

E. H. Kerimli<sup>1,2</sup>, Yu. B. Kerimov<sup>1</sup>, J. I. Isaev<sup>1</sup>, P. V. Zulfugarova<sup>2</sup>,  
E. Yu. Akhmedov<sup>3</sup>, O. Yu. Maslov<sup>3</sup>

<sup>1</sup> Azerbaijan Medical University

<sup>2</sup> The Institute of Botany of Azerbaijan National Academy of Science

<sup>3</sup> National University of Pharmacy of the Ministry of Health of Ukraine

## The study of some pharmacognostic aspects of *Ferula persica* Wild. (*Apiaceae*) roots in the flora of Azerbaijan

**Aim.** To determine the component composition of the monoterpene fraction of *F. persica* roots and identify the localization of biologically active substances in the raw material.

**Materials and methods.** The identification and quantitative analysis were performed using gas chromatography – mass spectrometry. The raw material was collected during the full seed ripening in the vicinity of the village Dzhangi in the Gobustan region of Azerbaijan.

**Results and discussion.** Using gas chromatography – mass spectrometry, 15 compounds of monoterpenes were identified. The predominant components were heneicosane – 5.10 %; tetradecane – 3.29 %; disulfide, bis(1-methylpropyl) – 2.86 %; heptadecane – 2.50 %; 9,12,15-octadecatrienoic acid 2,3-bis(acetyloxy)propyl ester – 2.39 %; thiophene, 2,3,4-trimethyl- – 2.05 % in the dry raw material. In addition, it was found that resin was localized in large schizogenous receptacles.

**Conclusions.** The content of monoterpenes in *F. persica* roots has been determined using gas chromatography – mass spectrometry. The roots contain monoterpenes of heneicosane; tetradecane; disulfide, bis(1-methylpropyl); heptadecane; 9,12,15-octadecatrienoic acid 2,3-bis(acetyloxy)propyl ester. Thiophene and 2,3,4-trimethyl predominate in the raw material.

**Keywords:** monoterpenes; sulfides; localization

E. Керімлі<sup>1,2</sup>, Ю. Керімов<sup>1</sup>, Д. І. Ісаєв<sup>1</sup>, П. В. Зульфугарова<sup>2</sup>, Е. Ю. Ахмедов<sup>3</sup>, О. Ю. Маслов<sup>3</sup>

<sup>1</sup> Азербайджанський медичний університет

<sup>2</sup> Інститут ботаніки НАН Азербайджану

<sup>3</sup> Національний фармацевтичний університет Міністерства охорони здоров'я України

### Вивчення деяких фармакогностичних аспектів коренів *Ferula persica* Wild. (*Apiaceae*) флори Азербайджану

**Метою** дослідження було визначити компонентний склад монотерпенової фракції коренів *F. persica* та виявити локалізацію біологічно активних речовин у сировині.

**Матеріали та методи.** Ідентифікацію та кількісний аналіз проведено за допомогою газової хроматографії – мас-спектрометрії. Сировину зібрано під час повного дозрівання насіння в навколишній місцевості села Джангі Гобустанського регіону Азербайджану.

**Результати та їх обговорення.** За допомогою газової хроматографії – мас-спектрометрії ідентифіковано 15 сполук монотерпенів. Переважні компоненти: генкумарин – 5,10 %; тетрадекан – 3,29 %; дисульфід, біс(1-метилпропіл) – 2,86 %; гептадекан – 2,50 %; ефір 2,3-біс(ацетилокси) пропілового ефіру октадекатрієнової кислоти – 2,39 %; тіофен, 2,3,4-триметил – 2,05 % у сухій сировині. Крім того, виявлено локалізацію смоли у великих схізогенних судинах.

**Висновки.** Визначено вміст монотерпенів у коренях *F. persica* за допомогою газової хроматографії – мас-спектрометрії, зокрема монотерпенів генкумарину, тетрадекану, дисульфиду, біс(1-метилпропілу), гептадекану, ефіру 2,3-біс(ацетилокси)пропілового ефіру октадекатрієнової кислоти. У сухій сировині переважають тіофен, 2,3,4-триметил.

