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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**THE STUDY OF BIOLOGICALLY ACTIVE SUBSTANCES OF
THE *HERACLEUM SOSNOWSKY* MANDEN., *ANGELICA
SACHOKIANA* (KARJAG) M.PIMEN. ET. V.TICHOMIROV AND
AMMI VISNAGA (L.) LAM. (*APIACEAE*) SPECIES
DISTRIBUTED IN THE AZERBAIJAN FLORA**

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INTRODUCTION

The relevance of the topic and degree of processing. The dissertation is devoted to the obtaining in an individual state of bioactive substances of the species of *Heracleum sosnowskyi* Manden., *Angelica sachokiana* (Karjag.) M.Pimen et Tichomirov and *Ammi visnaga* (L.) Lam. (*Apiaceae*) distributed in Azerbaijan, the determination of their formulas using modern spectroscopy (IR-, ¹H NMR, ¹³C NMR, Dept 135, Dept 90) and chromato-mass spectrometry method, to their identification and to the study of the possibilities of use in medical practice.

The smallest amount of 4,500 higher plants species distributed in the Azerbaijan flora has been chemically studied. Therefore, the study of biologically active substances in order to obtain them in an individual state is important both from a scientific and applied point of view.

Coumarin derivatives concerning to biologically active substances of plant origin are in the center of attention of most researchers due to their wide range of pharmacological activities. Thus, most researchers noted that the coumarin derivatives have analgesic, antibiotic, effective coronary vasodilator, against malignant tumors, photosensitizing etc. features.^{1,2,3} Coumarin compounds are widely distributed in higher plants, especially in *Apiaceae*, *Fabaceae*, *Rutaceae* and other plant families.

According to the literature data, coumarin derivatives have been identified in more than 1626 plant species belonging to 568 genera and 134 families in the world.⁴

¹ Абышев А.З., Агаев Э.М., Керимов Ю.Б. Химия и фармакология природных кумаринов. - Баку: - 2003. -112с

² Anand P., Singh B., Singh N. A review on coumarins as acetylcholinesterase inhibitors for Alzheimer's disease // Bioorganic & Medicinal Chemistry, - 2012. v. 20, No 3, - p. 1175-1180.

³ Venugopala K.N., Rashmi V., Odhav B. Review on natural coumarin lead compounds for their pharmacological activity // BioMed. Research International, - 2013, - Article ID 963248, - p.1-14.

⁴ Qasimova G.Q. *Heracleum pastinacifolium* C.Koch. və *Peucedanum ruthenicum* M.B. (*Apiaceae*) növlərinin kumarin törəmələrinin tədqiqi: - Biol. üzrə. fəls. dokt. dis. avtoref. - Bakı: - 2014, - 21s.

Azerbaijan flora *Apiaceae* family includes 75 genera and 184 species⁵, and according to S.C.Ibadullayeva 76 genera, 187 species and 1 subspecies⁶ and due to the importance of coumarin derivatives in medical practice, it is always in the centre of attention of researchers engaged in the study of biologically active substances of plant origin.

It is known that “peysedanin” has anti-tumor activity. Other coumarin derivatives bergapten, the drug "pastinasin" consisting of a mixture of sfondin and xanthotoxin is analgesic, the drug "beroxan" consisting of a mixture of bergaptene and xanthotoxin, the drug “ammifurin” consisting of a mixture of isopimpinelline and bergapten, the drug “psoralen” consisting of a mixture of psoralen and angelicin, the drug “melodinin” consisting a mixture of xanthotoxin and imperatorin are one of the drugs used in the treatment of vitiligo⁷.

For this reason, the obtaining in an individual state of coumarin compounds from plant species and their comprehensive study is one of the most important issues, both theoretically and practically.

Object and subject of the research. The object and subject of the research was the investigation of individual acquisition of biologically active substances of *H. sosnowskyi*, *A. sachokiana* and *A. visnaga* species belonging to the *Apiaceae* family, determination of their structural formulas, identification and possibilities of use in medical practice.⁷

Purpose and tasks of the study. The main purpose of the study is obtaining of biologically active substances from *Heracleum sosnowskyi* Manden., *Angelica sachokiana* (Karjag.) M.Pimen et Tichomirov and *Ammi visnaga* (L.) Lam. (*Apiaceae*) species in an individual state, identification of structural formulas of known substances using classical chemical and modern spectral methods, study of their importance in medical practice, development of technology for obtaining important compounds from a practical point

⁵ Ахундов Г.Ф. Род *Hippomaratum* Hoffm. et Link. Флора Азербайджана. - Баку: -АН Аз.ССР, - 1955, т. VI, - с. 413-415.

⁶ İbadullayeva S.C. Azərbaycan florasının Kərəvizkimilər – *Apiaceae* Lindl. fəsiləsi (bitki ehtiyatşünashği üzrə). Biol. elm. dokt. ... dis. avtoreferatı. - Bakı, - 2005, - 51s.

⁷ Абышев А.З., Агаев Э.М., Керимов Ю.Б. Химия и фармакология природных кумаринов. - Баку: - 2003. -112с.

of view.

In order to achieve the above, the following tasks are envisaged:

➤ Obtaining of the sum of extractive substances from *Heracleum sosnowskyi* (roots and fruits), *Angelica sachokiana* (roots and aboveground parts), *Ammi visnaga* species (roots, aboveground parts and flowers) using the extraction method;

➤ Obtaining of biologically active substances in an individual state from the sum of extractive substances of the roots of *H. sosnowskyi* and *A. sachokiana* species using the column chromatography method;

➤ Determination and identification of structural formulas of substances on the basis of the results obtained by drawing and detection of IR-, NMR ¹H, ¹³C, Dept 135, Dept 90 spectra of individual substances;

➤ Determination of chemical components of the sum of extractive substances obtained from the roots and fruits of the *H. sosnowskyi* specie using the chromato-mass spectrometry method;

➤ Identification of chemical components of the sum of extractive substances obtained from the roots and aboveground parts of the *A. sachokiana* specie using the chromato-mass-spectrometry method;

➤ Identification of chemical components of the sum of extractive substances obtained from the roots, aboveground parts and flowers of the *A. visnaga* specie by chromato-mass-spectrometry method;

➤ Comparative analysis of the results of the study of the qualitative composition of coumarin derivatives of the roots of *H. sosnowskyi* and *A. sachokiana* species using column chromatography and chromato-mass spectrometry methods.

Research methods. Extractive substances from the research objects were extracted using the total extraction method, and biologically active substances were obtained individually from the total extractive substances by the column chromatography method, using neutral Al₂O₃ with level III-IV activity as a sorbent, elution with hexane, benzene, chloroform and their mixtures in different proportions. Individuality of substances was carried out by thin-layer

chromatography method on Silufol UV-254 plates.

Identification of known substances was carried out with the help of IR-, NMR (^1H , ^{13}C) spectroscopy methods. The nature of the functional groups in the structures of the studied substances was determined using classical chemical methods. The component compositions of the research objects - *H. sosnowskyi* (roots and fruits), *A. sachokiana* (roots and aerial parts) *A. visnaga* (flowers, roots, aerial parts) were determined using the gas-chromato-mass-spectrometry method.

Basic provisions for defending:

➤ Obtaining extractive substances of *H. sosnowskyi* (roots and fruits), *A. sachokiana* (roots and aerial parts), *A. visnaga* species (roots, aerial parts and flowers) by extraction method is an important direction for individual extraction of biologically active substances from these plants;

➤ When using the column chromatography method, it is important to individually obtain biologically active substances from the sum of extractives obtained from the roots of *H. sosnowskyi*, *A. sachokiana* species and their use in medical practice;

➤ Determination and identification of chemical components of the sum of extractive substances obtained from the roots and fruits of the species *H. sosnowskyi*, roots and aerial parts of the species *A. sachokiana*, roots, aerial parts and flowers of *A. visnaga*. species using the method of chromatography-mass spectrometry, pharmaceutical industry specialists, selection of raw materials for drug manufacturers - a reference source for the purpose of obtaining biologically active substances;

➤ Comparative analysis of the results of studying the qualitative composition of coumarin derivatives in the roots of the species *H. sosnowskyi* and *A. sachokiana* using column chromatography and gas chromatography-mass spectrometry is a contribution to the use of effective drugs as prescription ingredients in the treatment of many diseases.

