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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

THE STUDY OF BIOLOGICAL ACTIVE SUBSTANCES OF *LACTUCA* L. SPECIES IN AZERBAIJAN

Speciality: 2406.02 - Biochemistry

Field of science: Biology

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INTRODUCTION

The relevance of the topic and degree of processing. It is scientifically known that approximately 70,000 plant species are used in the treatment of various diseases, but only 15% of the total plant species have been studied for their availability of pharmacological potential[1]. Also, taking into account the rapid disappearance of plants along with tropical forests, the comprehensive study of the plant kingdom is one of the current problems of biological science. The phytochemical research and pharmacological potential of a large proportion of the earth's estimated 391,000 terrestrial plant species remain unexplored[2].

Phytochemistry has traditionally been dealt with the isolation and determination of the structure of chemical compounds contained in plant species. Although the application of a number of spectroscopic techniques, mainly 1D-NMR and 2D-NMR, contributed to the process of structure determination, the separation procedure of the substances remained a complex issue that could take days to months depending on the study. Proper isolation and purification emphasize the importance of the process. The development and application of chromatographic methods that are rapid, and do not result in decomposition and material loss or the formation of new compounds are crucial[3]. Separation of compounds by high-performance liquid chromatography (HPLC) and and gas chromatography (GC) methods and their identification by mass spectrometry (MS), which is an analysis method based on the mass-to-charge ratio of the particles formed by ionization of compounds, are among the modern methods currently used. The species of the genus lettuce (*Lactuca* L.) are annual, biennial, or perennial plants distributed in the Greater Caucasus, the Lesser Caucasus, the Kur-Araz lowland, from the Aran

[1] Süntar, I. Importance of ethnopharmacological studies in drug discovery: role of medicinal plants // Phytochemistry Reviews, –2020, 19(5), –p.1199-1209.

[2] Kersey, P.J. Plant genome sequences: past, present, future // Current opinion in plant biology, –2019, 48, –p.1-8.

[3] Hostettmann, K., Marston, A. Twenty years of research into medicinal plants: Results and perspectives // Phytochemistry Reviews, –2002, 1(3), –p.275-285.

region to the middle mountain zone, in gravelly, stony areas, bushes, woodlands, vegetable garden, and orchards. Lettuce which belongs to this genus is a valuable vegetable and medicinal plant. Its leaves contain organic acids, sugar, carotene, and vitamins "K", "B", "C" and "E". In traditional folk medicine, its leaf juice is used to treat tumors and diabetes[4].

Taking into account all of these, *Lactuca serriola* L. (prickly lettuce) and *Lactuca tatarica* L. C.A.Mey. (blue lettuce), which belong to the genus lettuce (*Lactuca* L.) of the *Asteraceae* family that is widespread in the flora of Azerbaijan - detection of biologically active substances from these species, determination of their useful properties formed the main direction of the dissertation work.

Object and subject of the research. The underground and aboveground parts of *Lactuca serriola* L. (prickly lettuce) and *Lactuca tatarica* (L.) C.A. May (blue lettuce) were used as the object of the study. The subject of the research is the study of the distribution of the species and their reserve, the study of biologically active substances, and the investigation of the antifungal and antibacterial effect of those substances.

Purpose and tasks of the research. The purpose of the research work is to determine and identify the biologically active substances in *Lactuca serriola* L. (prickly lettuce) and *Lactuca tatarica* (L.) C.A.Mey. (blue lettuce) species from the *Asteraceae* Bercht. & J. Presl family by using modern methods, to study their antibacterial and antifungal effects on various strains and the determination of their distribution and reserve in different areas of the Republic of Azerbaijan.

To achieve all these purposes, the following tasks have been set:

- Determination of triterpene derivatives and fatty acids from underground parts of *Lactuca serriola L.* (prickly lettuce);
- Detection of phenolic compounds from aerial parts of *Lactuca serriola* L. (prickly lettuce);

[4] Əsgərov, A. Azərbaycan Bitki Aləmi (Ali bitkilər-Embryophyta) / A.Əsgərov. – Bakı: TEAS Press, – 2016. – 444 s.

- Determination of volatile compounds that belong to different chemical groups from the roots and leaves, as well as fatty acids from the leaves and seeds of *Lactuca serriola* L. (prickly lettuce);
- Determination of volatile compounds that belong to different chemical groups from the roots, leaves and seeds of *Lactuca tatarica* (L.) C.A.Mey. (blue lettuce);
- Study of the antibacterial and antifungal properties of the total extractive substances obtained from the underground and aboveground parts via various extractants of *Lactuca tatarica* (L.) C.A. May. (blue lettuce) and *Lactuca serriola* L. (prickly lettuce) species against pathogenic strains that cause various diseases in humans;
- Study of the antifungal properties of the total extractive substances obtained through ethanol from the aerial parts of *Lactuca tatarica* (L.) C.A. May. (blue lettuce) and *Lactuca serriola* L. (prickly lettuce) species against phytopathogenic fungi that cause various diseases in plants;
- Determination of the distribution and resource potential of the studied species in different areas of the Republic of Azerbaijan.

Research methods. To carry out the dissertation work, the extraction method, column chromatography, liquid chromatography-mass spectrometry (LC-MS),gas chromatography-mass spectrometry (GC-MS) methods, micro steam distillation-solid phase micro extraction technology (MSD-SPME), and modified Folch methods were used for the chemical research of plant species. The activity of the obtained extractive substances against microorganisms that are pathogenic to humans was determined by the disk diffusion (Kirby-Bauer) test, and the activity against phytopathogenic fungi was determined by the biomass acquisition method. During the research of the distribution and resource potential of the studied species, the map of the investigated area was studied by the AzNav national GPS navigation system (version 2.6.0.0), the statistical analysis of the results was carried out in MS Excel 16.0 version, and the Esri ArcGIS Pro 2.9.0 program was used for the visualization of geolocations and the analysis of attributive data.

Main points presented to the defense of the dissertation:

1. Biologically active substances that belong to various chemical groups found in the studied two *Lactuca* L. (lettuce) species (*Lactuca serriola* L., and *L. tatarica* (L.) C. A. Mey.) may contribute to the development of the pharmaceutical industry;
2. Extractive substances obtained from the mentioned species could be used as an antifungal and antibacterial agent against various pathogenic microorganisms;
3. From the economic point of view having a widespread distribution and sufficient stock of the studied plant species in the flora of the Republic of Azerbaijan might be significant.

Scientific novelty of the research: As a result of column chromatography and GC-MS analysis, 31 components were identified from the roots of *L. serriola* species. For the first time, by using micro-steam distillation solid-phase microextraction and GC-MS analysis 40 components were detected from leaves, and 26 components were detected from roots. Using the modified Folch method, 5 lipid compounds were detected from the leaves and 11 lipid compounds were detected from the seeds of *L. serriola* species. As a result of the analysis of *L. tatarica* species by microsteam distillation solid-phase microextraction and GC-MS methods, 34 components were identified from its leaves, 21 from its roots, and 16 from its seeds.

For the first time, the dry extract of the roots of *L. tatarica* species obtained with distilled water demonstrated antimicrobial activity against *Staphylococcus aureus*, the dry extracts of the roots and leaves obtained with ethanol against *Escherichia coli*, *S. aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Candida albicans*, the dry extract obtained with ethanol from the roots against *Bacillus anthracoides*, and the dry extract of the leaves obtained with acetone against *C. albicans* strains. For the first time, the dry extract of the leaves of *L. serriola* species obtained with acetone demonstrated antimicrobial activity against *P. aeruginosa*, the dry extracts of the roots and leaves obtained with ethanol against *S. aureus*, *P. aeruginosa*, *C. albicans*, the dry extract obtained with ethanol from the roots against *B. anthracoides*, the dry extract of the leaves obtained with distilled water against *P.*

aeruginosa and the dry extract of the roots obtained with distilled water against *S. aureus* strains.

Antifungal effect of *L. serriola* and *L. tatarica* species against *Fusarium acuminatum* and *Alternaria solani* fungi, and antifungal effect of dry extracts of both species obtained with ethanol against *Aspergillus flavus*, *F. acuminatum* and *A. solani* fungi were revealed.