**Ключові слова:** монотерпени; сульфід; локалізація

**Introduction.** *Ferula persica* is widespread in Central Asia, the Mediterranean, and North Africa. In the Caucasus, there are 10 species, and in Azerbaijan, there are 8 of it [1]. Species of the *Ferula* L. genus growing in different regions of the world have been chemically, biologically, and pharmacologically studied.

*F. persica* contains essential oil, sesquiterpene coumarins of germacrane and eudesmanolide types [2-8]. The essential oil of *Ferula* L. species is predominantly composed of monoterpenes and sulfides [9]. Ostol, sitosterol, L-chimgin, and L-chimganin have been isolated and identified from *F. persica* [10]. The aboveground

part of *F. persica* contains luteolin, apigenin, cinaroside, cosmosin, quercetin, and rutin [11, 12].

Sesquiterpene lactones – badkhyisin and badkhyisinin isolated from the roots of *Ferula oopoda* possess the anti-inflammatory action and are effective antimutagens and antioxidants [13]. Ferulen is the medicine with the estrogenic activity used for the treatment of prostate cancer [14]. The chloroform extract of *F. persica* var. inhibits the production of red pigment produced by *Serratia marcescens* [15]. Umbelliprenin exhibits anti-inflammatory and antipigment properties [16]. Sesquiterpene coumarins and polysulfides from *F. persica* have

cytotoxic, antibacterial, antifungal, anti-leishmanial, chemo-preventive actions against cancer, and inhibitory effects on lipoxygenase [17, 18]. Schematic diagrams of resin localization are available [19].

Thus, the **aim** of study was to determine the component composition of the monoterpene fraction of *F. persica* roots and identify the localization of biologically active substances in the raw material.

**Materials and methods. Raw material.** The raw material was collected in the phase of the full seed ripening in the vicinity of the village Dzhangi in the Gobustan region of Azerbaijan (40.50202801719172, 49.264562187572714). Accompanying plants are common sainfoin (*Onobrychis sativa*), cuneifolium (*Seseli cuneifolium*), gwathak (*Zosima absinthifolia*), wormwood (*Artemisia.sp.*), kozel (*Scorzonera sp.*), Persian camel thorn (*Alhagi persarum*), etc.

**Chemicals.** Ethanol ( $\geq 99\%$ , Merck KGaA, EMD Millipore Corporation).

**Extraction procedure.** The extraction of dried and crushed roots (500 g) was carried out three times with ethanol for 72 hours. During the procedure, 43 g of the total extractive substances were obtained (the yield – 8.6 % by weight of the raw material).

**Gas chromatography – mass spectrometry method of analysis.** The gas chromatography-mass spectrometric analysis was performed on a GC-MS-Agilent Technologies 7890B instrument coupled with a mass detector (Agilent 5975 C) equipped with an HP-5 MS fused silica column with an internal diameter of 30 m  $\times$  0.25 mm  $\times$  film thickness 0.25  $\mu$ m, fixed phase. The split ratio was 1:20. The inlet pressure was 88.5 kPa. The flow rate of the carrier gas helium (99.9 %, AGA Lithuania) was set at 1.58 mL/min. The oven temperature was maintained at 40°C for 2 min after injection, then programmed at 9°C/min to 200°C, 10°C/min to 250°C where the column was held for 17 min. The injector temperature was

275 °C. The volume of the injected sample was 0.2  $\mu$ L (chloroform). The electron ionization mass detector was set at 70 eV in the range of m/z 29–450 a.e.m. The percentage composition of essential oils was calculated based on the gas chromatographic peak areas without correction factors. The qualitative analysis was based on the comparison of retention times, indices, and mass spectra with the corresponding data from literature and NIST/FFSNC mass spectral libraries.

10 g of the total extractive substances obtained were subjected to chromatographic separation on a column with neutral aluminum oxide, grade II. Elution was performed with hexane; the volume of the collected fractions was 100 mL. In fractions 1–20, after evaporation of the solvent, an oily residue was obtained, and it was subjected to the gas chromatography-mass spectrometric analysis.

**Microscopic analysis.** The identification of diagnostic features in the plant raw material was conducted using well-established methods [19]. For the microscopic analysis, a BİOLAM-C microscope, a MBC-1 binocular, and a L74WIDE Samsung camera were used.