Scientific innovations. Three species belonging to the different generas of the family Celery (*Apiaceae* Lindl.): *Heracleum sosnowskyi* Manden (genus *Heracleum*), *Angelica sachokiana*

(Karjag.) M.Pimen et. Tichomirov (genus *Angelica*) and *Ammi visnaga* (L.) Lam. (genus *Ammi*) distributed in the Azerbaijan flora were studied for the first time at a modern level using phytochemical, chromatographic and spectroscopic methods. 6 substances - coumarin derivatives from the roots of *H. sosnowskyi* specie, 4 coumarin derivatives from the roots of *A. sachokiana* specie were obtained in and individual state by column chromatography method.

The component compositions of the roots and fruits of *H. sosnowskyi*, roots and aboveground parts of *A. sachokiana*, roots, aboveground parts and flowers (with flower umbrellas) of *A. visnaga* were studied for the first time using the gas chromato-mass spectrometry method. 8 coumarin derivatives in roots, 15 coumarin derivatives in fruits of *H. sosnowskyi*; 12 coumarin derivatives in roots, 17 coumarin derivatives in aboveground parts of *A. sachokiana*; 21 substances belonging to different groups of natural compounds in flowers, 39 components in roots and 41 components in aboveground parts of *A. visnaga* plant species was detected and identified.

The scientific and practical significance of the work.

Coumarin derivatives obtained in and individual state as a result of research can be used in medicine to develop new effective drugs. The activities of furocoumarin compounds derived from these plant species, which are considered important for practical medicine, are traditionally used as anti-inflammatory, diuretic, antipyretic, antiperspirant drugs, has been successfully applied in the treatment of different diseases: against colds, flu, hepatitis, arthritis, abnormal digestion, cough, chronic bronchitis, pleurisies, typhoid fever, headache, measles, cramps, rheumatism, bacterial and fungal infections and urinary tract⁸ etc.

Furocoumarins due to their antioxidant, photosensitizing, anti-tumor etc. activities, can be used in medical practice for appropriate purposes.

Obtained furocoumarins can be used as a prescription components

⁸ AAldulaimi O. Screening of fruits of seven plants indicated for medicinal use in Iraq // Pharmacogn. Mag., - 2017, v. 13, Suppl 2, - p. S189-S195.

of photosensitive drugs in the treatment of psoriasis, vitiligo, etc. diseases.

Approbation of the research work. Results of research work are discussed in the seminars of “Plant resources” department, joint general seminars and the Dissertation Council seminar of the Institute of Botany of the MSE of Republic of Azerbaijan; reported at the International scientific and practical conference dedicated to the “Achievements and prospects of phytochemistry development” (Kazakhstan, Karaganda, 2015), 11th International symposium on the Chemistry of Natural Compounds (Antalya, Turkey, 2015), 2nd International scientific and practical conference “Medicine - human. Modern problems of pharmacotherapy and prescription of medicines” (Ukraine, Kharkov, 2018); published in journals: “Proceeding of ANAS (biol. and med. sci.)” (2015, 2017), “Chemistry of plant raw materials” (2015, 2016, 2017), “Azerbaijan Journal of Pharmacy and Pharmacotherapy” (2016), “Kazakhstan Pharmaceutical Bulletin” (2016), “Modern Achievements of Azerbaijan Medicine” (2019), scientific-practical journal “Health” (2019).

The results of the dissertation work were published in 13 scientific works, of which 9 articles (3 in publications included in international indexing databases abroad), 4 conference materials and thesis.

The organization in which the dissertation work is being carried out. The dissertation work was carried out at the Department of Plant Resources of the Institute of Botany of the Ministry of Science and Education of the Republic of Azerbaijan.

The volume and structure of the dissertation. The dissertation comprising of content, introduction, six chapters, practical significance, conclusion, recommendations and list of references.

Introduction and table of contents – 10 pages, 15848; Chapter I – 39 pages, 67696; Chapter II – 7 pages, 7657; Chapter III – 9 pages, 14112; Chapter IV – 17 pages, 14606; Chapter V – 76 pages, 41539; Chapter VI – 7 pages, 13963; Practical significance – 2 pages, 2453; result – 2 pages, 2766; recommendation – 1 page, 1002; total volume – 192 pages, 215025 characters.

I CHAPTER. LITERATURE REVIEW

The literature review provides information on the results of worldwide studies on the *Heracleum*, *Angelica*, and *Ammi* genus species from the *Apiaceae* family, as well as showing the role of chromato-mass spectroscopy in the identification of plants with practical importance.

II CHAPTER. MATERIALS AND METHODS OF RESEARCH

As an objects of study were used: *Sosnovski baldirgani* - *Heracleum sosnowskyi* Manden. (roots and fruits), *Saxokiya melekotusu* - *Angelica sachokiana* (Karjag.) M.Pimen. et. Tichomirov (roots and aboveground parts) and *Dishqurtlayan* - *Ammi visnaga* (L.) Lam. (roots, aboveground parts and flowers).

Isolating of the sum of extractive substances from objects of research was performed by extraction method; obtaining of biologically active substances in an individual state from the sum of extractive substances by column chromatography method using as a sorbent neutral Al₂O₃ with activity III-IV, and elution using hexane, benzol, chloroform and their mixtures in various proportions. Verification of the individuality of the substances was carried out by the method of thin-layer chromatography on Silufol UV-254 plates. Identification of known substances was carried out using IR-, NMR (¹H, ¹³C, Dept 90, Dept 135) spectroscopy methods. The nature of the functional groups in the structure of the substances was determined using classical chemical methods (saponification reaction, etc.).

The component compositions of the studied plants – *H. sosnowskyi* (roots and fruits), *A. sachokiana* (roots and aboveground parts), *A. visnaga* (flowers, roots, aboveground parts) were determined using the gas-chromato-mass spectrometry method. For this purpose used Agilent Technologies 6890N Network CG System, a chromatograph with a mass spectrometer 5975 inert Mass Selective Detector, as a detector Split/Splitless, injection-Split, Inlet pressure 60,608 kpa, Split-100, Low Mass-40, High Mass-400, Threshold 150. In the experiments a 30-meter quartz capillary column, "HP-5MS 5% Methyl Siloxane" (inner diameter 0.25 mm, thickness of the stationary

phase 0.25 μ) was used.

Analyzes were performed in temperature programming regime from 50°C to 280°C at 15°C/min.

Column temperature mode:

- the starting temperature of the column is 50°C - 2 min, stable;
- temperature increase from 15°C to 200°C - 2 minutes, stable;
- temperature increase from 15°C to 280°C - 10 min, stable;
- vacuum HiVac - 3,38e-005.

Diluted with methanol-chloroform mixture (1:2 ratio);

Velocity of the gas (He) 1 ml/min. Identification of the individual substances was performed using the standard mass spectrometric library NIST. The duration of the analyzes was 33 minutes.

THE RESULTS OF RESEARCH AND DISCUSSION

In this part of the dissertation organically related and complementing each other chapters III (Experimental part: Obtaining of biologically active characteristic substances from plant species in an individual state), IV (Study of the complete component composition of research objects (all components of the species except the characteristic substances) using the gas-chromato-mass-spectrometry method) and V (Discussion of experimental results) are given by combining.

