Chemical composition and biological activity of *Zosima absinthifolia* (*apiaceae*)

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Zosima absinthifolia (Vent.) Link is a perennial herb and is found in Iran, Turkey, Iraq and different countries of the Caucasus, Middle East and Central Asia. It is the only member of *Zosima* genus growing in Azerbaijan. It has been used as a medicinal plant since ancient time in Iran, Turkey and Pakistan. The fruits are used as a food flavoring and as a food spice in Iran. The knowledge of *Z. absinthifolia* organs containing a great number of bioactive compounds is of high importance. The aim of this study is to sum up literature data on the results of experimental studies of the chemical composition and biological activity of *Z. absinthifolia*. The results of the chemical study of *Z. absinthifolia* show that fruits, roots, seeds, flowers and other aboveground parts of plants are rich in various biologically active substances such as coumarins, furocoumarins, pyranocoumarins, flavonoids, monoterpenes, sesquiterpenes and etc. Chemical components that isolated from different organs of *Z. absinthifolia* have allelopathic, high antibacterial, antifungal, antioxidant, anti-inflammatory and other properties. Some of the chemical constituents have substantial pharmacological properties. It is clear that *Z. absinthifolia* has significant potential for useful natural supplements in many contemporary diseases.

Keywords: *Zosima* a*bsinthifolia;* chemical composition; biological activity; essential oil; coumarin.

Zosima absinthifolia (apiaceae) химиялық құрамы және биологиялық қызметі

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Zosima absinthifolia (Vent.) Link – Иранда, Түркияда, Ирактa және Кавказ, Таяу Шығыс пен Орта Азияның түрлі елдерінде кездесетін көпжылдық шөп. Бұл Әзірбайжанда өсетін *Zosima* тұқымының жалғыз өкілі. Ол ежелгі дәуірден бастап Иран, Түркия және Пәкістанда дәрілік өсімдік ретінде қолданылған. Жемістер Иранда тағамдық хош иістендіргіш және тағамдық дәмдеуіш ретінде қолданылады. Көптеген биоактивті қосылыстары бар *Z. absinthifolia* ағзаларын білу үлкен маңызға ие. Бұл жұмыстың мақсаты – *Z. absinthifolia* химиялық құрамы мен биологиялық белсенділігін эксперименттік зерттеу нәтижелері бойынша әдеби деректерді жалпылау болып табылады. *Z. absinthifoli*a химиялық зерттеу нәтижелері өсімдіктердің жемістері, тамырлары, тұқымдары, гүлдері және басқа да жер үсті бөліктері кумариндер, фурокумариндер, пиранокумариндер, флавоноидтар, монотерпендер, сесквитерпендер және т.б. сияқты әртүрлі биологиялық белсенді заттарға бай екенін көрсетеді. Химиялық компоненттер әртүрлі *Z. absinthifolia* мүшелерінен оқшауланған, аллопатикалық, жоғары антибактериалды, саңырауқұлаққа қарсы, антиоксидантты, қабынуға қарсы және басқа да қасиеттерге ие. Кейбір химиялық компоненттер айтарлықтай фармакологиялық қасиеттерге ие. *Z. absinthifolia* қазіргі кезеңдегі көп таралған сырқаттарда пайдалы табиғи қоспалар ретінде айтарлықтай потенциалға ие екені анық.

Түйін сөздер: *Zosima* жусан жапырағы; химиялық құрам; биологиялық белсенділік; эфир майы; кумарин.