The dried roots were softened in a mixture of ethyl alcohol 95 % and glycerin (1:1), and longitudinal and transverse sections were studied to detect and determine the type of containers.

**Results and discussion.** The chromatogram shows 35 peaks indicating the presence of numerous components in the fraction 1–20. (Fig. 1) As a result of the chromatographic-mass spectrometric analysis of the fraction residue 1–20, 15 compounds were identified. The main substances include heneicosane – 5.10 %; tetradecane – 3.29 %; disulfide, bis(1-methylpropyl) – 2.86 %; heptadecane 2.50 %; 9,12,15-octadecatrienoic acid 2,3-bis(acetyloxy)propyl ester – 2.39 %; thiophene, 2,3,4-trimethyl- – 2.05 %. The remaining substances were not identified due to their presence in insignificant quantities and lack of practical significance (Table 1).

Table 1

The component composition of monoterpene residues in *F. persica* roots

No.	Identified compound	Chemical formula	Retention time, min	Content in the raw material
1	Disulfide, bis(1-methylpropyl)	C <sub>8</sub> H <sub>18</sub> S <sub>2</sub>	1.593	2.86
2	Thiophene, 2,3,4-trimethyl-	C <sub>7</sub> H <sub>10</sub> S	2.194	2.05
3	1,2-dithiolane	C <sub>3</sub> H <sub>6</sub> S <sub>2</sub>	9.880	1.49
4	3,5-diethyl-1,2,4-trithiolane	C <sub>6</sub> H <sub>12</sub> S <sub>3</sub>	9.953	2.10
5	Tetradecane	C <sub>14</sub> H <sub>30</sub>	10.545	3.29
6	Isoledene	C <sub>15</sub> H <sub>24</sub>	13.187	1.99
7	Heptadecane	C <sub>17</sub> H <sub>36</sub>	17.965	2.50
8	Sulfide, 1-ethyloctylmethyl	C <sub>9</sub> H <sub>20</sub> S	19.775	1.08
9	Heptacosane	C <sub>27</sub> H <sub>56</sub>	21.819	0.80
10	5-alpha-Cholest-8-en-3-one, 14-methyl-	C <sub>28</sub> H <sub>46</sub> O	25.005	0.29
11	Heneicosane	C <sub>21</sub> H <sub>44</sub>	25.882	5.10
12	9,12,15-Octadecatrienoic acid 2,3-bis(acetyloxy)propyl ester	C <sub>25</sub> H <sub>40</sub> O <sub>6</sub>	26.954	2.39
13	Tetratriacontane	C <sub>34</sub> H <sub>70</sub>	27.274	0.86
14	Octacosane	C <sub>28</sub> H <sub>58</sub>	29.864	1.28
15	Naphthalene, decahydro-2-methyl-	C <sub>31</sub> H <sub>60</sub>	31.360	0.19