For the first time, the stock potential of *L. serriola* species was studied in Lankaran, Masalli, Sabirabad, Saatli, Imishli, Shaki and Qakh regions, and the stock of *L. tatarica* species was studied in Qakh, Lankaran and Masalli regions.

Theoretical and practical significance of the research: In the research work, the experimental results obtained for the first time about the biologically active substances contained in *L. serriola* and *L. tatarica* species and about the antimicrobial effect of these substances against various pathogenic microorganisms, as well as the information about the distribution and stock potential of the plant species in the country, that we have chosen as the research object, are enriching the database in this field. Among the chemical compounds identified in both species, those important in medical practice have been determined, and this information opens new perspectives for further research related to the development of the methodology for obtaining these compounds from the respective species and their application in the pharmaceutical industry. The obtained information about the chemical composition of the species and the species' resource potential can be used in the new edition of the book "Flora of Azerbaijan", as well as in the preparation of the works "The medicinal plants of Azerbaijan".

Approbation of the research.

The results of the scientific research work were presented: at the International scientific conference on "Actual problems of modern nature and economic sciences" (Ganja, 2019), at the scientific conference dedicated to the 130th anniversary of academician A. A. Grossheim on the topic "Innovation and traditions in modern botany" (Baku, 2019), " At the international conference on XI Global science and innovations 2020: Central Asia (Kazakhstan, Nur-Sultan, 2020), at the International congress "Istanbul international modern scientific

research congress - II" (Istanbul, 2021), at the International scientific conference dedicated to the 90th anniversary of the Botanical garden of the Belarusian Academy of Sciences on the topic "Introduction, preservation and use of biological diversity of flora".

16 scientific works related to the dissertation (11 articles, 5 conference materials) have been published. 4 of them have been published in journals that are abstracted and indexed in international databases (Web of Science, Scopus, Pub Med, AGRIS, РИНЦ).

The organization where the dissertation was performed.

The dissertation work was carried out during the years 2017-2023 at the Department of "Plant Resources" of the Institute of Botany, "Microbiological Biotechnology" laboratory of the Institute of Microbiology of the Ministry of Science and Education of the Republic of Azerbaijan, "Medical Microbiology and Immunology" Department of the Azerbaijan Medical University, Anadolu University, Plant, Medicines and Scientific Research and Application Center (Bitki, İlaç ve Bilimsel Araştırmalar Uygulama ve Araştırma Merkezi) and "Pharmacognosy" department of Faculty of Pharmacy of Anadolu University in Eskişehir, Republic of Turkey.

The volume and structure of the dissertation.

The dissertation consisting 169 pages and includes an introduction, 6 chapters, conclusions, proposals and recommendations, a list of references and an appendix. 359 literary sources were used in the dissertation work, 12 of which are in Azerbaijani, 13 in Russian, and 334 in other foreign languages. The dissertation work presents 23 figures and 9 tables. The total number of characters in the dissertation is 192446, the table of contents is 2048, an introduction is 15490, the first chapter is 45463, the second chapter is 12617, the third chapter is 18414, the fourth chapter is 45934, the fifth chapter is 35772, the sixth chapter is 12905, conclusions is 2544, the proposals and recommendations are 1259 characters.

I CHAPTER. LITERATURE REVIEW

In this section of the dissertation, the systematic analysis of the genus *Lactuca* L. is demonstrated in chronological order, as well as

the study of the biologically active substances contained in the species of this genus. Moreover, the use of *Lactuca* L. species in traditional folk medicine and various pharmacological activities is also included[5].

II CHAPTER. MATERIALS AND METHODS OF RESEARCH

2.1. The object and materials of the research.

As research objects *L. tatarica* (L.) C.A.Mey. (blue lettuce) *and L. serriola* L. (prickly lettuce) of the genus *Lactuca* L. (lettuce) of the *Asteraceae* Bercht. & J. Presl family distributed in Azerbaijan, and as research materials the roots and aerial parts of both species (stem, leaf, and seed) were used. Herbarium materials (30 pieces) of the two mentioned species were collected and presented to the Herbarium Fund of the Institute of Botany of the Ministry of Science and Education of the Republic of Azerbaijan.

2.2. Biochemical research methods.

The total extract was separated into fractions using total column chromatography. The verification of the individuality or being at polycomponent composition of the compounds separated from the obtained fractions was determined by the thin layer chromatography method. The qualitative analysis of the total extractive substances and of the components obtained from different fractions has been performed by the "Agilent Technologies 6890N Network" gas chromatograph system equipped with "Agilent Technologies 5975 inert Mass Selective Detector" mass spectrometer, Shimadzu 20A HPLC (high-performance liquid chromatography) system combined with an Applied Biosystems AB Sciex 3200 Q-Trap LC-MS/MS (liquid chromatography-mass spectrometry) that is provided with an ESI (electrospray ionization) source operating in negative ion mode. Micro steam distillation - solid phase micro extraction technology was used for the analysis of volatile compounds. The qualitative analysis of the lipids was carried out by their extraction, methylation of fatty acids, and identification of obtained

[5]İbadullayeva, S. Xalq təbabətinin unudulmuş reseptləri (Qərbi Azərbaycan, Şərqi Zəngəzur və Qarabağ icmaları yaddaşlarından) / S.İbadullayeva. –Bakı: Elm, –2023. –268 s.

methyl esters of the lipid compounds by gas chromatography-mass spectrometry method operating with a flame ionization detector.

The standard mass-spectrometric NIST (US National Institute of Standards and Technology) library was used for component identification [6]. Identifications of substances were confirmed by comparison of their mass spectra using the Wiley-NIST GC/MS Library (Wiley, NY, USA), MassFinder software 4.0 (Dr. Hochmuth Scientific Consulting, Hamburg, Germany)[7], and Adams libraries [8]. Verification of the identified constituents was also demonstrated using the "Başer Library of Essential Oil Constituents" database, which has been set up from chromatographic tests of pure compounds performed under the same equipment and conditions.

2.3. Microbiological research methods.

The disk diffusion method (Kirby-Bauer test) was used to study the antibacterial and antifungal activity of extracts obtained from various parts of the *L. serriola* and *L. tatarica* species[9]. The microorganisms used in the study were: *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, Staphylococcus aureus, *Bacillus anthracoides*, *Candida albicans*. The antifungal activity of the studied species against phytopathogenic fungi (Aspergillus flavus, *Fusarium acuminatum*, and *Alternaria solani*) was carried out using the biomass acquisition method[10].

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[6]NIST/EPA/NIH Mass Spectral Database (NIST 11) and NIST Mass Spectral Search Program (Version 2.0g): [Electronic resource] / ed. Stein S.E. et al.; US Department of Commerce, National Institute of Standards and Technology, Standard Reference Data Program. –Gaithersburg, MD, USA, 2011. URL: http://www.nist.gov/srd/upload/NIST1a11Ver2-0Man.pdf

[7]Hochmuth, D. H. MassFinder 4.0: [Electronic resource] / Hochmuth Scientific Consulting. –Hamburg, Germany, 2008. URL: http://www.massfinder.com

[8] Adams, R.P. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry. Fourth edition / R.P.Adams. – Carol Stream, Illinois: Allured Publishing Corporation, – 2007. – 804 p.

[9] Bauer, A.W. Antibiotic susceptibility testing by a standardized single disk method / A.W. Bauer, W.M.M. Kirby, J.C. Sherris [et al.] // American journal of clinical pathology, – 1966. 45(4), – p. 493–496.

[10] Baxşəliyeva, K.F. Azərbaycanda yayılan toksigen göbələklərin ekobioloji xüsusiyyətləri: / biologiya üzrə elmlər doktoru dis.avtoreferatı. / – Bakı, 2017. – 45 s.

2.4. Botanical research methods.

During the expedition trips, traditional methods were used to determine the productivity, exploitation, and biological resources of raw materials[11].

The distribution area was mapped using the national GPS navigation system AzNav (version 2.6.0.0). Statistical analysis of the results was carried out in MS Excel version 16.0. Esri ArcGIS Pro 2.9.0 software was used for the visualization of geolocations and analysis of the attributive data.