Химический состав и биологическая активность *Zosima absinthifolia (apiaceae)*

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Zosima absinthifolia (Vent.) Link — многолетнее травянистое растение, встречается в Иране, Турции, Ираке и различных странах Кавказа, Ближнего Востока и Средней Азии. Это единственный представитель рода *Zosima*, произрастающий в Азербайджане. Он использовался как лекарственное растение с древних времен в Иране, Турции и Пакистане. Плоды используются в качестве пищевого ароматизатора и пищевой приправы в Иране. Большое значение имеет знание органов *Z. absinthifolia*, содержащих большое количество биоактивных соединений. Целью настоящей работы является обобщение литературных данных по результатам экспериментальных исследований химического состава и биологической активности *Z. absinthifolia.* Результаты химического изучения *Z. absinthifolia* показывают, что плоды, корни, семена, цветки и другие надземные части растений богаты различными биологически активными веществами, такими как кумарины, фурокумарины, пиранокумарины, флавоноиды, монотерпены, сесквитерпены и др. Химические компоненты выделенные из различных органов *Z. absinthifolia*, обладают аллелопатичными, высокими антибактериальными, противогрибковыми, антиоксидантными, противовоспалительными и другими свойствами. Некоторые из химических компонентов обладают существенными фармакологическими свойствами. Ясно, что *Z. absinthifolia* обладает значительным потенциалом в качестве полезных натуральных добавок при многих современных заболеваниях.

Ключевые слова: *Zosima* полуннолистная; химический состав; биологическая активность; эфирное масло; кумарин.

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1. Introduction

Zosima absinthifolia (Vent.) Link belongs to *Zosima* Hoffm. genus of the *Apiaceae* family and is a perennial dense deciduous plant. The genus includes 10 species distributed from Arabia to Baluchistan (Pakistan) in the Caucasus, Central Asia, and Asia Minor. In the Caucasus and Azerbaijan, genus is represented by a species of *Z. absinthifolia*. It as an ordinary plant is distributed in various botanical-geographical regions of Azerbaijan (Absheron, Gobustan, Khazar lowland, Kur-Araz lowland, central, South Caucasus, Nakhchivan, Diabar), from lowland to middle mountainous areas. It is often found in wormwood semi-deserts, dry clay soils, dry rocky and rocky slopes [1-3]

Z. absinthifolia is known as a medicinal plant in Iran, Turkey, Pakistan, etc. since ancient times. In folk medicine, fruits, flowers, and aerial parts of plants are used. In Turkish folk medicine, the mixture made from the leaves is used in the treatment of diabetes [4-6]. In the Kalat and Khudzar districts of Pakistan's Balochistan province, the plant seed extract has an effective effect against coughs and other sore throats in children, and from the aerial parts against gastrointestinal, cough and other diseases [7-9]. Aqueous infusion of the flowers of the plant is used as a hemostatic agent in internal bleeding [10]. Another factor is the use of *Z. absinthifolia* fruits and aerial parts as a sedative in traditional medicine [11].

The medicinal and nutritional features of *Z. absinthifolia* are due to the presence of various groups of compounds-flavonoids, coumarins, mono-, sesquiterpenes, various groups of biologically active substances, essential oils in it.

A number of literature data show that the chemical components isolated from *Z. absinthifolia* have antibacterial, antioxidant, anti-inflammatory, allergic, antifungal and other biological properties. Biological activity and use of various organs of *Z. absinthifolia* in traditional medicine mainly depend on the quantity of different groups of biologically active components in plant.

2. Main part. Chemical composition of *Z. absinthifolia*

Z. absinthifolia plant material collected from different places contains essential oil, flavonoids, coumarin, etc. have been found to contain biologically active substances such as.

2.1 Essential oil

Many biological features of *Z. absinthifolia* are associated with the presence of essential oil in various organs. Quantitative composition of essential oil was in terms of dry raw materials in flowers – 0.11%, in the aerial parts during flowering – 0.26%, in leaves – 0.08%, in the green parts of stems – 0.037%, in green leaves – 0.08%, in small green fruits – 0.55%, 1.4-1.8% in immature large fruits, 1.3% and 0,9-1,6% in ripe fruits and 0.72% in dried fruits [12,45].

The oil obtained from the fruits of samples taken from Azerbaijan had a multi-component composition, the main components of which was octyl alcohol, octyl butyrate and octyl acetate [12,13].

An analysis of the literature on the amount and composition of essential oils shows that it depends on plant growth and soil-climatic conditions.

A study of the composition of the essential oil in different areas shows that both the main and the minor components quantity change significantly (Table 1).