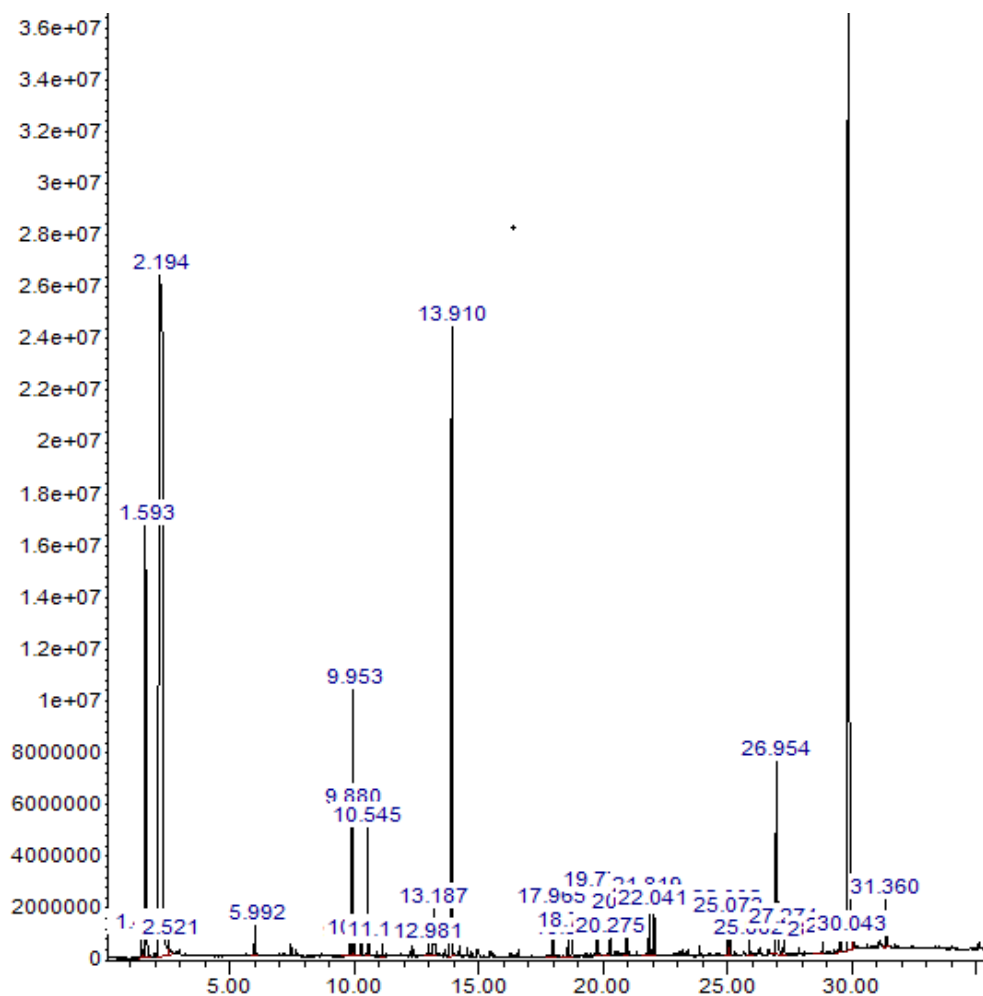
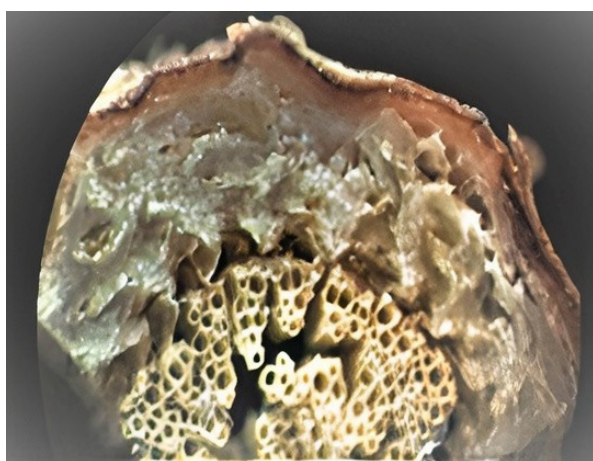


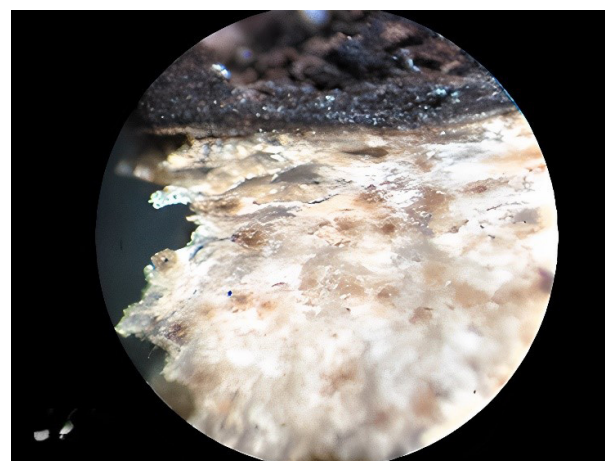
Figure 1. The HPLC fingerprint of monoterpene residues in *F. persica* roots

The roots of *F. persica* contain valuable biologically active substances and are a promising plant material for the development of herbal medicinal products. The main substance in the roots is resin. There is information about the presence of lysigenous, schizogenous, and schizolysigenous receptacles in the parenchyma of the bark of *F. foetida* depicted in a schematic diagram; however, they are not clearly visible in microscopic

images. To determine the exact diagnostic features of the plant material, we examined the transverse section of the root and found the presence of schizogenous receptacles in the root parenchyma. Larger receptacles on the transverse section are located at the junction with the xylem. On the longitudinal section of the root, schizogenous receptacles are visible in the parenchyma of the bark (Fig. 2).