CHAPTER III. BOTANICAL CHARACTERISTICS AND DISTRIBUTION OF SPECIES OF THE GENUS *LACTUCA* L.

3.1. Analysis of the genus.

On Earth, 17 species of the genus *Lactuca* L. have been identified on the European continent, 51 species on the Asian continent, 43 species on the African continent, and 12 species on the American continent[12]. According to the data from 2016, there are 8 species of *Lactuca* L. genus in Azerbaijan, and this also includes lettuce (*L. sativa*), which is a valuable vegetable plant[13].

3.2. Botanical description of species of the genus *Lactuca* L.

The botanical description of *L. serriola* and *L. tatarica* species of the genus *Lactuca* L. is demonstrated based on "Флора Азербайджана" and various literatures, as well as the analysis of herbarium materials that we have collected[14].

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[11] Негробов, В.В. Ресурсоведение лекарственных растений / В.В.Негробов. – Воронеж: Издательский дом ВГУ, – 2015. – 57 с.

[12] Lebeda, A. Geographical distribution of wild Lactuca species (Asteraceae, Lactuceae) / A. Lebeda, I. Dolezalová, V. Feráková [et al.] // The Botanical Review, – 2004. 70, – p.328-356.

[13] Əsgərov, A. Azərbaycan Bitki Aləmi (Ali bitkilər-Embryophyta) / A.Əsgərov. – Bakı: TEAS Press, – 2016. – 444 s.

[14] Флора Азербайджана: [в 8 томах] / Под ред. Р.К. Аскерова, Г.Ф. Ахундов, Я.М. Исаев, И.И. Карягин, Л.И. Ирилипко, Р.М. Софиева. – Баку: Изд-во АН Азербайджанской ССР, – т. 8. – 1961. – 691 с.

CHAPTER IV. QUALITATIVE COMPOSITION OF BIOLOGICALLY ACTIVE SUBSTANCES IN DIFFERENT ORGANS OF *LACTUCA SERRIOLA* L. AND *LACTUCA TATARICA* (L.) C.A. MEY.

4.1. Triterpene derivatives and fatty acid composition of roots of *Lactuca serriola* L. (Prickly lettuce).

The dry extract obtained by the acetonic extraction of the roots of *L. serriola*, collected in the flowering phase from the village of Novkhani, Absheron region, was analyzed by column chromatography. For this purpose, silica gel was used as the stationary phase, and a hexane:benzene mixture in a ratio of (4:1) was used as the eluent. Substances obtained from fractions 7-9 were separated by precipitation in an acetone-water environment and their content was determined by the gas chromatography-mass spectrometry method. Obtained results are demonstrated in Table 1.

Table 1.

List of constituents identified from hexane-benzene fractions of the acetone extract of the roots of *Lactuca serriola*

№	RT, min.	Fragments	Mole-cular weight (g/mol)	Chemical formula	Compound name	% of total:
1	**2**	**3**	**4**	**5**	**6**	**7**
Fatty acid esters and fatty acids						
1	14.395	242, 143, 88, 75, 70, 57, 55, 43, 41	242	$C_{15}H_{30}O_2$	Methyl myristate	0.16
2	16.828	98, 97, 88, 84, 75, 70, 56, 42	268	$C_{17}H_{32}O_2$	Methyl palmitelaidate	0.85
3	17.163	227, 143, 88, 75, 69, 57, 55, 43, 41	270	$C_{17}H_{34}O_2$	Hexadecanoic acid methyl ester	9.42

Table 1: (continued)

1	2	3	4	5	6	7
4	17.675	129, 83, 74, 71, 69, 61, 58, 57, 44, 42	256	$C_{16}H_{32}O_2$	Hexadecanoic acid	0.32
5	19.838	109, 96, 83, 82, 79, 68, 56, 41	294	$C_{19}H_{34}O_2$	Methyl linoleate	11.44
6	19.969	98, 96, 87, 84, 75, 70, 56, 43, 41	296	$C_{19}H_{36}O_2$	Methyl oleate	21.44
7*	20.042	97, 96, 87, 84, 83, 74, 70, 56, 43, 41	296	$C_{19}H_{36}O_2$	Methyl 11-octadecenoate	4.07
8	20.338	298, 255, 199, 143, 88, 75, 57, 55, 43	298	$C_{19}H_{38}O_2$	Methyl stearate	5.03
9	20.504	98, 96, 84, 70, 57, 56, 44	282	$C_{18}H_{34}O_2$	Oleic acid	0.88
10*	20.626	96, 83, 82, 79, 68, 56, 44, 42	294	$C_{19}H_{34}O_2$	7, 10 – octadecadienoic acid, methyl ether	0.42
11*	20.674	96, 83, 82, 69, 68, 56, 55, 42	294	$C_{19}H_{34}O_2$	10, 13-octadecadienoic acid methyl ester	0.2
12*	22.891	109, 97, 96, 83, 82, 70, 69, 68, 56, 41	322	$C_{21}H_{38}O_2$	Methyl eicosa-10, 13 - dienoate	0.27
13*	22.981	292, 98, 96, 84, 74, 70, 67, 56	324	$C_{21}H_{40}O_2$	11-eicosenoic acid methyl ester	0.49
14	23.364	326, 143, 88, 75, 69, 57, 55, 43, 41	326	$C_{21}H_{42}O_2$	Methyl arachidate	0.29
15*	24.753	265, 99, 81, 70, 67, 56, 44, 42, 31	340	$C_{21}H_{40}O_3$	Oleic Acid, 3-hydroxypropyl ester	0.31
Monoacylglycerol						
16*	25.412	265, 98, 84, 82, 70, 68, 57, 56, 44, 42	356	$C_{21}H_{40}O_4$	2-Monoolein	0.22
Dicarboxylic acid esters						
17*	26.161	167, 150, 83, 71, 70, 57, 55, 43, 41	390	$C_{24}H_{38}O_4$	Phthalic acid, bis (6-methylheptyl) ester	0.73
18*	29.512	186, 112, 98, 83, 71, 70, 57, 55, 43	426	$C_{26}H_{50}O_4$	Bisoflex	0.24
Triterpene derivatives						
19*	39.870	219, 203, 189, 136, 110, 96, 82, 69, 44	468	$C_{32}H_{52}O_2$	Olean-12-en-3-yl-acetate	5.34
20	40.137	218, 205, 190, 178, 132, 121, 109, 95	426	$C_{30}H_{50}O$	Germanicol	12.05

Table 1: (continued)

1	2	3	4	5	6	7
21	41.178	190, 122, 110, 108, 96, 94, 82, 70, 56, 44	468	$C_{32}H_{52}O_2$	Lupeol acetate	24.56
22*	43.431	469, 206, 139, 136, 124, 122, 96, 70, 44	468	$C_{32}H_{52}O_2$	13,27-Cycloursan-3-ol, acetate, (3β, 13β, 14β)-	1.28

Note: RT – retention time of compounds.

* – During the literature search, no information was found that the indicated components were obtained from *L. serriola* species.

As seen from the table, fractions 7-9 of the roots of *Lactuca serriola* L. contain 22 compounds. Of the substances identified, 13 are fatty acid esters, 4 are triterpene compounds, 2 are fatty acids, 2 are dicarboxylic acid esters, and one is a monoacylglycerol derivative. The highest relative percentage component was lupeol acetate, at 24.56%.

The content of biologically active substances in the precipitated mass obtained during the acetone extraction of *L. serriola* roots, collected from Vilash village in the Masalli region, was determined by gas chromatography-mass spectrometry. The list of identified components in the analyzed sample is shown in Table 2.

Table 2 shows that a total of 21 components were identified. Among them, 9 were triterpenoid compounds and 8 were fatty acid esters. Additionally, 2 fatty acids and 2 dicarboxylic acid esters were identified.

Table 2.

List of components of the crystalline mass obtained from the acetonic extract of the roots of *Lactuca serriola* determined by the GC-MS method.