In the essential oil obtained from the fruits distilled by hydro-distillation of samples collected from Turkey, octyl acetate (38.4%), octyl hexanate (31.9%), octanol (12.9%), nonane – 27.1%, α-pinene 12.7% and germacrene B-10.3%. were dominant [14]. Another group of scientists in Turkey studied the composition of the essential oil and determined

Table 1 – Component composition of essential oil of *Z. absinthifolia* in different areals

Components	Content in essential oil				
	Turkey, %	Cyprus, %	Iran, %	Azerbaijan, %	References
1	2	3	4	5	6
Octylbutyrate	2.0	1.0	0.27	5.1, 0.97, 9.47	[12, 14, 16, 19, 41, 42]
Octyl acetate	38.4, 1.0, 19.9, 81.6	63.2	3.8, 87.48, 7.52, 10.5, 59.72, 66.82, 69.69	79.7, 89.44, 44.76	[12, 14-19, 41, 42]
Octyl hexanoate	31.9, 0.6, 0.2	19.8	4.5	0.06, 0.12	[14-17, 41, 42]
Octanol	12.9, 2.8, 4.6, 3.2	2.2	9.6, 2.16, 3.12, 7.62, 14.22, 17.06	19.1	[12-17, 19]
α-pinene	0.2, 1.3, 2.2, 0.1		1.1, 7.08, 2.23, 1.38, 0.11	0.08, 0.22	[14-17, 19, 41, 42]
β-pinene	8.9		0.1, 5.32, 2.12, 0.31, 0.21	0.02	[15, 17, 19, 41]
p-cymene	2.2, 0.1		0.99, 0.37		[15, 16, 19]
β-bourbonene	0.2, 0.1, 0.3		2.95, 0.69, 0.45	0.05, 0.72	[14-16, 19, 41, 42]
Linalool	0.4, 0.4, 0.2		1.8, 0.19, 0.17		[14, 15, 17, 19]
Limonen	2.7, 1.5, 0.1		3.28, 0.7		[15, 19]
Octanal	1.0, 2.5, 0.2	0.3	0.2, 1.27, 0.8	0.68, 1.29	[14-17, 19, 41, 42]
Germacren-d	0.2, 2.0, 0.5	0.1	13.42, 4.14, 1.59, 0.38	4.54	[14-17, 19, 42]
Octyl octanoate	6.0, 0.8, 0.9	9.2	5.03		[14-16, 18]
Germakren B	10,3				[14]
2-Nonanon	2.6				[15]
Hexadecanoic acid	0.3, 1.3, 0.5	0.4	0.8, 0.15, 0.52		[14-17, 19]
Ostol	1.5		0.4		[14, 17]
Camphene	0.1		0.2, 2.99, 1.66, 0.92, 0.9, 0.1		[15, 17, 19]
Sabinene	0.1		0.1, 3.43, 1.26, 0.31, 0.2, 0.1		[15, 17, 19]
Myrcene	3.0, 1.3		0.9		[15, 17]
β-phellandrene	0.4, 0.7, 0.1		1.1		[15, 17]
(Z) -4-octenyl acetate	0.5, 5.1	0.5			[15, 16]
Bornyl acetate	0.3, 1.3, 0.2		1.5, 1.54, 0.62, 1.06, 1.36, 0.53	1.07, 0.67	[15, 17, 19, 41, 42]
β-caryophyllene	0.2, 1.0, 0.2	0.5	13.9, 7.84, 5.47, 2.57, 0.77	0.26	[15-17, 19, 41]
Myrtenal	1.5		0.2		[15]
(E)-2-Decenal	26.7, 0.1		0.1, 0.34		[15, 17]
trans-pinocarvyl acetate	1.4, 0.1, 26.7				[15, 17, 19]
trans piperitol	0.4				[15]
Myrtenyl acetate	0.9				[15]
α-terpineol	0.3		0.1, 0.41, 0.28	0.05	[15, 17, 19, 41]
cis-piperitol	0.5				[15]
Citronellol	0.4				[15]
(E, E) -2,4-decadienal	0.9				[15]
Myrtenol	0.6				[15]
Cuparene	0.6, 0.1				[15]
(Z) -4-octenyl hexanoate	0.7	0.1			[15, 16]
Geranyl acetone	1.4, 0.1				[15]
2,5-dimethoxy-p-cymene	3.6				[15]
Caryophyllene oxide	0.8, 0.4, 0.1	0.2	5.7, 1.10, 5.87, 1.85, 0.5		[15-17, 19]
Spatulenol	0.5, 0.1	0.1	2.46, 2.68, 2.63, 1.05	0.71	[15, 16, 19, 42]
α-cadinol	0.6				[15]