1. Study of coumarin derivatives of the *Heracleum sosnowskyi* Manden (Sosnovski baldirgani) specie.

Species of the genus *Heracleum* L. distributed in the flora Azerbaijan was studied by S.V.Serkerov (1970; 2006), Kh.G.Guliyeva et al. (1970; 1975), Aбыshev, Denisenko (1973), S.J.Ibadullaeva (1994; 2003).

1.1. Obtaining in an individual state and study of *Heracleum sosnovsky* Manden. specie coumarin derivatives

Six coumarin derivatives (HS) were obtained in individual state using a column chromatography method filled with neutral Al₂O₃ from the sum of extractive substances isolated from the plant roots collected in the fruiting phase (September 2013).

Table 1

Coumarins obtained from the roots of *Heracleum sosnowskyi*

№	Name of compound	Element of composition	Melting temperature, °C	Characteristic absorption bands in the IR spectrum, ν , cm^{-1}
1	HS-1	$\text{C}_{11}\text{H}_6\text{O}_3$	161-163	1720, 1630, 1568, 983
2	HS-2	$\text{C}_{11}\text{H}_6\text{O}_3$	138-139	1720, 1629, 1565, 985
3	HS-3	$\text{C}_{12}\text{H}_8\text{O}_4$	145-146	1730, 1625, 1600, 1560
4	HS-4	$\text{C}_{12}\text{H}_8\text{O}_4$	189-191	1730, 1620, 1580
5	HS-5	$\text{C}_{13}\text{H}_{10}\text{O}_5$	116-118	1760, 1728, 1580, 1545
6	HS-6	$\text{C}_{13}\text{H}_{10}\text{O}_5$	118-120	1755, 1720, 1660, 1558

HS-1. Elemental composition $\text{C}_{11}\text{H}_6\text{O}_3$, m.t. 161-163°C, IR-spectrum: 1720, 1630, 1568, 983 cm^{-1} . ^1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 6.37 (1H, d., J=9.60, H-3), 6.85 (1H, d., J=2.3, H-3'), 7.46 (1H, s., H-8), 7.70 (1H, s., H-5), 7.72 (1H, d., J=2.30, H-2'), 7.80 (1H, d., J=9.60, H-4).

HS-2. Elemental composition $\text{C}_{11}\text{H}_6\text{O}_3$, m.t. 138-139°C, IR-spectrum: 1720, 1629, 1565, 985 cm^{-1} . ^1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 6.38 (1H, d., J=9.60, H-3), 7.12 (1H, d., J=1.98, H-3'), 7.36 (1H, d., J=8.50, H-5), 7.42 (1H, d., J=8.50, H-6), 7.70 (1H, d., J=1.98, H-2'), 7.80 (1H, d., J=9.60, H-4).

HS-3. The composition of the element $\text{C}_{12}\text{H}_8\text{O}_4$, m.t. 145-146°C, IR-spectrum: 1730, 1625, 1600, 1560 cm^{-1} . ^1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 4.26 (3H, s., CH_3O), 6.30 (1H, d., J=9.65, H-3), 6.80 (1H, d., J=2.00, H-3'), 7.32 (1H, s, H-5), 7.60 (1H, d., J=2.00, H-2'), 7.73 (1H, d., J=9.65, H-4).

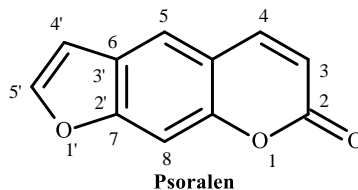
HS-4. Elemental composition $\text{C}_{12}\text{H}_8\text{O}_4$, m.t. 189-191°C, IR-spectrum: 1730, 1620, 1580 cm^{-1} . ^1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 4.22 (3H, s., H_3O), 6.30 (1H, d., J=9.65, H-3), 7.30 (1H, s, H-8), 7.40 (1H, d., J=2.30, H-3'), 8.00 (1H, d., J=2.30, H-2'), 8.20 (1H, d., J=9.65, H-4).

HS-5. Elemental composition $\text{C}_{13}\text{H}_{10}\text{O}_5$, m.t. 116-118°C, IR-spectrum: 1760, 1628, 1580, 1545 cm^{-1} . ^1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 3.95 (3H, s., CH_3O), 4.10 (3H, s., CH_3O), 6.45 (1H, d., J=11.0, H-3), 7.25 (1H, d., J=2.30, H-3'), 8.14 (1H, d., J=2.30, H-2'), 8.15 (1H, d., J=11.0, H-4).

HS-6. Elemental composition $C_{13}H_{10}O_5$, m.t. 118-120°C, IR-spectrum: 1755, 1720, 1660, 1558 cm^{-1} . 1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 4.05 (3H, s., CH_3O), 4.15 (3H, s., CH_3O), 6.35 (1H, d., $J=10.11$ H-3), 7.40 (1H, d., $J=2.30$, H-3'), 8.10 (1H, d., $J=2.30$, H-2'), 8.20 (1H, d., $J=10.11$, H-4).

Study of individual coumarin derivatives.

Compound HS-1. Absorption bands proving the presence of the δ -lactone cycle (1720 cm^{-1}) and the aromatic system (1630 , 1568 , 983 cm^{-1}) were identified in the IR spectrum of compound. To determine the structural



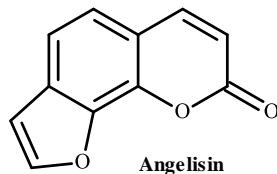
formula of the studied compound, its 1H NMR spectrum was drawn. Two doublets, each with an area of 1H in the spectrum, characterize the H-3 and H-4 protons in the coumarin structure at 6.37 ppm ($J = 9.60$ Hz) and 7.80 ppm ($J=9.60$ Hz), respectively. Two singlet signals (7.46 and 7.70 ppm) with an area of 1H each in the spectrum were assigned to the aromatic protons in the 8th and 5th positions of the structure. In the weak magnetic field of the spectrum 2 doublets according to the value of the spin-spin coupling constant of 6.85 ppm ($J=2.30$ Hz) and 7.72 m.h ($J=2.30$ Hz) characterizes the furan cycle protons H-3' and H-2', respectively (Mikayilova, Serkerov, 2013).

Thus, comparing the IR and 1H NMR spectra of substance HS-1 with the same parameters of psoralen in the literature allows us to prove that the studied coumarin derivative has the same structure as psoralen, and the IR spectrum of HS-1 coincides with the IR spectrum of psoralen.

Compound HS-2. In the area of characteristic absorption bands of the IR spectrum of the substance, there are absorption bands belonging to the carbonyl ($C=O$) group (1720 cm^{-1}) and the aromatic system (1629 , 1565 and 985 cm^{-1}) of the δ -lactone cycle. These bands allow to belong the compound to the group of furocoumarins.

The 1H NMR spectrum of the studied compound is very close to the spectrum of HS-1. So that, all signals in the spectrum are in a weak magnetic field of the spectrum. Therefore, the substance HS-2 does not have a methoxy group or groups to characterize vinyl and other

methyl groups. The doublets (1H, d., 6.38 ppm, $J=9.60$ Hz and 1H, d., 7.80 ppm, $J=9.60$ Hz) detected in the ^1H NMR spectrum belong to protons near atoms C-3 and C-4 of coumarin. Two doublets (7.36 and 7.42 ppm) with $J=8.50$ Hz belong to the H-5 and H-6 protons, respectively. Two doublets (7.12 and 7.70 ppm) with $J=1.98$ Hz characterize the protons H-3 and H-2 of the furan cycle in the compound.



Thus, according to the results obtained upon detection of IR- and ^1H NMR spectra of the HS-2, the structure of the studied compound is similar to that of angelicin. The IR spectrum of HS-2 completely coincides with the IR spectrum of angelicin (Kuznetsova, 1967).

Compound HS-3. The absorption bands (1625 , 1600 , 1560 cm^{-1}) of the δ -lactone cycle carbonyl ($\text{C}=\text{O}$) group (1730 cm^{-1}) and the $-\text{CH}=\text{CH}-$ bonds of the aromatic system were revealed in the IR spectrum.