№	RT, min.	Fragments	Molecular weight (g/mol)	Chemical formula	Compound name	% of total:
1	2	3	4	5	6	7
Fatty acid esters and fatty acids						
1	16.822	99, 97, 88, 84, 75, 70, 56, 42	268	$C_{17}H_{32}O_2$	Methyl palmitoleinate	0.25

Table 2: (continued)

1	2	3	4	5	6	7
2	17.147	227, 143, 88, 75, 69, 57, 55, 43, 41	270	$C_{17}H_{34}O_2$	Palmitic acid methyl ester	3.10
3	17.660	129, 83, 74, 71, 61, 58, 56, 44, 42	256	$C_{16}H_{32}O_2$	n-hexadecanoic acid	0.21
4	19.815	109, 96, 83, 82, 79, 68, 56, 41	294	$C_{19}H_{34}O_2$	Methyl linoleate	2.47
5*	19.935	97, 96, 87, 84, 83, 74, 70, 56, 44,42	296	$C_{19}H_{36}O_2$	Methyl-trans-oleate	7.17
6*	20.022	97, 96, 87, 84, 83, 74, 69, 56, 41	296	$C_{19}H_{36}O_2$	11-Octadecenoic acid methyl ester	1.45
7	20.325	298, 143, 88, 75, 69, 57, 55, 43, 41	298	$C_{19}H_{38}O_2$	Methyl stearate	1.51
8	20.487	98, 97, 96, 84, 83, 70, 57, 56, 43	282	$C_{18}H_{34}O_2$	Oleic acid	0.37
9*	21.285	109, 96, 95, 82, 81, 79, 69, 68, 55	294	$C_{19}H_{34}O_2$	Methyl 9-cis, 11-trans-octadecadienoate	0.39
10*	22.973	292, 98, 97, 96, 84, 83, 74, 69, 67,55	324	$C_{21}H_{40}O_2$	11-Eicosenoic acid methyl ester	0.16
Dicarboxylic acid esters						
11*	26.161	279, 167, 150, 71, 70, 57, 55, 43, 41	390	$C_{24}H_{38}O_4$	Bis(2-ethylhexyl) phthalate	2.96
12*	29.504	186, 112, 98, 83, 71, 70, 57, 55, 43, 41	426	$C_{26}H_{50}O_4$	Decanedioic acid, bis (2-ethylhexyl) ester	0.18
Triterpene derivatives						
13*	37.086	219, 203, 135, 95, 81, 69, 55, 43, 41	424	$C_{30}H_{48}O$	Olean-12-en-3-one	1.08
14*	37.257	425, 206, 139, 124, 122, 110, 96, 82, 70, 56	424	$C_{30}H_{48}O$	13,27-Cycloursan-3-one	0.70
15*	37.887	467, 392, 255,96,82,70,56, 45, 43	466	$C_{32}H_{50}O_2$	Ursa-9(11),12-dien-3-yl acetate	1.21
16	38.795	110, 96, 94, 82, 70, 69, 68, 56, 44, 42	426	$C_{30}H_{50}O$	Lupeol	0.30

Table 2: (continued)

1	2	3	4	5	6	7
17*	39.863	219, 203, 189, 136, 110, 96, 82, 69, 44	468	$C_{32}H_{52}O_2$	Olean-12-en-3-yl acetate	5.383
18	40.225	218, 205, 190, 178, 132, 121, 109, 95	426	$C_{30}H_{50}O$	Germanicol	27.20
19	41.224	190, 122, 110, 108, 96, 94, 82, 70, 56, 44	468	$C_{32}H_{52}O_2$	Lup-20(29)-en-3-ol, acetate, 3β (lupeol acetate)	37.50
20*	42.609	263, 207, 204, 119, 81, 70, 57, 56, 44, 42	470	$C_{31}H_{50}O_3$	Methyl ursolate	0.67
21*	43.466	469, 206, 139, 136, 124, 122, 110, 96, 70, 44	468	$C_{32}H_{52}O_2$	13,27-Cycloursan-3-ol, acetate, (3β, 13β, 14β)-	5.73

Note: RT – retention time of compounds.

* – During the literature search, no information was found that the indicated components were obtained from *L. serriola* species.

The chemical structures of relatively abundant and medically significant compounds are depicted in Figure 1:

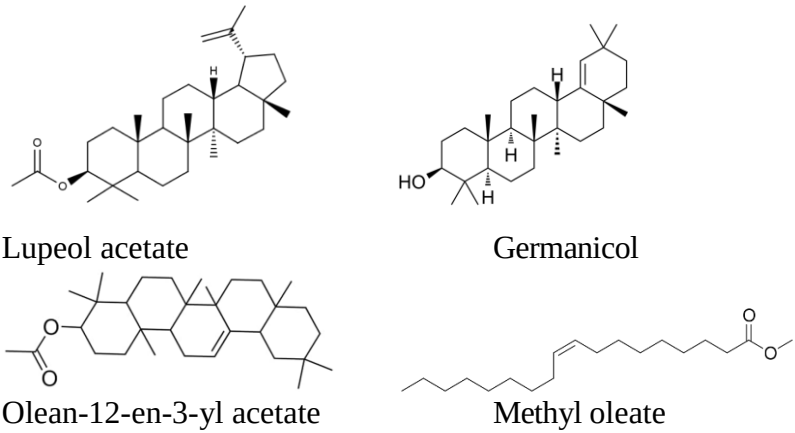


Figure 1. Medically significant compounds from *L. serriola* roots.

4.2. Composition of phenolic components of aerial parts of *Lactuca serriola* L. (Prickly lettuce).

The analysis of the composition of the dry acetonic extract of the above-ground parts of the *L. serriola* species collected from Novkhani village of Absheron region demonstrated in Table 3.

Table 3.

Summary of components identified in the extract of the aerial parts of *Lactuca serriola* species by the LC-MS/MS method.

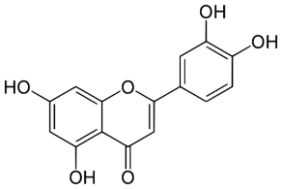
Peak	RT, min	M-H	Molecular ion fragments	Components
1	**2**	**3**	**4**	**5**
1	3.5	195	177, 159, 129	Gluconic acid
2	5.99	198	163	glucose + hexoside
3	8.392	235	189, 167	Unidentified
4	11.744	485	439, 421, 215, 197	Unidentified
5	13.216	353	191, 179, 161, 135	5-caffeoylquinic acid
6	14.031	277	226, 215, 197, 185, 171	Unidentified
7	14.429	401	269, 161, 143	apigenin pentoside
8	15.239	179	135, 117, 109, 107	caffeic acid
9	16.047	277	215, 203, 185, 149, 133, 121	Unidentified
10	16.556	471	425, 225, 179, 113	Unidentified
11	21.01	515	353, 335, 191, 179, 173, 161, 135	3,5-Dicaffeoylquinic acid
12	21.648	357	-	358 molecular weight compound (not fragmented)
13	22.181	447	285, 284, 256, 151, 133	Luteolin glucoside
14	23.014	463	300, 271, 255, 243, 179, 151	Quercetin glucoside
15	24.594	431	268, 161, 135, 133	Apigenin glucoside
16	25.085	461	446, 297, 283, 269, 255	300 molecular weight trimethoxy flovonoid hexoside
17	25.980	543	409, 313, 175, 151, 133, 107	Unidentified

Table 3: (continued)

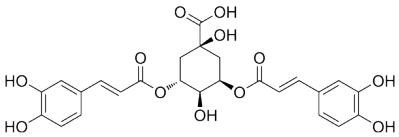
1	2	3	4	5
18	26.849	411	277, 233, 215, 199, 151, 107	Unidentified
19	27.407	257	242, 213, 198, 185, 169, 161	Unidentified
20	29.005	301	227, 183, 163, 151, 121, 107	Quercetin

Note: RT – retention time of compounds.
M-H – molecular mass after the loss of hydrogen (deprotonation) during ionization.

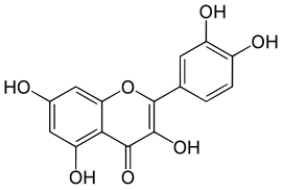
20 compounds were detected from the extract of the aerial parts of *L. serriola* by the LC-MS/MS method. Ten of these compounds were identified, while the others could not be identified as they were not available in the MS device's library. Among the identified compounds, the chemical structures of the medically important ones are shown in Figure 2.