Table 1 – Component composition of essential oil of *Z. absinthifolia* in different areals (Continued)

1	2	3	4	5	6
(2E, 6E) – Farnesyl acetate	2.3		0.15, 0.52, 0.8, 0.15, 0.52		[15, 17, 19]
(2E, 6E) –Farnesal	0.4				[15]
Tricosan	0.7	0.4	0.4		[15-17]
(2E, 6E) –Farnesol	1.7			0.38	[15, 43]
Heptacosan	0.5				[15]
Dodecanoic acid	0.2	0.7			[15, 16]
Phytol	0.5			0.22	[15, 42]
Tetradecanoic acid	1.0	0.8			[15, 16]
Bicyclogermacrene		0.1	2.3		[16, 17]
Octyl heptanoate		18.6			[16]
Geranial			2.0		[17]
δ-elemene			0.1, 2.49, 1.15, 0.95, 0.43		[17, 19]
Geranyl butyrate			1.5		[17]
Caryophylla-4 (14), 8 (15) diene-5β-ol			0.6		[17]
geranyl valerate			9.6		[17]
(E)–sesquilavandulyl acetate			1.9		[17]
3-methyl nonane			6.07, 2.65		[19]
Cineole			0.36	0.52	[19, 41]
β-ocimene	0.4		0.4, 4.82, 1.06, 0.28	0.12	[15, 17, 19, 41]
Myrcene			2.64, 1.21		[19]
1-hexyl-3-methyl cyclopentane			2.92, 1.15		[19]
3-methylundecane			4.71, 1.11, 0.1, 0.18, 0.1		[19]
Camphor			35.24		[19]
Borneol			2.76		[19]
(4)-Decen-1-ol			1.89, 0.34		[19]
Hexyl Hexanoate			0.52, 0.7, 0.78		[19]
Geranyl acetate			0.31		[19]
Decenyl acetate			0.59, 5.02, 4.4, 0.31		[19]
N-octyl 2-methylbutyrate			0.41, 0.92, 0.4, 0.68, 0.71		[19]
β-Selinene			1.73, 1.37		[19]
β-Eudesmol			0.71, 1.84		[19]
α-Bisabolol oxide B			1.45		[19]
Octadecanal			0.1, 2.12, 4.06, 6.09		[19]
α-bisabolol			0.85, 0.57, 0.38		[19]
Meta-cymene				0.02	[41]
Cyclopropane, pentyl				4.79, 13.88	[41, 42]
L-4-terpineol				0.04	[41]
Decanal				0.08	[41]
α-copaene				0.05, 0.58	[41, 42]
β-copaene				0.03, 0.27	[41, 42]
Eicosane				0.08, 0.04	[41, 42]
γ-terpinene				0.06	[42]

Table 1 – Component composition of essential oil of *Z. absinthifolia* in different areals (Continued)

1	2	3	4	5	6
β-elemene					[42]
γ-pironene				3.03	[42]
α-Cubebene				0.06	[43]
β-Cubebene				0.24	[43]
Ylangene				0.06	[43]
β-Yglanene				5.32	[43]
Cedrene				2.45	[43]
α-Muurolene				0.21	[43]
γ-cadinene				0.89	[43]
α-Amorphene				1.3	[43]
γ -Muurolene				0.82	[43]
Allo-Aromadendrene				1.3	[43]

that the main components of this oil are octyl acetate – 81.6% and trans-pinocarvil acetate – 26.7% [15].