The ^1H NMR spectrum of the HS-4 component differs from the ^1H NMR spectrum of HS-3 by presence of some signals (methoxy groups) and by the values of the chemical shifts of some signals (methoxy groups) and some $-\text{CH}=\text{CH}-$ bonds. Thus, these signals in the spectrum were assigned to the methoxy-group (s., 4.26 ppm, 3H, $-\text{OCH}_3$) and to the $-\text{CH}=\text{CH}-$ groups (1H, d., 6.30, $J=9.65$ Hz, H-3; 1H, d., 7.73, $J=9.65$ Hz, H-4; 1H, s., 7.32 ppm, H-5) in the structure of coumarin.

Two doublet signals (6.80 and 7.60 ppm) with an area in the spectrum equal to one proton unit (1H) prove that there is a furan cycle in the molecule. The results from the interpretation of the IR and ^1H NMR spectra of the compound are similar to those from the xanthotoxin furocoumarin. Direct comparison of IR and ^1H NMR spectra of compounds (xanthotoxin and compound HS-4) proves their similarity (Mikayilova, Serkerov, 2016).

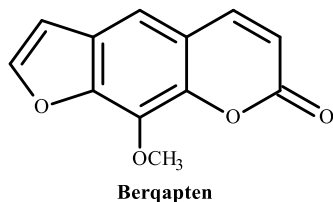


Compound HS-4. In the field of characteristic absorption bands of the IR spectrum related to the carbonyl ($\text{C}=\text{O}$) group of the 6-

membered δ -lactone cycle (1730 cm^{-1}) and to the $-\text{C}=\text{C}-$ bonds of the aromatic system ($1620, 1580\text{ cm}^{-1}$) were revealed.

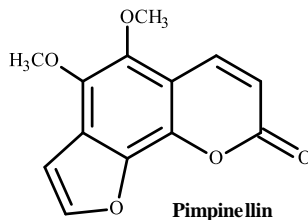
The ^1H NMR spectrum of the studied substance (HS-4) differs from the ^1H NMR spectra of HS-1 and HS-2 by the presence of a singlet signal (3H, s., 4.22 m.p.) of the methoxy group ($\text{CH}_3\text{O}-$). In addition, although six signals belonging to the $-\text{CH}=\text{CH}-$ groups were detected in the spectrum of HS-1 and HS-2 substances, in the ^1H NMR spectrum of such five signals were registered (1H, d., 6.30 ppm, $J=9.65\text{ Hz}$, H-3; 1H, d., 8.20 ppm, $J=9.65\text{ Hz}$, H-4; 1H, s., 7.30 ppm, H-8; 1H, d., 7.40 ppm, $J=2.30\text{ Hz}$, H-3'; 1H, d., 8.00 ppm, $J=2.30\text{ Hz}$, H-2').

Thus, studied by us the substance HS-4 is linear furocoumarin, containing the methoxy group in the structure. The results obtained from the detection of IR and ^1H NMR spectra show that the substance HS-4 has the same structure as furocoumarin bergapten, the IR spectrum of the substance HS-4 and bergapten are identical (Kuznetsova, 1967).



Compound HS-5. The absorption band in the IR spectrum characterizes the $\text{C}=\text{O}$ group of the δ -lactone cycle (1760 cm^{-1}) and the double bonds of the aromatic cycle ($-\text{CH}=\text{CH}-$) ($1628, 1580, 1545\text{ cm}^{-1}$).

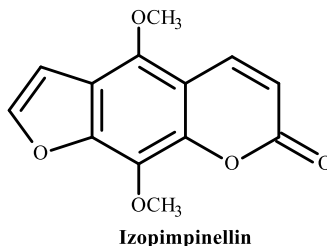
In the ^1H NMR spectrum of the substance, 2 separate signals with an area of 3H (s., 3.95 and 4.10 ppm) indicate the presence of 2 methoxy ($-\text{OCH}_3$) groups in the structure of the compound. Two doublets in the spectrum of coumarin – 6.45 (1H, d., $J=11.00\text{ Hz}$, H-3) and 8.15 ppm (1H, d., $J=11.00\text{ Hz}$, H-4) with an area of 1H characterizes the H-3 and H-4 protons of the structures. Two doublets (7.25, $J=2.30\text{ Hz}$ and 8.14 ppm, $J=2.30\text{ Hz}$) with an area of 1H each were assigned to protons in the C-2' and C-3' states of the furan cycle.



Thus, according to the results obtained upon detection of the IR

and ¹H-NMR spectra the structure of the compound HS-5 is the same as that of pimpinellin.

Compound HS-6. In the IR spectrum of the compound the absorption bands related to the carbonyl group (1660, 1558 cm⁻¹) and double bonds of the δ-lactone cycle aromatic system (1755, 1720 cm⁻¹) were determined. ¹H NMR spectrum reveals signals characteristic for coumarin derivatives: 6.35 (1H, d., J=10.11 Hz, H-3), 8.20 (1H, d., J=10.11 Hz, H-4) and protons of the furan cycle (1H, d., 7.40, J=2.30 Hz, H-3', 1H, d., 8.10 m.h, J=2.30 Hz, H-3'), in addition to these 2 singlet signals, confirming the existence of 2 methoxy groups (3H, s., 4.05 ppm, -CO₃ and 3H, s., 4.15 p.m, -CO₃) in the molecule. The results of the detection of the above IR and ¹H NMR spectra showed that the studied by us substance HS-6 has the same structure as isopimpinellin.



Researchers have shown that the coumarin derivatives pimpinellin and isopimpinellin, isolated in individual state from roots of *H. sosnowskyi*, *H. mantegazzianum*, *H. transcausicum* *H. pastinacifolium*, harvested in fruiting period are characteristic and identical for all 4 species belonging to the genus *Heracleum* L. A comparison of other individually obtained substances is shown below in the table 2.

Table 2

Comparison of coumarin derivatives obtained individually from the roots of *Heracleum* L. Species

No	<i>H. sosnowskyi</i> (H.I.Imanli)	<i>H. mantegazzianum</i> (M.Walesek)	<i>H. transcausicum</i> (F.Q.Qurbanova)	<i>H.pastinacifolium</i> (G.Q.Qasimova)
1	angelicin	angelicin	osthol	osthol
2	bergapten	bergapten	bergapten	izobergapten
3	pimpinellin	pimpinellin	pimpinellin	pimpinellin
4	isopimpinellin	isopimpinellin	isopimpinellin	isopimpinellin
5	xanthotoxin	xanthotoxin	isobergapten	allobergapten
6	psoralen	imperatorin		psoroheraclin
7		phellopterin		

2. The study of coumarin derivatives of roots and aboveground parts of the *Angelica sachokiana* (Karjag.) M.Pimen. et Tichomirov specie.

The roots and aboveground parts of species *Angelica sachokiana* widespread in the flora of Azerbaijan were collected during the fruiting phase (September 2013) around Kuzun village of Gusar district of the Azerbaijan Republic.

2.1. Obtaining in an individual state of coumarin derivatives of *Angelica sachokiana* plant roots and their study.

Four individual coumarin derivatives (AS) were obtained by column chromatography in a glass column filled with neutral Al₂O₃ (having III-IV degree of activity) the sum of extractive substances obtained from the *Angelica sachokiana* roots with acetone extraction.

