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Д.В. Сокольский атындағы «Жанармай,
катализ және электрохимия институты» АҚ

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
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NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
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NAS RK is pleased to announce that News of NAS RK. Series of chemistry and technologies scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of chemistry and technologies in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of chemical sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Химия және технология сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Химия және технология сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді химиялық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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CHEMICAL RESEARCH AND BIOLOGICAL ACTIVITY OF PLANTS OF THE GENUS *ATRAPHAXIS* (*A. SPINOSA*)

Abstract. In this article identifies new sources of obtaining biological substances from plants of the genus *Atraphaxis* (*A. spinosa*) prepared in the Almaty region.

According to well - known methods, the analysis of indicators and standards of raw material quality-humidity, total ash, sulphate ash, insoluble ash in 10% hydrochloric acid-was developed and carried out.

Micro- and macroelements determined by atomic absorption spectroscopy. Analysis of the elemental composition shows that iron predominates from microelements, and sodium, potassium and calcium from macronutrients.

Conditions for obtaining a biologically active complex from the aboveground part of *Atraphaxis spinosa* developed for the first time. The optimal conditions for obtaining the complex are extractant – 50% ethanol, the ratio of extractant and raw materials – 1:8, double extraction time – 48 hours, temperature – 22 - 26 °C.

The lipophilic composition identified by chromatography-mass spectroscopy. Since lipophilic fractions of plant samples include such classes of compounds as fatty acids; mono-; di-; triglycerides, phospholipids, sterols, Sterol esters, glycolipids, fat-soluble vitamins, they can considered not only as nutritional products, but also as possible pharmacological agents. The content of lipophilic components – 26 organic compounds-was determined. It found that *A. spinosa* contains a large amount of di - (2-ethylhexyl) phthalate (54.66%) and β -sitosterol (13.11%).

A complex study of plant resources as medicinal raw materials provides for the chemical study of biologically active substances and biological screening of extracts and individual compounds obtained from plants. In most cases, the extract showed a wide range of antibacterial activity against the used strains of microorganisms.

Key words: *Atraphaxis spinosa*, mineral composition, plant quality, lipophilic composition, biological activity, Polygonaceae family.

Introduction. The family *Polygonaceae* includes about 27 genera and 800 species. Kazakhstan species of plants of the genus *Atraphaxis* have not systematically studied; therefore, the study of the chemical composition, the development of methods for the isolation of potentially biologically active substances, the study of biological activity, and the development of new drugs and herbal remedies are relevant [1].

The object of the study was *Atraphaxis spinosa* of the *Polygonaceae* family germinating in the Almaty region of the Republic of Kazakhstan [2-4].

Biologically active substances contained in the plant *Atraphaxis spinosa*. The roots of the plant contain flavonoids. In the aerial part - alkaloids. The leaves of the plant contain tannins. The flavonoids

compounds - spinoside, 3,8,3', 4'-tetrahydroxyflavon, luteolin 7-methyl ester, 3-β-L-rhamnopyranoside 3,8,3', 4'-tetrahydroxyflavone, 4'-α-D-glucofuranoside 7-luteolin 7-methyl ester, 4'-β-D-glucofuranosyl-6-β-D-glucopyranoside 7-O-luteolin methyl ester.

Materials and methods. The aerial part of *Atraphaxis spinosa*, which grows in the Almaty region, used as the object of study. In the studied object, the quantitative content of macro- and microelements was determined. The elemental composition determined by atomic absorption spectroscopy on an ASSIN instrument from Karl Zeiss [5].

For determination of the lipophilic composition of the plant, *Atraphaxis spinose* use Soxhlet apparatus. The resulting extract was concentrated under mild conditions (water bath temperature 40-45 °C) after them, sample concentrate and analyzed on Agilent Technologies 7000 GS / MS system. Component identification carried out automatically by analogy with the known mass spectra of samples stored in the Wiley database [8-18].

Determination of the biological activity of a plant. The plant extracts used in this study coded as AS-1. The following eight strains used in this study, which included two-Gram positive strains; *Staphylococcus aureus* ATCC 6533 and *Staphylococcus epidermidis* ATCC 12228. Four-Gram negative strains, which included;

Escherichia coli ATCC 10536, *Pseudomonas aeruginosa* ATCC 15442, *Klebsiella pneumoniae* ATCC 700603, *Stenotrophomonas maltophilia* ATCC 13637, *Candida albicans* ATCC 10231. In addition to fungi strains, *Aspergillus fumigatus* ATCC 36607. All strains obtained from ATCC, Medical Microbiology Laboratory, Gazi University, and Ankara, Turkey.