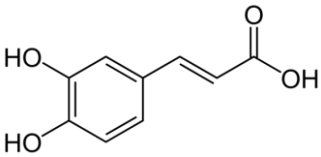
Luteolin ($C_{15}H_{10}O_6$)



3,5-Dicaffeoylquinic acid ($C_{25}H_{24}O_{12}$)



Quercetin ($C_{15}H_{10}O_7$)



Caffeic acid ($C_9H_8O_4$)

Figure 2. Medically important compounds detected in the aerial parts of *L. serriola* species.

4.3. Extraction of volatile compounds from the roots and leaves of *Lactuca serriola* L. (Prickly lettuce) using micro steam distillation - solid phase microextraction technology, and extraction of fatty acids from the leaves and seeds for analysis by the gas chromatography-mass spectrometry method.

The volatile components were identified in the roots and leaves of the *L. serriola* species collected from Vilash village in the Masalli region. Meanwhile, the lipid compounds in the leaves and seeds of the *L. serriola* species were extracted using the modified Folch method. The components identified from both analyses are shown in Table 4.

Table 4.

List of volatile compounds detected in the roots and leaves of *L. serriola* and lipid components identified in the leaves and seeds by the GC-MS method.

№	RRI[a]	Compounds	Composition in leaves[b] (%)	Composition in roots[b] (%)	FAE[c] Composition in leaves (%)	FAE[c] Composition in seeds (%)
1	2	3	4	5	6	7
1*	1092	Hexanal	4,1	4,8		
2*	1157	2-Propenoic acid, butyl ester	1,8	19,1		
3*	1194	Heptanal	1,3			
4*	1198	Isobutyl 3-methyl butyrate (=Isobutyl isovalerate)	0,9			
5*	1230	*n*-Butyl *n*-butyrate		2,8		
6*	1232	(*E*)-2-Hexenal	3,7			
7*	1244	Amyl furan (=2-Pentyl furan)	0,7			
8*	1247	6-Methyl-2-heptanone	0,4			
9*	1255	*(Z)*-4-Hepten-1-al	0,5			
10*	1296	Octanal	1,1	1,3		

Table 4: (continued)

1	2	3	4	5	6	7
11*	1298	2-[(2Z)-2-Pentenyl]furan	0,7			
12*	1304	1-Octen-3-one	0,6			
13*	1328	2,2,6-Trimethylcyclohexanone	1,2			
14*	1335	(*E*)-2-Heptenal	2,4			
15*	1348	6-Methyl-5-hepten-2-one	3,9	1,4		
16*	1358	2- Methyl -2-hepten-4-one	0,3			
17*	1388	4,8-Dimethyl-1,3,7-nonatriene	2,1			
18	1400	Nonanal	3,6	4,7		
19	1400	Tetradecane	0,5			
20*	1441	(*E*)-2-Octenal	2,2	1,1		
21*	1450	*trans*-Linalool oxide (Furanoid)		0,6		
22*	1479	(*E*,*Z*)-2,4-Heptadienal	9,1			
23*	1496	2-Ethyl hexanol		36,9		
24	1506	Decanal	1,5	1,9		
25*	1507	(*E*,*E*)-2,4-Heptadienal	8,2			
26*	1520	3,5-Octadien-2-one	1,4			
27*	1541	Benzaldehyde	4,2	6,0		
28*	1553	Linalool		0,6		
29*	1573	(*E*,*E*)-3,5-Octadien-2-one	0,3			
30*	1599	(*E*,*Z*)-2,6-Nonadienal	1,3			
31	1600	Hexadecane	0,3			
32*	1620	γ-Valerolactone		0,9		
33*	1628	4-methylbenzaldehyde		0,9		
34	1638	β-Cyclocitral	3,5			
35*	1655	(*E*)-2-Decenal		0,5		
36*	1663	Phenylacetaldehyde	18,0			

Table 4: (continued)

1	2	3	4	5	6	7
37*	1671	Acetophenone		1,3		
38*	1678	4-methyl-4-vinyl-butyrolactone		1,5		
39*	1740	Geranial	0,4			
40*	1756	2,5-Dimethylbenzaldehyde	0,3			
41*	1763	Naphthalene		1,0		
42*	1764	*(E)*-2-Undecenal	0,3			
43*	1868	(*E*)-Geranyl acetone	3,5	0,8		
44	1870	Hexanoic acid		1,3		
45	1958	(*E*)-β-Ionone	11,0			
46*	1971	Benzothiazol		2,2		
47*	1995	*trans*-β- Ionone-5,6-epoxide	1,5			
48	2018	Tetradecanoic acid, methyl ester (=Methyl myristate)				0,3
49*	2038	γ-Nonalactone		2,0		
50	2107	Hexahydro-farnesylacetone	0,5			
51*	2179	3,4-Dimethyl-5-pentylidene-2(5H)-furanone	0,6			
52*	2186	Eugenol		1,1		
53*	2218	4-Vinyl guaiacol	0,4			
54	2226	Methyl hexadecanoate (=methyl palmitate)			35,9	10,3
55*	2239	Carvacrol	0,2	0,8		
56*	2242	γ-Asarone		0,7		
57*	2245	Elemicine		0,5		
58*	2323	Methyl margarate (=Methyl heptadecanoate)				0,1
59*	2380	Dihydroactinidiolide	1,3			

Table 4: (continued)

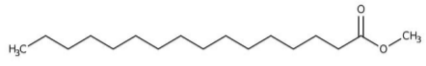
1	2	3	4	5	6	7
60	2431	Methyl octadecanoate (=Methyl stearate)			5,6	3,2
61	2468	(Z)-9-Methyl octadecenoate (=Methyl oleate)				16,1
62*	2469	Methyl elaidate (=Methyl (E)-9-Octadecenoate)				0,8
63	2509	(Z,Z)-9,12-methyl octadecadienoate (=Methyl linoleate)			5,9	57,7
64*	2534	Methyl nonadecanoate			38,3	9,4
65*	2565	Ethyl nonadecanoate				0,5
66	2572	Methyl linolenate (=Methyl (Z,Z,Z)-9,12,15-Octadecatrienoate)			14,3	0,4
67	2634	Methyl arachidate (=Methyl eicosanoate)				1,1

Note:
[a] RRI: relative retention indices calculated against n-alkanes.
[b] Relative percentage amounts of the separated compounds.
[c] FAE – Fatty acid esters.
* – During the literature search, no information was found that the indicated components were obtained from *L. serriola* species.

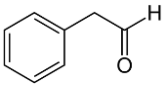
As seen from Table 4, a total of 67 components belonging to different chemical groups were identified. Among these, 16 compounds obtained from leaves belong to aldehydes, 9 compounds to terpenoids, and 7 compounds to ketones. Their relative percentage amounts were 61.8%, 24%, and 8.1%, respectively. Among the volatile compounds determined from the roots of *L. serriola*, 7 components belonged to aldehydes, 3 components to lactones, and 3 components to monoterpenes, with percentages determined to be 20.3%, 4.4%, and 2.2%, respectively.

As a result of lipid analysis, the ratio of saturated to polyunsaturated (S:P) fatty acids in *L. serriola* leaves was 79.8/20.2. Additionally, the ratio of saturated to monounsaturated to polyunsaturated (S:M:P) fatty acids in the seeds was 24.9/16.9/58.1.

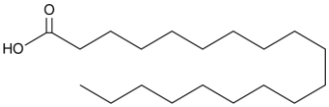
The chemical structures of medically important compounds detected in relatively high amounts are depicted in Figure 3:



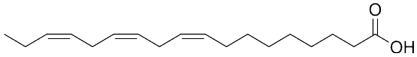
Methyl palmitate ($C_{17}H_{34}O_2$)



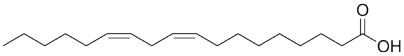
Phenylacetaldehyde (C_8H_8O)



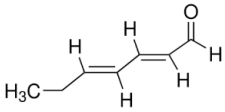
Nonadecanoic acid ($C_{19}H_{38}O_2$)



Linolenic acid ($C_{18}H_{30}O_2$)



Linoleic acid ($C_{18}H_{32}O_2$)



2,4-Heptadienal ($C_7H_{10}O$)

Figure 3. Medically important compounds detected in different organs of *L. serriola* species.