Table 3

Furocoumarins obtained from the roots of the plant
Angelica sachokiana

№	Name of compound	Element of composition	Melting temperature, °C	Characteristic absorption bands in the IR spectrum, v, sm ⁻¹
1	AS-1	C ₁₂ H ₈ O ₄	188-191	1732, 1621, 1583
2	AS-2	C ₁₂ H ₈ O ₄	145-146	1730, 1630, 1600, 1560
3	AS-3	C ₁₃ H ₁₀ O ₅	117-119	1740, 1628, 1580, 1545
4	AS-4	C ₂₁ H ₂₂ O ₇	137-138	1716, 1646, 1625, 1605, 1580, 1546

AS-1. Elemental composition C₁₂H₈O₄, m.t. 188-191°C; IR-spectrum: 1732, 1621, 1583 sm⁻¹; ¹H NMR-spectrum (300 MHz, DMSO-d₆, δ, ppm, J/Hz.): 6.30 (1H, d., J=9.65, H-3), 8.20 (1H, d., J=9.65, H-4), 7.30 (1H, s., H-8), 7.40 (1H, d., J=2.00, H-3'), 8.00 (1H, s., H-8). 1H, d., J=2.00, H-2').

AS-2. Elemental composition C₁₂H₈O₄, m.t. 145-146°C; IR-spectrum: 1730, 1630, 1600, 1560 sm⁻¹; ¹H NMR-spectrum (300 MHz, DMSO-d₆, δ, ppm, J/Hz.): 6.32 (1H, d., J=9.65, H-3), 7.73 (1H, d., J=9.65, H-4), 7.32 (1H, s, H-5), 6.80 (1H, d., J=2.00, H-3'), 7.60 (1H, d., J=2.00, H-2').

AS-3. Elemental composition $C_{13}H_{10}O_5$, m.t. 117-119°C; IR spectrum: 1740, 1628, 1580, 1545 cm^{-1} . 1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , mh, J/Hz): 6.45 (1H, d., J=11.00, H-3), 8.15 (1H, d., J=11.00, H-4), 3.95 (3H, s., CH_3O-), 4.10 (3H, s., CH_3O-), 7.25 (1H, d., J=2.30, H-3'), 8.15 (1H, d., J= 2.30, H-4').

AS-4. Elemental composition $C_{21}H_{22}O_7$, m.t. 137-138°C, IR spectrum: 1716, 1646, 1625, 1605, 1580, 1546 cm^{-1} . 1H NMR-spectrum (300 MHz, DMSO- d_6 , δ , ppm, J/Hz.): 1.88 (3H, d., J=7.20, $CH_3-CH=$), 1.98 (3H, s.), $CH_3-CH=$), 6.15 (1H, m., $CH=$), 1.35 (3H, s., CH_3-C-OH), 1.39 (3H, s., CH_3-C-OH), 4.60 (2H, k., $J_1=9.90$; $J_2=7.80$, $-CH_2-O-$), 5.45 (1H, k, $J_1=7.80$; $J_2=3.30$, $-CH-O-$), 6.17 (1H, d., J=10.00, $CH=$, H-4), 8.00 (1H, d., J=10.00, $CH=$, H-3), 6.95 (1H, d., J=2.50, $CH=$, H-3'), 7.57 (1H, d., J=2,50, $CH=$, H-2'), 6.98 ppm (1H, s., $CH=$, H-8).

2.2. Study of obtained individual coumarin derivatives.

Compound AS-1. $C_{12}H_8O_4$, m.t. 189-191°C. In the area of the IR spectrum characteristic bands, the absorption bands belonging to the C=O group of δ -lactone (1732 cm^{-1}) and characterizing the benzene cycle (1621, 1583 cm^{-1}) were revealed. Signals detected in the 1H NMR spectrum of AS-1 substance are 6.30, 1H, d., J=9.65 Hz, H-3; 8.20, 1H, d., J=9.65 Hz, H-4; 7.30, 1H, s., H-8; 7.40, 1H, d., J=2,00 Hz, H-3'; 8.00 ppm, 1H, d., J=2.00 Hz, H-2' are identical to the signals in the 1H NMR spectrum of furocoumarin bergapten.

The results obtained from IR and 1H NMR spectra of AS-1 prove that the structure of AS-1 is similar to that of the bergapten structure.

Compound AS-2. $C_{12}H_8O_4$, m.t. 145-146°C. Absorption bands belonging to the CO-group of the δ -lactone cycle (1730 cm^{-1}) and the aromatic system (1630, 1600, 1560 cm^{-1}) were identified in the IR spectrum. The signals detected in the weak magnetic field of the 1H NMR spectrum of the studied compound: 6.32, 1H, d., J=9.65, H-3; 7.73 ppm, 1H, d., J=9.65, H-4; singlet signal 7.32 ppm, 1H, H-5 and 2 doublets with an area of 1H each 6.80, J=2.00 Hz, H-3 and 7.60 ppm, J=2.00, along with the protons of the furan ring in the H-2' position of the molecule, were assigned to the proton of the C-5 carbon atom.

Thus, the IR and 1H NMR spectra of the studied compound AS-

2 are the same as the IR and ^1H NMR spectra of furocoumarin xanthotoxin, proving that the AS-2 coumarin we studied is identical to xanthotoxin.

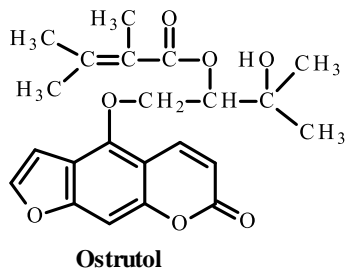
Substance AS-3. $\text{C}_{13}\text{H}_{10}\text{O}_5$, *a.t.* 117-119°C. Absorption bands of the δ -lactone cycle carbonyl group (1740 cm^{-1}) and the aromatic system ($1628, 1580, 1545\text{ cm}^{-1}$) were revealed in the IR-spectrum.

The ^1H NMR spectrum of the studied substance is similar to the spectrum of furocoumarins. Thus, two doublet signals in the spectrum 6.45 (1H, d., $J=11.00\text{ Hz}$) and 8.15 (1H, d $J=11.00\text{ Hz}$) characterize the H-3 and H-4 protons in the structure of the compound respectively. Two singlets with an area of 3H (3.95, 3H, s., OCH_3 ; 4.10, 3H, s., OCH_3) belong to 2 methoxy groups in the molecule. Two doublets with an area of 1H each (7.25, 1H, d., $J=2.30\text{ Hz}$, H-3 and 8.15 ppm, 1H, d., $J=2.30\text{ Hz}$) in the structure of the compound 2 proves the existence of two methoxy groups.

Comparison of the above-mentioned spectrum data with the known parameters of furocoumarins proves that AS-3 has the same structure as that of pimpinellin.

Substance AS-4. $\text{C}_{21}\text{H}_{22}\text{O}_7$, *a.t.* 137-138°C. In the IR spectrum absorption bands belonging to the hydroxyl group (3486 cm^{-1}), carbonyl ($\text{C}=\text{O}$) group of the δ -lactone cycle and complex ester groups (1717 cm^{-1}), double bonds of the ether and aromatic system ($1645, 1624, 1604, 1579, 1545\text{ cm}^{-1}$) were revealed.

In the ^1H NMR spectrum of the compound the 2 signals 1.88 (3H, d., $J=7.20\text{ Hz}$, $\text{CH}_3\text{-C}=\text{C}$), 1.98 (3H, s., $\text{CH}_3\text{-C}=\text{C}$) belonging to vinyl methyl ($\text{CH}_3\text{-C}=\text{C}$) groups characterizing the complex ester groups in the molecule and multiplet (1H, m., $\text{CH}=\text{C}$) belonging to vinyl proton; two singlets 1.35 (3H, s, $\text{CH}_3\text{-C-OH}$), 1.39 (3H, s, $\text{CH}_3\text{-C-OH}$) of simple ether methyl groups, methylene group bounding with heteroatom (with oxygen) (2H, q., 4.60 ppm, $J_1=9.90$; $J_2=7.89\text{ Hz}$, $\text{CH}_2\text{-O-}$) and a methyl group bounding with



oxygen (1H, q., 5.45 ppm, $J_1=7.80$; $J_2=3.30$ Hz, $-\text{CH}-\text{O}-$); with the exception of these signals main signals of furocoumarin detected in a weak magnetic field of the spectrum, 6.17 (1H, d., $J=10.00$ Hz, H-3), 8.00 (1H, d., $J=10.00$ Hz, H-4), 6.95 (1H, d., $J=2.50$ Hz, H-3'), 7.57 (1H, d., $J=2.50$ Hz, H-2'), 6.98 ppm, (1H, s., $-\text{CH}=\text{}$, H-8) proves that the studied by us substance (AS-4) has the identical structure that the ostrutol furocoumarin derivative.