As briefly, all strains cultured on tryptic soy agar (OXOID, Turkey) and aerobically incubated at 35 °C for 24 hours. Then the bacterial cultures were suspended into steril saline (0.85% NaCl) and adjusted to 0.5 McFarland turbidity (10^8 cfu/mL). We used 96-well, round-bottom microtiter included negative controls (medium with plant extract only) and positive controls (medium with bacteria only) and 10 serial twofold dilutions of each eight plant extracts ranging from 0,0075-5 mg/mL with a final concentration of the bacterial cell suspension equal to 1×10^5 colony forming units per milliliter (CFU/ml). All inoculated plates incubated as mentioned above. MICs evaluated after 24 hours. MBC/MFCs performed by subculturing of 10 µl from all wells, which exhibited no visible growth (concentration equal or higher than of MICs) on Mueller Hinton agar-free plant extract and incubated as mentioned above. MBC/MFCs evaluated after 24 hours. Tests repeated twice or more and mean values reported.

Results and its discussion. Medicinal vegetable raw materials must not contain moisture above acceptable standards, so as increased humidity, it is not necessary to store food. For the majority of species of medicinal, healthy raw materials, the acceptable moisture limit is usually 12–15%. The data presented in tables 1.

Table 1 - Benign indicators of the aerial part of *Atraphaxis spinose*

Index	Content, %
Humidity	5,7
Total ash	7,32
Ash insoluble in 10% hydrochloric acid	0,36
Sulfate ash	6,9

It was found that humidity corresponds to "not more than 10%", total ash - "not more than 11%", ash insoluble in 10% hydrochloric acid "not more than 1%", sulfate ash - "not more than 10%".

The study of the content of macro- and microelements in the studied sample of the aerial part of *Atraphaxis spinosa* is of interest in connection with the high biological role of individual chemical elements. In the etiology of many diseases, a significant role-played by a violation of the exchange of elements in the human body at the subcellular, tissue and organism levels. So, correlations between their imbalance and various pathologies are noted. In many diseases, the level of micro and macro elements decreases, so the search for new types of plant materials as valuable additional sources of micro and macro elements is an urgent task [3,5].

Data on the mineral composition obtained by atomic absorption analysis carried out on the material and technical basis of the center of physicochemical methods of analysis.

The results are presented in tables 2 and 3.

Table 2 - The quantitative content of trace elements in the aerial part of *Atraphaxis spinosa*

Element	Cu	Cd	Pb	Fe	Ni	Mn
Mass in sample, mg/ml	0.9827	0.5031	2.8704	92.0683	2.2263	14.2490
The content in the sample, %	0.00009	0.00005	0.00023	0.00915	0.00022	0.00138

Table 3 - The quantitative content of macronutrients in the aerial part of *Atraphaxis spinosa*

Element	Zn	K	Na	Mg	Ca
Mass in sample, mg/ml	343.2117	2600.0997	1161.3053	210.0357	4790.358
The content in the sample, %	0.0339	0.260	1.161	0.021	0.479

From these tables it follows that the content of Na, K exceeds the concentration of Na⁺, K⁺ in the *Atraphaxis spinosa* plant under saline conditions, and they quickly diffuse inward and easily saturate the cell sap. For halophytes, ion pumps operate in the opposite direction, pumping out excess Na⁺, K⁺ cations in exchange for H⁺ ions. The highest Ca content is also noted.

It is known that a number of trace elements that accumulate by plants play a positive role in the biosynthesis of biologically active substances. It is established that plants producing polyphenolic compounds, coumarins, vitamins, selectively absorb copper, zinc, manganese. By the quantitative content of trace elements, iron dominates in the aerial part of *Atraphaxis spinosa*. In addition, a large amount contains manganese.

The specific need of halophytes for a certain concentration and composition of ash elements serves as the scientific basis for developing methods for introducing halophytes in botanical gardens. The content of macro- and micronutrients in raw materials meets the MPC standards.

Biologically active substances from *A. spinosa* extracted with 50% ethyl alcohol in the ratio of raw solvent 1:8, at room temperature for 48 hours. The resulting extract was concentrated in the vacuum of a water-structural pump. For preliminary separation of BAS, fractional hexane extraction performed. Hexane extract was analyzed by chromatography - mass spectrometry. The data presented in table 4.

