrations than leaves. Such variation may be associated with differences in physiological functions and metabolite distribution between vegetative and reproductive organs.

The elevated saponin content in fruits suggests their potential contribution to improving the bioavailability of other phytochemicals, whereas the higher tannin concentration in leaves may explain their potential astringent and antimicrobial effects. The presence of alkaloids mainly in leaves further supports the biological activity of leaf extracts.

Elemental analysis demonstrated that potassium, calcium, and magnesium are the principal mineral constituents of *Maclura pomifera*. The high calcium concentration in leaves is consistent with its role in structural stabilization and regulation of cellular processes in photosynthetically active tissues. Potassium accumulation in fruits may reflect its involvement in fruit maturation and metabolic regulation. Importantly, cadmium and lead concentrations remained within acceptable limits, confirming the safety of the studied raw material for potential pharmaceutical applications.

The amino acid profile revealed substantial differences between leaves and fruits. Fruits contained more than four times higher total amino acid levels, indicating their function as metabolically active storage organs. The predominance of arginine is of particular interest due to its role as a precursor of nitric oxide and its involvement in vascular regulation, immune response, and tissue repair. In contrast, the relatively high cysteine content in leaves may contribute to antioxidant defense mechanisms through glutathione biosynthesis.

Overall, the results demonstrate that both leaves and fruits of *Maclura pomifera* represent promising sources of biologically active compounds. Their rich phytochemical composition, favorable mineral profile, and diverse amino acid content support the potential use of this species in the development of phytopharmaceutical products and functional health-promoting formulations.

Conclusion. During the study, the moisture content, total ash, and extractive substance content were determined in the leaves and fruits of *Maclura pomifera*. The obtained data confirm the quality of the plant raw material and its suitability for further processing. It was established that 80% ethyl alcohol provides a higher yield of extractive substances, making it the optimal extractant for obtaining biologically active complexes.

Quantitative analysis showed that the main biologically active compounds are flavonoids and coumarins, which possess antioxidant and anti-inflammatory activity. Saponins, tannins, alkaloids, and organic acids were also identified. Elemental analysis confirmed a high content of potassium, calcium, and magnesium, with no exceedance of permissible levels of toxic elements. In addition, an analysis of the amino acid

composition was carried out. Comparative analysis has shown that maclura fruits are characterized by a higher content and variety of amino acids than leaves. Thus, Maclura pomifera represents a promising medicinal plant raw material for the development of phytopharmaceuticals with antioxidant and anti-inflammatory effects.

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