4.4. Extraction of volatile compounds from various parts of the *Lactuca tatarica* (L.) C.A.Mey. (Blue lettuce) plant using micro steam distillation - solid phase micro extraction technology and analysis by the gas chromatography-mass spectrometry method.

The list of components identified in the roots, leaves, and seeds of *L. tatarica* collected from Novkhani village in the Absheron region is shown in Table 5.

Table 5.

List of volatile components identified in roots, leaves, and seeds of *L. tatarica* by GC-MS.

№	RRI[a]	Compounds	Composition in leaves[b] (%)	Composition in roots[b] (%)	Composition in seeds[b] (%)
1	**2**	**3**	**4**	**5**	**6**
1	1093	Hexanal	1,8	18,0	6,3
2	1194	Heptanal	0,7		
3	1203	Limonene	0,5		
4	1213	1,8-Cineole		3,5	
5	1280	p-Cymene		4,9	
6	1296	Octanal			1,6
7	1341	(Z)-2-Heptenal	1,6		
8	1348	6-Methyl-5-hepten-2-one	3,6		
9	1360	Hexanol		1,9	3,8
10	1400	Nonanal	4,1	8,5	16,3
11	1416	3-Octen-2-one			1,1
12	1431	4,8-Dimethyl-1,3,7-nonatriene	1,8		
13	1441	(*E*)-2-Octenal	1,8	1,7	1,2
14	1451	o-Methylanisol (=1-Methoxy-2-methylbenzene)		0,7	t
15	1474	6,10-Dihydromyrcenol			2,6
16	1479	(*E*,*Z*)-2,4-Heptadienal	10,6		
17	1506	Decanal	2,2	1,4	4,0
18	1507	(*E*,*E*)-2,4-Heptadienal	7,6	1,3	
19	1523	3,5-Octadien-2-one		1,0	0,6
20	1535	(E,Z)-3,5-Octadien-2-one	3,5		
21	1538	*trans*-Chrysanthenyl acetate		8,1	

Table 5: (continued)

1	2	3	4	5	6
22	1541	Benzaldehyde	3,3	4,1	4,7
23	1553	Linalool	3,4	5,1	8,9
24	1572	2-tert-butyl-Cyclohexanol	4,0		
25	1573	(*E*,*E*)-3,5-Octadien-2-one	1,9		
26	1608	6-Methyl-3,5-heptadiene-2-one	1,0		
27	1611	Undecanal			3,0
28	1621	2-tert-butyl-Cyclohexanol isomer*	2,6		
29	1638	b-Cyclocitral	1,5		
30	1641	Methyl benzoate		1,0	
31	1663	Phenylacetaldehyde	13,3		
32	1671	Acetophenone	4,3	13,4	15,1
33	1711	Styrallyl acetate (=1-Phenylethyl acetate)	0,3	3,1	2,6
34	1722	Dodecanal	0,8		
35	1792	*4-tert*-butyl-Cyclohexanol*	3,00		
36	1838	(*E*)-b-Damascenone	0,4		
37	1845	(*E*)-Anethol		0,4	
38	1868	(*E*)-Geranyl acetone	1,8		
39	1958	(*E*)-b-Ionone	2,1		
40	1999	*trans*-b-Ionone-5,6-epoxide	0,2		
41	2021	Diphenyl oxide (=Diphenyl ether)	5,2	9,7	9,0
42	2047	Isoamyl salicylate	1,2	0,7	
43	2112	Amyl salicylate	1,2	1,1	
44	2133	Phenoxy ethyl isobutyrate*	0,6		

Table 5: (continued)

1	2	3	4	5	6
45	2179	3,4-Dimethyl-5-pentylidene-2(5H)-furanone	0,5		
46	2193	Methoxynaphthalene	0,8	1,6	

Note:

[a] RRI: relative retention indices calculated against n-alkanes.

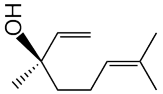
[b] Relative percentage amounts of the separated compounds.

[t] components with an amount of less than 0.1%.

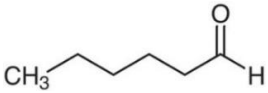
* tentatively identified components.

As seen from Table 5, a total of 46 components belonging to different chemical groups were identified. In general, the leaves were characterized by having more volatile compounds than the roots and seeds. Thus, 34 volatile compounds were identified from leaves, 21 from roots, and 16 from seeds. Among the compounds obtained from the leaves, 11 belong to aldehydes, 8 to terpenoids, 6 to benzenoids, and 5 compounds to ketones, and their relative percentage amounts were 47.8%, 11.7%, 9.3%, and 14.3%, respectively. Of the 21 volatile compounds identified from *L. tatarica* roots, 6 components belong to aldehydes, 6 components to benzenoids, 4 components to terpenoids, and 2 components to ketones, with relative percentage amounts of 35%, 17.2%, 21.6%, and 14.4%, respectively. While the amount of aldehydes in the leaves of *L. tatarica* was higher than in the roots, terpenoids were quantitatively higher in the roots. Of the 16 volatile compounds identified from *L. tatarica* seeds, 7 components belong to aldehydes, 3 components to ketones, 2 components to benzenoids, and 1 component to terpenoids, with relative percentages of 37.1%, 16.8%, 11.6%, and 8.9%, respectively. Among the compounds obtained by the MSD-SPME method from *L. serriola* and *L. tatarica* species, 21 components were found to be in common. During the literature search, none of the components we identified had been previously reported to have been obtained from *L. tatarica* species.

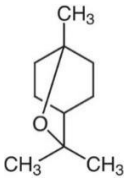
The chemical structures of medically significant compounds detected in relatively high amounts are depicted in Figure 4:



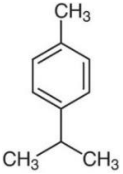
Linalool ($C_{10}H_{18}O$)



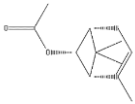
Hexanal ($C_6H_{12}O$)



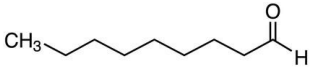
1,8-Cineole (eucalyptol) ($C_{10}H_{18}O$)



p-Cymene ($C_{10}H_{14}$)



trans-Chrysanthenyl acetate ($C_{12}H_{18}O_2$)



Nonanal ($C_9H_{18}O$)

Figure 4. Medically important compounds detected from various organs of *L. tatarica* species.

CHAPTER V. STUDY OF THE ANTIBACTERIAL AND ANTIFUNGAL PROPERTIES OF EXTRACTS FROM DIFFERENT ORGANS OF *LACTUCA TATARICA* (L.) C.A.MEY. AND *LACTUCA SERRIOLA* L. SPECIES.

5.1. Antibacterial and antifungal activity of dry extracts of *Lactuca serriola* L.

The roots of the *L. serriola* species collected from the Azizabad village of the Masalli region were extracted with distilled water and 96% ethanol, while the leaves were extracted with acetone along with the aforementioned solvents. The stock solutions prepared from these extracts were used for antimicrobial activity assay. The results are shown in Table 6.

Table 6.

The diameter of the zone of inhibition caused by various extracts obtained from the *L. serriola* plant on microorganisms (mm).

Test-cultures	Diz / D_{sddm}								
	Aqueous extract		Ethanolic extract		Acetonic extract	Negative control		Positive control	
	Root	Leaf	Root	Leaf	Leaf	DMSO	distilled water	Furacilin 20 mg	Nystatin 250000 IU
Escherichia coli	– / –	– / –	– / –	– / –	– / –	– / –	– / –	9±1/ –	– / –
Pseudomonas aeruginosa	– / –	–/36±2	–/39±4	–/25±3	–/19±1	– / –	– / –	10±2/ –	– / –
Klebsiella pneumoniae	– / –	– / –	– / –	– / –	– / –	– / –	– / –	10±1/ –	– / –
Staphylococcus aureus	– / 26 ±3	– / –	27±3/ –	15±2/ –	– / –	– / –	– / –	9±2/ –	– / –
Bacillus anthracoides	– / –	– / –	–/12±1	– / –	– / –	– / –	– / –	– / –	– / –
Candida albicans	– / –	– / –	12±1/ –	–/13±1	– / –	– / –	– / –	– / –	18±3 / –

Note: D_{iz} – The diameter of the inhibition zone in mm

D_{sddm} – The diameter of a sharp decrease in the development of microorganisms (mm)

According to Table 6, the diameter of inhibition zones observed for the studied dry extracts against susceptible microorganisms ranges from 12 to 39 mm.