Researches by scientists has shown that from coumarin derivatives obtained individually from the roots of *A. sachokiana*, *A. japonica*, *A. archangelica*, *A. purpurescens*, belonging to the genus *Angelica* L., harvested during flowering and fruiting phases, the xanthotoxin for all 4 species and ostrutol for 3 species (except *A. japonica*) are characteristic. A comparison and analysis of other individually purchased items is shown in the tables below.

Table 4

Comparison of coumarin derivatives obtained individually from the roots of species of the genus *Angelica* L.

№	<i>A. sachokiana</i> (H.E.Imanli)	<i>A. japonica</i> (T.Fijioka et al.)	<i>A. archangelica</i> (R.D.Murray)	<i>A. purpurescens</i> (H.Q.Heydarov)
1	bergapten	bergapten	bergapten	Phellopterin
2	xanthotoxin	xanthotoxin	xanthotoxin	xanthotoxin
3	ostrutol	byakangelicin	ostrutol	ostrutol
4	pimpinellin	ostol	ostol	byakangelicin
5		oxypeucedanin hydrate	oxypeucedanin hydrate	
6		isoimperatorin	imperatorin	
7		scopoletin	xanthotoxol	
8		japoangelon	oxypeucedanin	
9		japoangelol A-D	umbelliferon	

Table 5

Quantitative analysis of coumarin derivatives obtained individually from dried, crushed, suspended roots of *H. sosnowskyi*, *A. sachokiana*

№	Substances	(HS) Roots of <i>H. sosnowskyi</i> (238 gr)		(AS) Roots of <i>A. sachokiana</i> (330 gr)	
		Yield		Yield	
		gram	%	gram	%
	Total extractives	12	5.04	18	5.45
	Obtained individual substances	5.84	48.62	3.83	21.27
1	HS-1 (psoralen)	0.008	0.06		
2	HS-2 (angelicin)	1.18	9.83		
3	HS-3 (xantatoxin)	0.62	5.16		
4	HS-4 (bergapten)	1.30	10.83		
5	HS-5 (pimpinellin)	1.82	15.16		
6	HS-6 (isopimpinellin)	0.91	7.58		
7	AS-1 (<i>bergapten</i>)			1.12	6.22
8	AS-2 (<i>xantotoxin</i>)			0.83	4.61
9	AS-3 (<i>pimpinellin</i>)			1.36	7.55
10	AS-4 (<i>Ostrutol</i>)			0.52	2.89

3. Study of coumarins and other extractive compounds from the roots and fruits of *Heracleum sosnowskyi* Manden. specie by chromatography-mass spectrometry.

The component composition of the roots and fruits of *Heracleum sosnowskyi* specie was studied by chromato-mass spectroscopy. In **roots** 8 coumarin derivatives (%): psoralen (3.91), angelicin (10.389), umbelliferon (0.095), bergapten (26.35), xanthotoxin (6.18), pimpinellin (30.12), oroselon (0.12), isopimpinellin (18.05); in **fruits** 15 coumarin derivatives (%): angelicin (14.9), psoralen (0.07), bergapten (14.72), xanthotoxin (4.48), pimpinellin (15.54), isopimpinellin (7.14), aflatoxicol (0.01), fellopterin (0.04), byakangelicol (0.15), xanthotoxol (1.02), prangenin (2.75), 7-hydroxy-3-(1.1-dimethylprop-2-enyl) coumarin (0.21), aurapten (0.003), 8-hydroxypsoralen (0.05), 9-(2-hydroxy-3-methyl-3-butenyloxy)-4-

methoxy-furo(3.2g) chromium-7-on (neobyakangelikol) (0.12) were found.

In addition to coumarin derivatives in the roots and fruits hydrocarbons, ketones, aldehydes, terpenoids, alcohols, nitrogen-containing compounds have been identified. While only one ether compound was found in the roots, in fruits 10 ether compounds, including ethers of acetic, propionic, fatty, caprylic, caproic and valeric acids with ethyl alcohol were determined. In total, 114 components have been identified in the roots and fruits of the *H. sosnowskyi* plant.

4. Study of coumarin derivatives of roots and aboveground parts of *Angelica sachokiana* (Karjag.) M.Pimen. et. Tichomirov specie by chromato-mass spectrometry method.

The component composition of coumarin derivatives of the roots and aboveground parts of *Angelica sachokiana* was studied by chromatography-mass spectroscopy method. In sum of extractive compounds of the **roots** obtained by extraction with acetone revealed following components (in %): psoralen (0.13), umbelliferon (0.14), scopoletin (1.79), xanthotoxin (0.10), bergapten (1.30), seselin (0.02), fellopterin (0.02), pimpinellin (0.99), nodakenetin (0.1), aurapten (0.61), decursin (1.02), byakangelicol (3.93);

In sum of extractive compounds of the **aboveground parts** (in %): bergapten (0.03), psoralen 0.03), umbelliferone (0.06), xanthotoxin (10.09), phellopterin (0.02), pimpinellin (1.35), aurapten (13.26), byakangelicol (8.31), angelicin (0.04), bergaptol (0.03), isopimpinellin (3.31), prangenin (3.39), oxypeucedanin (13.26), decursin (5.87), oxypeucedanin hydrate (2.17), osthrotol (0.27) and byakangelicin (1.49) were identified. In total, 118 components have been identified in the roots and aboveground parts of the *A. sachokiana* plant.

5. Chromato-mass spectrometric study of components of the roots, aboveground parts and flowers (including floral umbrellas) of the *Ammi visnaga* (L.) Lam. specie.

The component composition of biologically active substances of the sum of extractive compounds obtained by extraction with acetone from the roots, aboveground parts and flowers collected in July 16,

2012 from the side of the highway around Sigirli village of Kurdamir district of the Azerbaijan Republic has been studied by chromatomass-spectrometry method.