A



B

Figure 2. Receptacles in the cortical parenchyma of *F. persica* root: A – transverse, (Zoom x 12); B – longitudinal (Zoom. x 12)

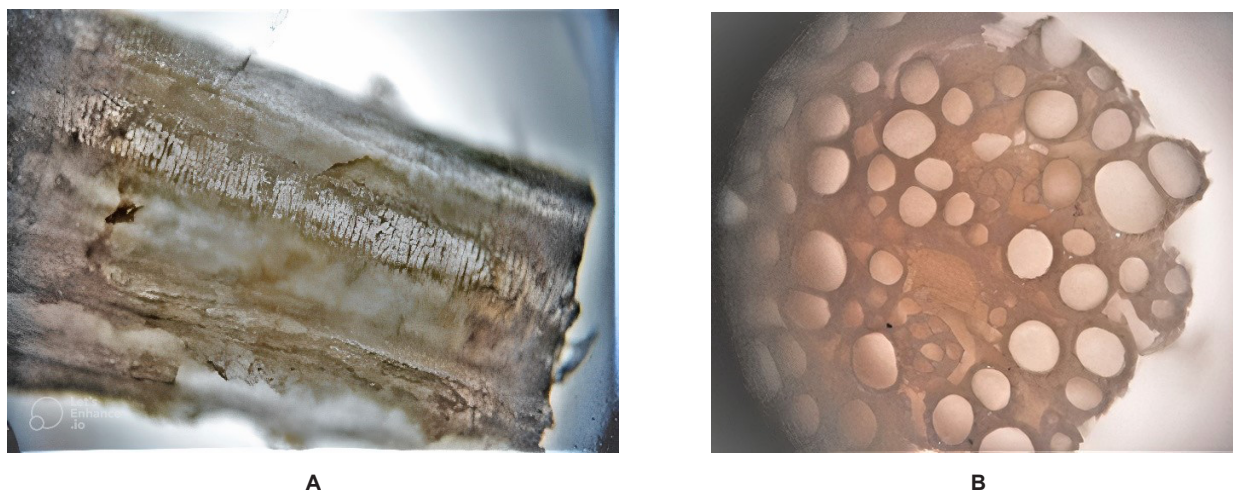


Figure 3. Conductive vessels in the xylem of *F. persica* root: A – longitudinal section of the root (Zoom x 12); B – cross section of the root (Zoom x 100)

Conductive vessels are visible on the longitudinal and transverse sections of the root in the xylem area (Fig. 3).

**Conclusions.** The content of monoterpenes in *F. persica* roots has been determined using gas chromatography – mass spectrometry. The roots contain monoterpenes of heneicosane – 5.10 %; tetradecane – 3.29 %; disulfide, bis(1-methylpropyl) – 2.86 %; heptadecane –

2.50 %; 9,12,15-octadecatrienoic acid 2,3-bis(acetyloxy) propyl ester – 2.39 %. Thiophene and 2,3,4-trimethyl – 2.05 % predominate in the raw material.

It has been identified that the resin is localized in large schizogenous-type reservoirs located in the parenchyma of the root bark.