5.2. Antibacterial and antifungal activity of dry extracts obtained from different parts of *Lactuca tatarica* (L.) C. A. Mey plant.

The roots of *L. tatarica* collected from Novkhani village of Absheron region were extracted with distilled water and 96% ethanol, while the leaves were extracted with acetone, in addition to the aforementioned solvents. The stock solutions prepared from these extracts were used for the antimicrobial activity assay. The results are shown in Table 7. As indicated in Table 7, the diameter of the inhibition zones caused by the studied dry extracts against the development of susceptible microorganisms varies from 6 to 12 mm.

Table 7.

The dependence of the diameter of the inhibition zone caused by various extracts obtained from *L. tatarica* plant on microorganisms (mm) on the dose of the extract.

Test - cultures	Aqueous extract				Ethanolic extract				Acetonic extract		Negative control	
	Roots	Roots	Leaves	Leaves	Roots	Roots	Leaves	Leaves	Leaves		DMSO	Distilled water
	The dosage of the extract											
	1.05 mg/disk	525 µg/disk	1.05 mg/disk	525 µg/disk	1.05 mg/disk	525 µg/disk	1.05 mg/disk	525 µg/disk	1.05 mg/disk	525 µg/disk		
Escherichia coli	–	–	–	–	8±2	7±1	7±1	10±2	–	–	–	–
Pseudomonas aeruginosa	–	–	–	–	–	7±1	9±2	7±1	–	–	–	–
Klebsiella pneumoniae	–	–	–	–	10±1	12±2	–	6±1	–	–	–	–
Staphylococcus aureus	8±1	9±1	–	–	10±2	–	9±1	7±1	–	–	–	–
Bacillus anthracoides	–	–	–	–	11±1	10±1	–	–	–	–	–	–
Candida albicans	–	–	–	–	8 ±1	9±1	7±1	12±2	11±2	7±1	–	–

5.3. Antifungal effect of extracts obtained from aerial organs of *Lactuca tatarica* (L.) C. A. Mey. and *Lactuca serriola* L. species against some phytopathogens.

The aerial parts of both species, collected from Novkhani village, Absheron region, were extracted with 96% ethyl alcohol. The effect of dried plant raw materials and the sum of the extractive substances obtained from them on the development of microscopic fungi *Aspergillus flavus*, *Fusarium acuminatum*, and *Alternaria solani* was determined. The obtained results are illustrated in Figures 5 and 6.

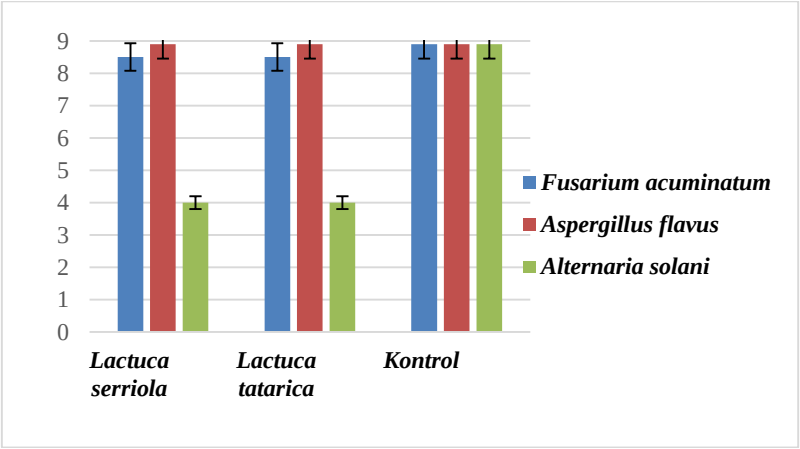


Figure 5. Effect of plant material on fungal development.

The most pronounced effect was observed against the fungus *A. solani*, with both investigated parts of the plant species generating a 50 mm diameter inhibition zone against its development.

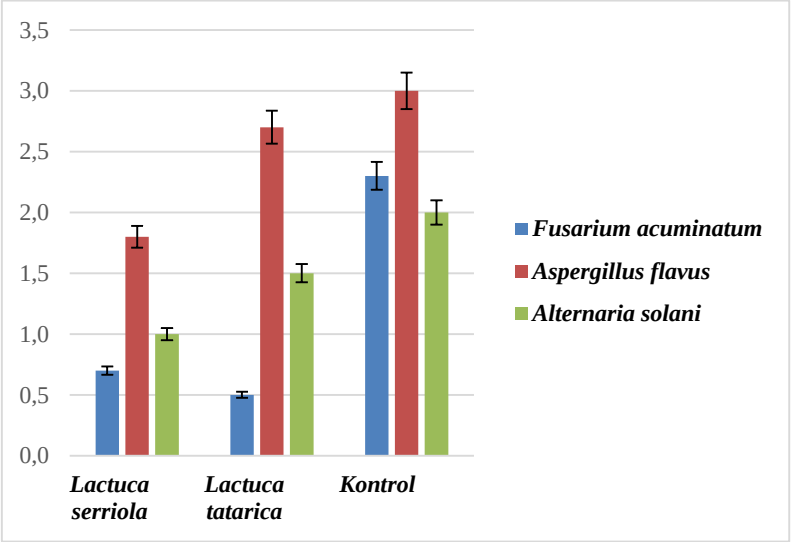


Figure 6. The effect of plant extractive substances on fungal development.

In all three fungal cultures, fungal growth was relatively low compared to the control. The strongest effect of *L. tatarica* and *L. serriola* extracts was observed against the *F. acuminatum* strain, resulting in 0.5 and 0.7 g/l development, respectively.

CHAPTER VI. RESERVE OF *LACTUCA TATARICA* (L.) C.A.MEY. AND *LACTUCA SERRIOLA* L. (ASTERACEAE) SPECIES IN SOME REGIONS OF AZERBAIJAN

The biological and exploitational resources of both species have been determined in different regions of the Republic of Azerbaijan. GPS data of the explored zones were recorded and mapped (Figure 7, Figure 8).