5.1. Chemical components determined and identified in the roots of the *Ammi visnaga* plant (in %): Acetic acid, 2-methylpropyl ester $C_6H_{12}O_2$, (0.017), octanal $C_8H_{16}O$ (0.008), 2-propyl malonic acid $C_6H_{10}O_4$ (0.006), 2-methoxy-4-vinylphenol $C_9H_{10}O_2$ (0.095), 4-propylphenol $C_9H_{12}O_4$ (0.016), oxalic acid, isobutyl nonyl ester $C_{15}H_{28}O_4$ (0.016), vanillin $C_8H_8O_3$ (0.016), 1-(3,5-dimethyl-1-adamantanoyl) semicarbazide $C_{14}H_{23}N_3O_2$ (0.018), cis-isoeugenol $C_{10}H_{12}O_2$ (0.009), 1-methyl-N-vanilil - (+)-S-2-phenethanamine $C_{17}H_{21}NO_2$ (0.017), (1-butylheptyl) benzene $C_{17}H_{28}$ (0.010), 3-phenylpropionic acid 4-cyanophenyl ester $C_{16}H_{13}NO_2$ (0.017), 3-butylidene-1(3H)-isobenzofuranone $C_{12}H_{12}O_2$ (0.021), (1-methyldecyl) benzene $C_{17}H_{28}$ (0.010), hexadecanal $C_{16}H_{32}O$ (0.020), 3-(1-methylbutyliden)-4,5-dihydrophthalide $C_{13}H_{16}O_2$ (2.302), coniferol $C_{10}H_{12}O_3$ (0.085), (3Z) butylidene-4,5-dihydro-isobenzofuran-1-one $C_{12}H_{14}O_2$ (0.076), oxalic acid allyl decyl ester $C_{15}H_{26}O_4$ (0.009), psoralen $C_{11}H_6O_3$ (0.038), ferulic acid $C_{10}H_{10}O_4$ (0.078), norvisnagin $C_{10}H_{12}O_{12}$ (0,022), n-hexadecanic acid $C_{16}H_{32}O_2$ (6,304), noreugenin $C_{10}H_8O_4$ (0,018), falcarinol $C_{17}H_{24}O$ (17,691), visnagin $C_{13}H_{10}O_4$ (14,521), cis-Z-alpha-B-bisabolene-epoxide $C_{15}H_{24}O$ (0.065), bergapten $C_{12}H_8O_4$ (8.701), 9,12-octadecadienic acid $C_{18}H_{32}O_2$ (6,464), methyl ester 5,8,11-heptadecatrienic acid $C_{18}H_{24}O_2$ (24.071), 2,3,3 α ,4,5 α ,6,7,9 α ,9 β -decahydro-3,5 α , 9-trimethyl-7,9 α -peroxy-naphtho [1,2b] furan-2-one $C_{15}H_{20}O_4$ (0.005), viminalol $C_{30}H_{50}O$ (0.012), diisooctyl phthalate $C_{24}H_{38}O_4$ (6.794), decursin $C_{19}H_{20}O_5$ (7.617), 8,11,14-eicosatetraenoic acid $C_{20}H_{34}O_2$, (0.027), 7-methoxy-3 α , 9 β -dimethyl-1,2,3 α , 4,5,9 β -hexahydro-3H-cyclopenta [a] naphthalene-3-on $C_{16}H_{20}O_2$ (2,390), 8,13-diol-cedrin $C_{15}H_{26}O_2$ (0.021), campesterol $C_{28}H_{48}O$ (0.012), stigmasterol $C_{29}H_{48}O$ (0.056);

5.2. Chemical components determined and identified in the aboveground parts of the *Ammi visnaga* plant (in %): 4-methyl-3-penten-2-one $C_6H_{10}O$ (0.021), 4-hydroxy-4-methyl-2-pentanone $C_6H_{10}O_2$ (4.032), 1-methyl-4- [(2-propenyloxy) methyl] benzene

C₁₁H₁₄O (0.007), linalool C₁₀H₁₈O (0.026), butanoic acid 2-methyl-3-methyl-butyl ester C₁₀H₂₀O₂ (0.014), 2,5-dimethyl-[1,3] dioxane-4-carboxaldehyde C₇H₁₂O₃ (0.024), 2-methoxy-4 vinylphenol C₉H₁₀O₂ (0.016), butanic acid 3,7-dimethyl-6-octenyl ester C₁₄H₂₆O₂ (0.012), 1,6-anhydro-beta-D-glucopyranose C₆H₁₀O₅ (0.022), mellein C₁₀H₁₀O₃ (0.013), pentanic acid octyl ester C₁₃H₂₆O₂ (0.015), cisnerolidol C₁₅H₂₆O (0.009), isoacetic acid tetradecyl ether C₁₈H₃₆O₂ (0.023), coniferol C₁₀H₁₂O₃ (0.012), farnesol C₁₅H₂₆O (0.010), pentadecanal C₁₅H₃₀O (0.012), 9,12,15-oktadecatrienal C₁₈H₃₀O (0.011), norvisnagin C₁₂H₈O₄ (1.045), n-hexadecanoic acid C₁₆H₃₂O₂ (0.045), noreugenin C₁₀H₈O₄ (0.034), visnagin C₁₃H₁₀O₄ (29.105), sis-Z- α -bisabolene epoxide C₁₅H₂₄O (0.438), bergapten C₁₂H₈O₄ (0.013), seselin (amyrolin) C₁₄H₁₂O₃ (0.009), phytol C₂₀H₄₀O (0,134), geranyl linalool C₂₀H₃₄O (4.805), khellin C₁₄H₁₂O₅ (24.190), 4-oxo-1,2,3,3a,4,5-hexahydropyrrolo [1,2-a] quinoxaline-7-carboxylic acid C₁₂H₁₂N₂O₃ (0.026), khellol C₁₃H₁₀O₅ (0.366), 17-hydroxyestran-3-one C₁₈H₂₈O₂ (2.011), Z, Z-, 5-pentadecadien-1-ol C₁₅H₂₈O (0.024), decursin C₁₉H₂₀O₅ (0,023), 3,4-dihydro-6,7-dimethoxy-3,3-dimethylisoquanololine-1-carbo-nitrile C₁₄H₁₆N₂O₂ (7.410), 7-Methoxy-3 α ,9 β -dimethyl-1,2,3 α , 4,5,9 β -hexahydro-3H-cyclopenta [a] naphthalene-3-on C₁₆H₂₀O₂, (15.812), prayeruptorin B C₂₄H₂₆O₇ (0.116), longiborneol C₁₅H₂₆O (6.887), bisnorallocholanolic acid C₂₂H₃₆O₂ (0.016), cholesterol-20,24-dien-3,6-diol, (3 β ,5 α ,6 α) C₂₇H₄₄O₂ (0.078), (3 β)-cholest-5-en-3-ol carbono-chloride C₂₈H₄₅ClO₂ (0.029), ramnazin C₁₇H₁₄O₇ (0.030), 4,14-dimethyl-9,19-cycloerqost-24 (28)-en-3-ol-acetate C₃₂H₅₂O₂ (0.031).

5.3. Component composition of flowers (with flower umbrellas) of the *Ammi visnaga* specie (in %): 4-hydroxy-4-methyl pentanone C₆H₁₀O (0.016), 1,1,2,2-tetra-chloroethane C₂H₂Cl₄ (0.014), 2-(2-ethoxyethoxy) ethanol C₆H₁₄O₃ (0.016), 3,7-dimethyl-1,6-octadiene-3-ol C₁₀H₁₈O (0.029), pentanoic acid octyl ester C₁₃H₂₆O₂ (0.015), 3,7,11,15-tetramethyl-2-hexadecen-1-ol C₂₀H₄₀O (0.025), isopsoralen (angelicin) (0.015), norvisnagin C₁₂H₈O₄ (0.015), palmitic acid C₁₆H₃₂O₂ (0.036), noreugenin C₁₀H₈O₄ (0.039), visnagin C₁₃H₁₀O₄ (15.035), amyroline (seselin) C₁₄H₁₂O₃ (0.036), Bicycle [9.3.1] pentadeca-3,7-dien-12-ol, 4,8,12,15,15-pentamethyl-,

(vertisiol) $C_{20}H_{34}O$ (18,033), khellin $C_{14}H_{12}O_5$ (24.217), estafiatin $C_{15}H_{18}O_3$ (1.051), androstan-17-ol $C_{19}H_{32}O$ (2.115), 1,2-benzenedicarboxylic acid, diisooctyl ester $C_{24}H_{38}O_4$ (3.024), n-heneicosane $C_{21}H_{44}$ (1.053), 3,4-dihydro-6,7-dimethoxy-3,3-dimethyl-1-isoquinoline-carbonitrile $C_{14}H_{16}N_2O_2$ (32.384), prayeruptorin B $C_{24}H_{26}O_7$ (2.89), stigmastan-3.5-dien $C_{29}H_{48}$ (0.019). In total, 101 components were identified in the roots, aboveground parts, and flowers (along with flower umbrellas) of *A. visnaga* plant.