**Conflict of interests:** authors have no conflict of interests to declare.

## REFERENCES

1. Флора Азербайджана. 6 изд. Баку : Изд-во АН Аз.ССР, 1955. 540 с.
2. Javidnia K., Miri R., Kamalinejad M., Edraki N. Chemical composition of *Ferula persica* Wild. essential oil from Iran. *Flavour and Fragrance Journal*. 2005. Vol. 20, № 6. P. 605-606. DOI: 10.1002/ffj.1496.
3. New Germacrane Derivative from *Ferula persica* / M. Iranshahi, Gh. R. Amin, H.Jalalizadeh, A.Shafiee. *Pharmaceutical Biology*. 2003. Vol. 41, № 6. P. 431-433. DOI: 10.1076/phbi.41.6.431.17834.
4. Crystal structure and Hirshfeld surface analysis of (5*S*,8*aR*)-3,5*a*-dimethyl-8-methylidene-2-oxododecahydrooxireno[2',3':6,7]naphtho[1,2-*b*]furan-6-yl (*Z*)-2-methylbut-2-enoate extracted from *Ferula persica* / E. G. Karimli et al. *Acta Crystallographica Section E Crystallographic Communications*. 2023. Vol. 79, № 5. DOI: 10.1107/s205698902300333x.
5. Crystal structure and Hirshfeld surface analysis of 7-[(6-hydroxy-2,5,5,8*a*-tetramethyldecahydronaphthalen-1-yl)methoxy]-2*H*-chromen-2-one / E. G. Karimli et al. *Acta Crystallographica Section E Crystallographic Communications*. 2023. Vol. 79, № 9. DOI: 10.1107/s2056989023006552.
6. Керимли Э. Г., Ибадуллаева С. Дж., Алескерова А. Н. Бадракемин и остол в корнях *Ferula persica* (Ариáceе), произрастающей в Азербайджанской Республике. *Растительные ресурсы*. 2023. Т. 59, вып. 3. С. 314-320. DOI: 10.31857/S0033994623030093
7. Iranshahi M., Amin G., Shafiee A. A New Coumarin from *Ferula persica*. *Pharmaceutical Biology*. 2004. Vol. 42, № 6. P. 440-442. DOI: 10.1080/13880200490886102.
8. Kerimli E. H., Kerimov Yu. B., Mamedov A. M. Constituents of the EtOH extract of *Ferula persica* roots. *Chemistry of Natural Compounds*. 2023. Vol. 59, № 6. P. 1171-1172. DOI: 10.1007/s10600-023-04220-3.
9. Iranshahi M., Amin Gh. R., Amini M. A. Shafiee Sulfur containing derivatives from *Ferula persica* var. *latisecta*. *Phytochemistry*. 2003. Vol. 63, № 8. P. 965-966. DOI: 10.1016/s0031-9422(03)00296-6.
10. Phenol derivatives from the roots of *Ferula persica* / Y. B. Kerimov et al. *Chemistry of Natural Compounds*. 1992. Vol. 28, № 5. P. 506. DOI: 10.1007/bf00630666.
11. Стецков В. В., Луговской А. И., Баньковский А. И., Пакалн Д. Н. *Ferula persica* flavonoids. *Химия природных соединений*. 1980. Вып. 3. С. 415.
12. Phytochemical Study of Methanolic Extract of *Ferula persica* Willd. Inflorescence and its Antinociceptive Effect in Male Mice / S. Nasri et al. *J. Med. Plants*. 2018. Vol. 17, № 68. P. 136-144.
13. Серкеров С. В. Терпеноиды и фенолпроизводные растений семейства Asteraceae и Ariáceae. Баку, 2004. 312 с.
14. Халилов Р. М., Маматханов А. У., Котенко Л. Д. Технология выделения эстрогенного препарата ферулен из корней ферулы тонкорассеченной. *Химико-фармацевтический журнал*. 2009. Вып. 1. С. 40-43.
15. Umbelliprenin from *Ferula persica* roots inhibits the red pigment production in *Serratia marcescens* / M. Iranshahi et al. *Z Naturforsch.* 2004. Vol. 59. P. 506-508.
16. Iranshahi M., Askari M., Sahebkar A., Adjipavlou-Litina D. Evaluation of antioxidant, anti-inflammatory and lipoxygenase inhibitory activities of the prenylated coumarin umbelliprenin. *DARU Journal of Pharmaceutical Sciences*. 2009. Vol. 17. P. 99-103.

17. Identification of Antifungal Compounds from *Ferula persica*. var. *persica* / R. Mirjani et al. *Pharmaceutical Biology*. 2005. Vol. 43, № 4. P. 293-295. DOI: 10.1080/13880200590951658
18. Sattar Z., Iranshahi M. Phytochemistry and pharmacology of *Ferula persica* Boiss.: A review. *Iran J. Basic Med. Sci.* 2017. Vol. 20. P. 1-8. DOI: 10.22038/ijms.2017.80855.
19. Керимов Ю., Исламова Н. А., Халилов Д. С., Исаев Д. И. Практикум по ботанике. Баку : Азербайдж. мед. университет, 1999. 238 с.