Table 4 - Lipophilic composition of the plant

№	Name of compound	Formula	RT	Share, %
1	Tridecan	C ₁₃ H ₂₈	6,79	1,20
2	Gibylphthalate	C ₁₆ H ₂₂ O ₄	20,53	1,15
3	Palmitic acid	C ₁₆ H ₃₂ O ₂	20,63	1,22
4	9.17 - Octadecandianal	C ₁₈ H ₃₂ O	23,98	3,95
5	2 -Nadonecanone	C ₁₉ H ₃₈ O	26,70	1,44
6	1.21- Docosadien	C ₂₂ H ₄₂	28,64	0,56
7	Di (2-ethylhexyl) phthalate	C ₂₄ H ₃₈ O ₄	30,65	54,66
8	Tricosan	C ₂₃ H ₄₈	32,72	0,68
9	α - Toxopyro B	C ₂₉ H ₅₀ O ₄	34,92	1,92
10	Eicosan	C ₂₀ H ₄₂	35,50	1,10
11	4,5-Dimethyl benzenediol-1,3	C ₈ H ₁₀ O ₂	37,65	0,48
12	1-Chlorheptacosan	C ₂₇ H ₅₅ Cl	38,10	0,76
13	Vitamin E	C ₂₉ H ₅₀ O ₂	38,60	0,75
14	P- (3-methoxy-2-methyl) propanamide	C ₅ H ₁₁ NO ₂	38,70	0,50
15	1,3-Benzenediol 5-pentadecyl	C ₆ H ₆ O ₂	39,65	4,70

16	Campester	C ₂₈ H ₄₈ O	39,79	0,74
17	Stigmaster	C ₂₉ H ₄₈ O	40,20	1,50
18	2-Methyl-5- (methyl ethyl) cyclohex sen	C ₁₀ H ₁₆ O	40,29	2,57
19	β-Systerol	C ₂₉ H ₅₀ O	41,03	13,11
20	α-Amirin	C ₃₀ H ₅₀ O	41,73	1,89
21	lanosterol	C ₃₀ H ₅₀ O	42,02	0,50
22	lupeol	C ₃₀ H ₅₀ O	42,10	2,40
23	Stigmast-4-en- 3-one	C ₂₉ H ₄₈ O	42,90	0,86

Various derivatives of hydrocarbons of lipophilic substances of a plant of the genus *A. spinosa* were found: tridecane (1.20%), dibylphthalate (1.15%), palmitic acid (1.22%), 9.17 - octadecandianal (3.95%), 2 -nadonecanone (1.44%), 1.21-backed (0.56%), di (2-ethylhexyl) phthalate (54.66%), tricosan (1.02%), α - toxopyro B (0.90%), α - toxocipro B (1.10%), eicosan (10.48%), 4,5-dimethyl benzenediol-1,3 (0.76%), 1-chlorheptacosan (0.75%), vitamin E (0.64%), P- (3-methoxy-2-methyl) propanamide (4.70%), 1,3-benzenediol 5-pentadecyl (4.70%), campester (1.50%), stigmaster (1.89%), 2-methyl-5- (methyl ethyl) cyclohexsen (2.57%), β-systerol (13.11%), α-amirin (1.89%), lanosterol (0.50%), lupeol (2.40%), stigmast-4-en- 3-one (0.86%).

It found that a large amount of *A. spinosa* contains Di - (2-ethylhexyl) phthalate (54.66%) and β-sitosterol (13.11%).

The MIC and MBC/MFC values shown in table 5 and 6.

Table 5 - Minimum Inhibitory Concentration (MIC) of various plant extracts against different strains

Microbial strains	MIC mg/mL	
	AS-1	
<i>S. aureus</i>	0.075	
<i>S. epidermidis</i>	0.0075	
<i>E. coli</i>	0.625	
<i>P. aeruginosa</i>	0.156	
<i>K. pneumonia</i>	0.078	
<i>S. maltophilia</i>	0.156	
<i>C. albicans</i>	0.312	
<i>A. fumigatus</i>	2.5	

Table 6 - Minimum Bactericidal Concentration (MBC/MFC) of various plant extracts against different strains.

Microbial strains	MBC/MFC mg/mL	
	AS-1	
<i>S. aureus</i>	0.03	
<i>S. epidermidis</i>	0.03	
<i>E. coli</i>	1.25	
<i>P. aeruginosa</i>	0.625	
<i>K. pneumonia</i>	0.312	
<i>S. maltophilia</i>	0.625	
<i>C. albicans</i>	1.25	
<i>A. fumigatus</i>	>5	>5

In most cases, extracts exhibited a broad spectrum of antibacterial activity against used microbial strains. AS-1 showed the lowest MIC values (0.0075 mg/mL) with respect to *S. aureus* and *S. epidermidis*. MBC values of 0.03 mg/mL for AS-1.

Conclusion. Thus, the elemental composition and benignity of the aerial parts of the plant *Atraphaxis spinosa* studied. It established that the benignity of the plant does not exceed acceptable values.

As a result, the plant can be considered medicinal raw materials. An analysis of the elemental composition showed that Fe prevails from microelements, and Na, K and Ca from macroelements.

The lipophilic composition and biological activity of the plant was also established. It found that a large amount of *A. spinosa* contains di - (2-ethylhexyl) phthalate (54.66%) and β -sitosterol (13.11%).