CONCLUSIONS

1. Three species: *Heracleum sosnowskyi* Manden, *Angelica sachokiana* (Karjag.) M.Pimen et Tichomirov and *Ammi visnaga* (L.) Lam. belonging to the three genera of *Apiaceae* Lindl. family have been investigated chemically. In individual state 6 coumarin derivatives isolated from the roots of *H. sosnowskyi*: $C_{11}H_6O_3$, m.t. 161-163°C; $C_{11}H_6O_3$, m.t. 138-139°C; $C_{12}H_8O_4$, m.t. 145-146°C; $C_{12}H_8O_4$, m.t. 189-191°C; $C_{13}H_{10}O_5$, m.t. 116-118°C; $C_{13}H_{10}O_5$, m.t. 118-120°C; 4 coumarin derivatives isolated from *Angelica sachokiana* roots: $C_{12}H_8O_4$, m.t. 188-191°C; $C_{12}H_8O_4$, m.t. 145-146°C; $C_{13}H_{10}O_5$, m.t. 117-119°C; $C_{21}H_{22}O_7$, m.t. 137-138°C [1,2,3,4,5].
2. Based on the data obtained at the determining of physicochemical properties, IR- and 1H -NMR spectra coumarin derivatives obtained from the roots of *H. sosnowskyi* were identified as psoralen, angelisin, bergapten, xanthotoxin, pimpinellin, isopimpinellin, respectively. Furocoumarins psoralen, angelicin, bergapten, and xanthotoxin are new to *H. sosnowskyi* roots and were obtained from this species for the first time [4,7,9,11].
3. Coumarin compounds obtained in individual state from the roots of *Angelica sachokiana* by comparing physicochemical properties (elemental composition, m.t.) with the same parameters of known coumarin derivatives and also on the basis of the results obtained by interpreting of IR-, 1H NMR, ^{13}C , ^{13}C Dept 135 spectra individually obtained substances were identified as bergapten, xanthotoxin, pimpinellin and osthrutol, respectively. Xanthotoxin and pimpinellin are new to *A. sachokiana* and from this specie

obtained for the first time [1,2,3,6,11,13].

4. Component composition of the roots and fruits of the *Heracleum sosnowskyi* Manden., the roots and aboveground parts of the *Angelica sachokiana* (Karjag.) M.Pimen. et Tichomirov; the roots, aboveground parts and flowers (with flower umbrellas) of the *Ammi visnaga* (L.) Lam. plant species were studied by the of chromatomass spectrometry method for the first time [1, 2, 3, 4, 6, 7, 8, 9 11, 12, 13].
5. 8 coumarin derivatives in the roots, 15 in the fruits of the *H. sosnowskyi*; 12 coumarin derivatives in the roots, 17 in the aboveground parts of the *A. sachokiana*; 39 components in the roots of the *Ammi visnaga* plant species, including psoralen, norvisnagin, visnagin, bergapten, decursin; 41 components in the aboveground parts, including norvisnagin, noreugenin, visnadin, bergapten, seselin, khellin, khellol, decursin and praeruptorin B; 21 components in the flowers, including angelisin, norvisnagin, noreugenin, visnagin, seselin, khellin, estafiatin were identified [1,4,5,6,7,8,10,11,12,13].
6. As a result of scientific research can be said that the studied coumarin derivatives having analgesic, effective coronary vasodilator, antioxidant, antimicrobial, aleopathic, hematonic, antimycobacterial, anti-malignant, antiviral, antibiotic, anti-dermatophytic, antiperspirant, photosensitizing etc features and are successfully used in official medical practice and folk medicine [2, 5, 7, 11, 12].

RECOMMENDATIONS

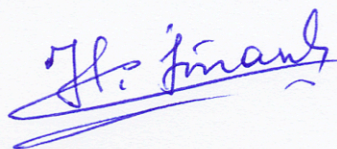
1. Sosnovski baldırğanı - *Heracleum Sosnowskyi* Manden., Saxokiya melekotusu - *Angelica sachokiana* (Karyag.), Diş dişqurtlayan - *Ammi visnaga* (L.) Lam. coumarin derivatives, obtained and prescribed as a result of scientific research, are analgesics, effective dilators of coronary vessels, antioxidant, antimicrobial, alleopathic, hematonic, antimycobacterial, antidermatophytes, antitumor, antiviral, antibiotics, antiperspirants, etc. its effects are recommended for use in medical practice and folk medicine

- according to the recommendations of pharmacists [1,3,4,5].
2. Furocoumarins obtained from research are useful in psoriasis, vitiligo, antifungal, etc. It is recommended to use photosensitizing drugs as prescription drugs in the treatment of diseases [5,7,11].
 3. It is recommended to be a reference source when choosing a raw material base for specialists in the pharmaceutical industry, manufacturers of medicines from individual substances and designated components obtained from specified plant species, in order to obtain the necessary and necessary substances [11,12,13].

PUBLICATIONS ON THE DISSERTATION WORK

1. Imanli H.A., Serkerov S.V. Study of coumarin derivatives of the roots and aboveground parts of the *Angelica sachokiana* specie by chromato-mass-spectroscopy method // Proceedings of Azerbaijan NAS (biol. and medical sciences), – 2015, v. 70, No 2, – p. 15-20.
2. Imanly H.A., Serkerov S.V. Coumarin derivatives of the roots *Angelica sachokiana* (Karjag.) M.Pimen. et Tichomirov // Chemistry of Plant Raw Materials, – 2015, No 4, – p. 165-168.
3. Imanli H.A., Serkerov S.V. Coumarin derivatives and other concomitant components of overgrounds and roots of the *Angelica sachokiana* / Proc. of Int. research-practical conf. “Achievements and prospects for the development of phytochemistry”. Kazakhstan: – Karaganda, – 2015, – p. 92.
4. Imanli H.A., Serkerov S.V. Coumarins and other extractives of *Heracleum sosnowskyi* roots and fruits / Proc. of Int. research-practical conf. “Achievements and prospects for the development of phytochemistry”. Kazakhstan: – Karaganda, – 2015, – p. 93.
5. Imanli H.A., Serkerov S.V. Bioactive coumarins and chromones of roots, flowers and leaves of the *Visnaga daucooides* / 11th International Symposium on the Chemistry of Natural Compounds. Turkey: – Antalya, –2015, p. 40.
6. Imanly G.A., Serkerov S.V. Chemical components of the aboveground parts of *Angelica sachokiana* (Karjag.) M.Pimen. et Tichomirov // Chemistry of Plant Raw Materials, – 2016, No 3, – p. 147-150.

7. Imanly H.A., Sarkarov S.V. Study the component composition of roots and fruits of the *Heracleum sosnowskyi* Manden. specie // Azerbaijan Journal of Pharmacy and Pharmacotherapy, – 2016, No 1, – p. 24-25.
8. Imanly G.A., Serkerov S.V. Chemical components of inflorescences *Ammi visnaga* (L.) Lam. // Pharmaceutical Bulletin of the Republic of Kazakhstan, – 2016, No 3-4, – p. 111-113.
9. Imanli H.A., Serkerov S.V. The coumarines of the roots of *Heracleum sosnowskyi* // Proceeding of Azerbaijan NAS (biol. and med. sciences), – 2016, v. 71, №3, – p. 35-38.
10. Imanly G.A., Serkerov S.V. Chemical components of the roots and aboveground parts of *Ammi visnaga* (L.) Lam. // Chemistry of Plant Raw Materials, – 2017, No 3, – p. 237-240.
11. Imanly G.A., Serkerov S.V. *Heracleum sosnowskyi* and *Angelica sachokiana* (*Apiaceae*) - sources of linear furocoumarins with photosensitizing properties / Materials of the 2nd International scientific-practical conf. “Medicines for humans. Modern problems of pharmacotherapy and prescribing”. Kharkov: 2018, –p. 135-136.
12. Imanli H.A. Study of the component composition of the roots and aboveground parts of *Ammi visnaga* (L.) Lam. // Modern Achievements of Azerbaijan Medicine, – 2019, No 3, – p. 276-279.
13. Imanli H.A. Study of bioactive substances *Angelica sachokiana* (*Apiaceae*) by chromatography-mass spectrometry // Scientific-Practical Journal of Health, – 2019, No 5, – p. 182-187.



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