## REFERENCES

1. Flora Azerbaidzhana (1955). (6-te vyd.). Baku.
2. Javidnia, K., Miri, R., Kamalinejad, M., Edraki, N. (2005). Chemical composition of *Ferula persica* Wild. essential oil from Iran. *Flavour and Fragrance Journal*, 20 (6), 605-606. doi: 10.1002/ffj.1496.
3. Iranshahi, M., Amin, G.-R., Jalalizadeh, H., Shafiee, A. (2003). New Germacrane Derivative from *Ferula persica*. *Pharmaceutical Biology*, 41 (6), 431-433. doi: 10.1076/phbi.41.6.431.17834.
4. Karimli, E. G., Khrustalev, V. N., Kurasova, M. N., Akkurt, M., Khalilov, A. N., Bhattarai, A. et al. (2023). Crystal structure and Hirshfeld surface analysis of (5a*S*,8a*R*)-3,5a-dimethyl-8-methylidene-2-oxododecahydrooxireno[2',3':6,7]naphtho[1,2-*b*]furan-6-yl (*Z*)-2-methylbut-2-enoate extracted from *Ferula persica*. *Acta Crystallographica Section E Crystallographic Communications*, 79 (5). doi: 10.1107/s205698902300333x.
5. Karimli, E. G., Khrustalev, V. N., Akkurt, M., Khalilov, A. N., Bhattarai, A., Aleskerova, A. N. et al. (2023). Crystal structure and Hirshfeld surface analysis of 7-[(6-hydroxy-2,5,5,8a-tetramethyldecahydronaphthalen-1-yl)methoxy]-2*H*-chromen-2-one. *Acta Crystallographica Section E Crystallographic Communications*, 79 (9). doi: 10.1107/s2056989023006552.
6. Kerymly, Э. H., Ybadullaeva, S. Dzh., Aleskerova, A. N. (2023). Badrakemyn y ostol v korniakh *Ferula persica* (Apiaceae), proy-zrastaiushchei v Azerbaidzhanskoi Respublyke. *Rastytelnyye resursy*, 5 9(3), 314-320. doi: 10.31857/S0033994623030093.
7. Iranshahi, M., Amin, G., Shafiee, A. (2004). A New Coumarin from *Ferula persica*. *Pharmaceutical Biology*, 42 (6), 440-442. doi: 10.1080/13880200490886102.
8. Kerimli, E. H., Kerimov, Y. B., Mamedov, A. M. (2023). Constituents of the EtOH Extract of *Ferula persica* Roots. *Chemistry of Natural Compounds*, 59, 6. doi: 10.1007/s10600-023-04220-3.
9. Iranshahi, M., Amin, G.-R., Amini, M., Shafiee, A. (2003). Sulfur containing derivatives from *Ferula persica* var. *latisecta*. *Phytochemistry*, 63 (8), 965-966. doi: 10.1016/s0031-9422(03)00296-6.
10. Kerimov, Y. B., Abyshev, A. Z., Serkerov, S. V., Isaev, D. I., Bairamov, P. B. (1992). Phenol derivatives from the roots of *Ferula persica*. *Chemistry of Natural Compounds*, 28 (5), 506. doi: 10.1007/bf00630666.
11. Ctetkov, V. V., Luhovskoi, A. Y., Bankovskiy, A. Y., Pakaln, D. N. (1980) *Ferula persica* flavonoids. *Khimiya pryrodnikh soedyneniy*, 3, 415.
12. Nasri, S., Ghorbani Nohooji, M., Amin, G. R., Sharifi, A., Borbor, M., Shamohamadi, F. et al. (2018). Phytochemical study of methanolic extract of *ferula persica* willd. inflorescence and its antinociceptive effect in male mice. *J. Med. Plants*. 17 (68), 136-144.
13. Serkerov, S. V. (2005). Terpenoıdy y fenolproyzoıdnyye rastenyi semeıstv Asteraceae y Apiaceae. Baku.
14. Khalylov, R. M., Mamatkhanov, A. U., Kotenko, L. D. (2009). Tekhnolohiya vydeleniya estroıhennoho preparata ferulen yz korneı feruly tonkorassechennoı. *Khimiya-farmatsevticheskiy zhurnal*, 43 (10), 40-43.
15. Iranshahi, M., Shahverdi, A. R., Mirjani, R., Amin, G., Shafiee, A. (2004). Umbelliprenin from *Ferula persica* roots inhibits the red pigment production in *Serratia marcescens*. *Zeitschrift für Naturforschung C*, 59 (7-8), 506-508.
16. Iranshahi, M., Askari, M., Sahebkar, A., Hadjipavlou, L. D. (2009). Evaluation of antioxidant, anti-inflammatory and lipoxigenase inhibitory activities of the prenylated coumarin umbelliprenin. *DARU Journal of Pharmaceutical Sciences*, 17, P. 99-103.
17. Mirjani, R., Shahverdi, A. R., Iranshahi, M., Amin, G., Shafiee, A. (2005). Identification of Antifungal Compounds from *Ferula persica*. var. *persica*. *Pharmaceutical biology*, 43 (4), 293-295. doi: 10.1080/13880200590951658.
18. Sattar, Z., Iranshahi, M. (2017). Phytochemistry and pharmacology of *Ferula persica* Boiss.: A review. *Iranian Journal of Basic Medical Sciences*, 20 (1), 1. doi: 10.22038/ijms.2017.80855.
19. Kerymov, Yu., Yslamova, N., Khalylov, D., Ysaev, D. (1999). Praktikum po botanyke. Baku.