These plant extracts could be new antimicrobial agents with significant potential. This matter may be due to the materials extracted from various solvents

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ATRAPHAXIS (A.SPINOSA) ТЕКТЕС ӨСІМДІГІН ХИМИЯЛЫҚ ЗЕРТТЕУ ЖӘНЕ БИОЛОГИЯЛЫҚ БЕЛСЕНДІЛІГІ

Аннотация. Мақалада Алматы облысында дайындалған *Atraphaxis (A. spinosa)* тектес өсімдіктен биологиялық зат алудың жаңа көзі айқындалды. Белгілі әдістер бойынша шикізат сапасының көрсеткіші мен нормалары – ылғалдылық, жалпы күл, сульфатты күл әрі 10% тұз қышқылында ерімейтін күл анықтау сараптамалары жүргізілді. Атомдық-абсорбциялық спектроскопия әдісімен микро және макроэлементтік құрамы анықталды. Элемент құрамын талдау микроэлементтерден темір басым, ал макроэлементтерден натрий, калий және кальций басым екенін көрсетеді.

Алғаш рет *Atraphaxis spinosa* жерүсті бөлігінен биологиялық белсенді кешенді алу жағдайы жасалды. Кешен алу үшін анықталған оңтайлы жағдайлар: экстрагент – 50% этанол, экстрагент пен шикізаттың арақатынасы – 1:8, екiреттiк экстракция уақыты – 48 сағат, температура – 22-26 °С.

Хромато-масс-спектроскопия әдісімен липофильді құрам анықталды. Өсімдік үлгілерінің липофильді фракциясында май қышқылы сияқты қосылыс кластары, яғни моно-; ди-; триглицерид, фосфолипид, стерол, стерол эфирі, гликолипид, майда еритін витаминдер кіретіндіктен оларды тек қоректік зат ретінде ғана емес, фармакологиялық агенттер ретінде де қарастыруға болады. Липофильді компоненттер құрамы анықталды, яғни ол – 26 органикалық қосылыс. *A. spinosa* құрамында көп мөлшерде ди- (2-этилгексил) фталат (54,66%) және β -ситостерол (13,11%) бар екені анықталды.

Дәрілік шикізат ретінде өсімдік ресурстарын кешенді зерттеу биологиялық белсенді заттарды химиялық зерттеуді, сондай-ақ өсімдіктерден алынған экстрактілер мен жеке қосылыстардың биологиялық скринингін жүргізуді көздейді. Көп жағдайда экстракт қолданылған микроорганизмдер штамына қарсы антибактериалды белсенділіктің кең спектрін көрсетті.

Түйін сөздер: *Atraphaxis spinosa*, минералды құрам, өсімдік сапасы, липофильді құрам, биологиялық белсенділік, Polygonaceae тұқымдасы

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ХИМИЧЕСКОЕ ИССЛЕДОВАНИЕ И БИОЛОГИЧЕСКАЯ АКТИВНОСТЬ РАСТЕНИЙ РОДА ATRAPHAXIS (A.SPINOSA)

Аннотация. В данной статье определены новые источники получения биологических веществ из растений рода *Atraphaxis (A. spinosa)*, заготовленных в Алматинской области.

По известным методикам отработаны и проведены анализы показателей и норм качества сырья: влажность, общая зола, сульфатная зола, зола нерастворимая в 10% -ной соляной кислоте.

Методом атомно-абсорбционной спектроскопии установлены микро- и макроэлементы. Анализ элементного состава показывает, что из микроэлементов преобладает железо, а из макроэлементов – натрий, калий и кальций.

Впервые разработаны условия получения биологически активного комплекса из надземной части *Atraphaxis spinosa*. Оптимальными условиями для получения комплекса являются: экстрагент – 50% этанол, соотношение экстрагента и сырья – 1:8, время двукратной экстракции – 48 часа, температура – 22 - 26 °С.

Методом хромато-масс-спектроскопии идентифицирован липофильный состав. Поскольку липофильные фракции растительных образцов включают такие классы соединений, как жирные кислоты; моно-; ди-; триглицериды, фосфолипиды, стеринны, эфиры стериннов, гликолипиды, жирорастворимые витамины, можно рассматривать их не только в качестве питательных продуктов, но и как возможные фармакологические средства. Установлено содержание липофильных компонентов – 26 органических соединений. Выявлено, что в составе *A.spinosa* большое количество содержится ди - (2-этилгексил) фталата (54,66%) и β-ситостерола (13,11%).

Комплексное исследование растительных ресурсов как лекарственного сырья предусматривает и химическое изучение биологически активных веществ, и проведение биологического скрининга экстрактов и индивидуальных соединений, полученных из растений. В большинстве случаев экстракт проявлял широкий спектр антибактериальной активности в отношении использованных штаммов микроорганизмов.

Ключевые слова: *Atraphaxis spinosa*, минеральный состав, доброкачественность растения, липофильный состав, биологическая активность, семейство *Polygonaceae*.

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