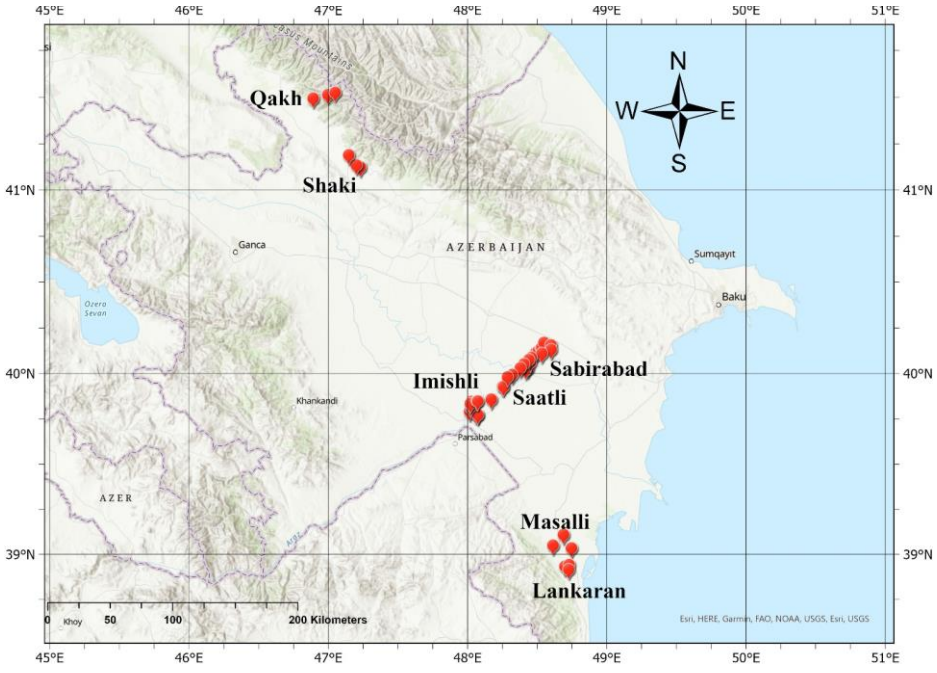


Figure 7. Explored resource area of the *L. serriola* species

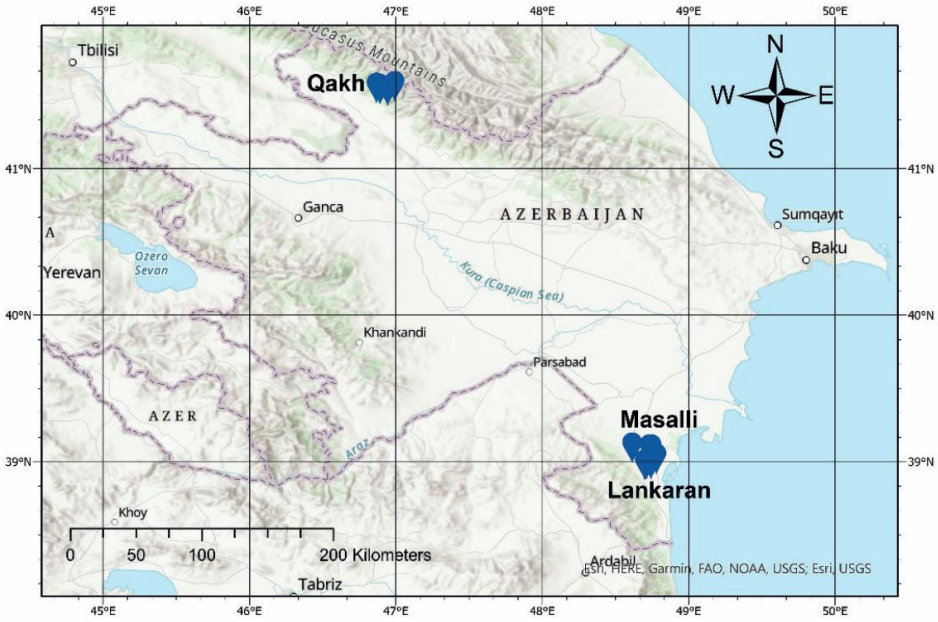


Figure 8. Explored resource area of the *L. tatarica* species

In general, the reserve values of the *L. serriola* species were determined through calculations conducted in 7 regions and 37 different villages. It was determined that the highest exploitational reserve values per 0.1 hectare unit of land were sequentially in the Saatli, Imishli, and Sabirabad regions, with values of 0.55 t, 0.42 t, and 0.38 t, respectively.

Reserve values of *L. tatarica* species were determined based on our calculations in 3 regions and 11 different villages. As a result, the exploitational reserve values per 0.1 hectare unit were determined at decreasing rates in the Masalli, Lankaran, and Qakh regions (0.16 t, 0.117 t, and 0.112 t, respectively). Thus, the central Aran regions were found to have a higher stock of *L. serriola* species compared to the mountainous areas located at higher elevations above sea level.

CONCLUSIONS

1. As a result of the analysis of the roots of *Lactuca serriola* species 31 different components have been identified, of which 16 were fatty acid esters, 9 were triterpene compounds, two were fatty acids, three were dicarboxylic acid esters, and one was a monoacylglycerol derivative [1, 3, 4].

2. As a result of the analysis of the aerial parts of *L. serriola* species, 10 biologically active substances such as gluconic acid, glucose (+hexoside), 5-caffeoylquinic acid, apigenin pentoside, caffeic acid, 3,5-dicaffeoylquinic acid, luteolin glucoside, quercetin glucoside, apigenin glucoside, quercetin were identified [8, 10].

3. During the analysis of the volatile compounds of the roots and leaves, and the fatty acids of the leaves and seeds of the *L. serriola* species, 67 various compounds were identified. 52 of them were encountered for the first time of this species. Among the detected components, the relative percentage amounts of phenylacetaldehyde, (E)-β-ionone, (E,E)-2,4-heptadienal, and 2-ethyl hexanol were higher [16].

4. As a result of the analysis of volatile compounds in the roots, leaves, and seeds of *Lactuca tatarica* species, 46 components were identified. Of these, 43 were encountered for the first time in this species. Higher relative percentages of hexanal, nonanal, diphenyl ether, linalool, and p-cymene were observed in this species [2, 5, 6, 7, 13].

5. Dry aqueous, ethanolic extract of *L. serriola* roots and ethanolic extract of leaves showed antibacterial effect against *Staphylococcus auerus*, aqueous, ethanolic, acetonic extract of leaves and ethanolic extract of roots showed antibacterial effect against *Pseudomonas aeruginosa*, ethanolic extract of roots showed antibacterial effect against *Bacillus anthracoides*, ethanolic extract of roots and leaves showed antifungal effect against *Candida albicans*. Dry aqueous extract of *L. tatarica* roots showed an antibacterial effect against *S. aureus*, ethanolic extract of roots showed an antibacterial effect against *B. anthracoides*, ethanolic extract of roots and leaves showed an antibacterial effect against *Escherichia coli*, *P.*

aeruginosa, *S. aureus*, *Klebsiella pneumoniae*, ethanolic extract of roots and ethanolic, acetonic extracts of leaves showed an antifungal effect against *C. albicans* [11, 15].

6. *L. tatarica* and *L. serriola* species showed antifungal activity against *F. acuminatum* and *A. solani*, and ethanolic dry extracts of the aerial parts of these plants showed the same effect against the aforementioned fungi, along with *A. flavus* [14].

7. The biological reserve of *L. serriola* species in Imishli, Saatli, Sabirabad, Lankaran, Masalli, Shaki and Qakh regions was determined to be from 128.39 tons to 0.56 tons, and the exploitation reserve was from 75.83 tons to 0.34 tons. It was determined that the biological reserve of *L. tatarica* in Masalli, Lankaran, and Qakh regions is from 1.67 tons to 0.42 tons, and the exploitation reserve is from 1.12 tons to 0.27 tons [9, 12].

PROPOSALS AND RECOMMENDATIONS

1. A high proportion of hexanal was found in the roots of *Lactuca tatarica* species. Hexanal has been approved as a food additive by the US Food and Drug Administration. High amounts of phenylacetaldehyde were detected in the leaves of both species. Based on these findings, the use of both species as sources of raw materials in the food and perfumery industries is recommended.

2. A high amount of β-ionone was found in the leaves of *Lactuca serriola*, and considering its antiproliferative and antimetastatic effects, it is recommended to use it in the preparation of anticancer medicines.

3. The anti-inflammatory activity of lupeol acetate obtained from the roots of the *L. serriola* species, its inhibitory effect on the development of rheumatoid arthritis, and its effectiveness in the skin regeneration process, as well as the antimicrobial, anti-diabetic, and anti-amylase inhibitory effects of olean-12-en-3-yl acetate, justify recommending the use of these compounds in the pharmaceutical industry, due to their presence and high amounts in the roots of this species.

4. Considering the inhibitory effect of the ethanolic dry extracts obtained from the roots and aerial parts of L. tatarica and *L. serriola* species on the development of pathogenic microorganisms (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Candida albicans*), it is recommended to use these extracts and their compounds in the composition of antimicrobial preparations.

THE LIST OF SCIENTIFIC PUBLICATIONS

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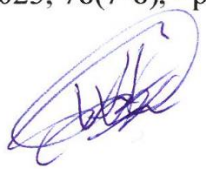

The defense of the dissertation will be held on 25th June 2024 at 03:00 PM at the meeting of the Dissertation Council ED 1.25 operating at the Institute of Molecular Biology and Biotechnologies, Ministry of Science and Education of the Republic of Azerbaijan.

Address: 11 Izzat Nabiyev, AZ1073, Baku.

The dissertation is accessible in the Library of the Institute of Molecular Biology and Biotechnologies, Ministry of Science and Education of the Republic of Azerbaijan.

Electronic versions of the dissertation and its abstract are available on the official website (https://www.imbb.az/) of the Institute of Molecular Biology and Biotechnologies, Ministry of Science and Education of the Republic of Azerbaijan.

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