*Information about authors:*

Kerimli E. H. ogly, Candidate of Pharmacy (Ph.D.), senior lecturer of the Department of Pharmacognosy, Azerbaijan Medical University, leading researcher of the Institute of Botany, Azerbaijan National Academy of Sciences. ORCID: <https://orcid.org/0009-0002-1804-6114>

Kerimov Yu. B. ogly, Doctor of Pharmacy (Dr. habil.), professor, Honored Teacher, Scientific Consultant of the Department of Pharmacognosy, Azerbaijan Medical University. ORCID: <https://orcid.org/0000-0002-2792-3687>

Isaev J. I. ogly, Doctor of Pharmacy (Dr. habil.), professor, head of the Department of Pharmacognosy of Azerbaijan Medical University. ORCID: <https://orcid.org/0000-0003-1728-4559>

Zulfugarova P. V. kyzy, researcher of the Institute of Botany, Azerbaijan National Academy of Sciences

Akhmedov E. Yu. ogly, Candidate of Pharmacy (Ph.D.), associate professor of the Department of General Chemistry, National University of Pharmacy of the Ministry of Health of Ukraine. ORCID: <https://orcid.org/0000-0001-6727-8259>

Maslov O. Yu., Candidate of Pharmacy (Ph.D.), teaching assistant of the Department of General Chemistry, National University of Pharmacy of the Ministry of Health of Ukraine. ORCID: <https://orcid.org/0000-0001-9256-0934>

*Відомості про авторів:*

Керімлі Е., кандидат фармацевтичних наук, старший викладач кафедри фармакогнозії, Азербайджанський медичний університет, провідний науковий співробітник, Інститут ботаніки НАН Азербайджану. ORCID: <https://orcid.org/0009-0002-1804-6114>

Керімов Ю., доктор фармацевтичних наук, професор, науковий консультант кафедри фармакогнозії, Азербайджанський медичний університет. ORCID: <https://orcid.org/0000-0002-2792-3687>

Ісаєв Д. І., доктор фармацевтичних наук, професор, завідувач кафедри фармакогнозії, Азербайджанський медичний університет. ORCID: <https://orcid.org/0000-0003-1728-4559>

Зульфугарова П. В., науковий співробітник, Інститут ботаніки НАН Азербайджану

Ахмедов Е. Ю., кандидат фармацевтичних наук, доцент кафедри загальної хімії, Національний фармацевтичний університет Міністерства охорони здоров'я України. ORCID: <https://orcid.org/0000-0001-6727-8259>

Маслов О. Ю., кандидат фармацевтичних наук, асистент кафедри загальної хімії, Національний фармацевтичний університет. ORCID: <https://orcid.org/0000-0001-9256-0934>

*Надійшла до редакції 18.12.2023 р.*