Some components were identified in the essential oil obtained by hydrodistillation from the dried fruits of *Z. absinthifolia* collected from two various areas of Northern Cyprus. Of these, octylacetate (63.2-59.5%), octylhexanate (19.8-18.6%), octyllocanaate (9.9-9.2%), octanol (7.1-2.2%) are major components in composition [16]. Cavidnia and co-authors show that, octylbutyrate 19.2%, β-caryophylline 13.9%, octanol 9.6%, geranilvalerate 9.6%, caryophylline oxide 5.7%, octanol 2.37% were dominant groups in the essential oil obtained from plant fruits [17].

In 2013, the composition of the essential oil of fruits was analyzed and it was determined that the main components are octyl acetate (87.48%) and octyllocanoate (5.03%) [18].

When studying the composition of essential oils in various organs, it was determined that the maximum amount of essential oil is in ripe seeds (0.88%), and the lowest amount is in the leaves (0.31%). Also, octyl acetate and 1-octanol are the main constituents of seeds [19].

The essential oil in different phenological stages of *Z. absinthifolia* seeds were studied by different authors. Some components as α-pinene, n-octanol, germacrene-D, β-caryophyllene, octyl acetate, caryophyllene oxide were the main components of the essential oil in different stages of seed growth [20].

Literature data on the component composition of *Z. absinthifolia* in different areas show that there are quantitative and qualitative differences between essential oil.

It depends on geographical and climatic factors in the area where the plant grows. Thus, the number of components in the obtained essential oil, their percentage varies. Summarizing all this, we can say that the composition of the essential oil is different in different areas, but all of them have a high content of compounds belonging to the group of octylacetate and other ethers.

2.2 Flavonoids and coumarins

The results of the literature show that biologically active substances such as some flavonoids, alkaloids and different coumarin have been found and identified in various organs of *Z. absinthifolia.* [21-23]. Also, various coumarins, furo-, piranocoumarins were obtained individually from the roots, fruits, seeds and aerial parts of plant. Imperatorin and two coumarins, 7-preniloxicoumarin and aurapten were obtained from the plant seeds and were identificated by UV, ^{1}H and ^{13}C NMR data [18,21]. A number of studies have analyzed the deltoin and columbianadin content of coumarins in the aerial parts and root of the plant and found that the amount of deltoin in the plant over the amount of columbianadine [24,25]. Numerous studies show that these coumarine derivatives posses a variety of biological properties including anti-cancer, anti-inflammatory, antioxidant, enzyme inhibitory, antitubercular, antifungal, antibacterial, anticonvulsant and etc. activity [26-32]. Furthermore, bergapten, imperatorin, pimpinellin, and umbelliferon were isolated of the roots from *Z. absinthifolia* [15]. Two pyrano-coumarins, aegelinol and agacillin, were also been identificated in dichloromethane extract of plant roots by Razavi S.M. [18]. Besides, two compenents- zozimin and marmesin were identified in the roots of the plant in Absheron [33]. In addition, the fruit contains zozimin, deltoin, bergapten, imperatorin, isobergapten, isopimpinellin, pimpinellin, sfondin, umbelliferon and others. coumarin substances were found [46,47].

2.3 Fatty acids

The fact that the plant has various beneficial therapeutic properties may also be due to the presence in it of fatty acids, which are part of the lipid components. During a number of studies, fatty acids were found in various parts of *Z. absinthifolia*.

During the initial research, 20.1% fat was found in the seeds of the plant [48]. In Azerbaijan, 1.2% capric acid was found in the fruits of *Z. absinthifolia* [13]. As a result of research

conducted in Iran, only caprylic and palmitic acid were detected in the plant. Their amounts were 1.69 and 0.15% in the leaf, respectively, and 3.47 and 0.52% in the early stages of seed development [19]. S. Karakaya and colleagues identified caprylic (0.1%), lauric (0.2%) and myristic (0.8), aerial parts (4.1%), root (1.3%) and palmitic fatty acid in the fruits of the plant [15]. In addition, 0.8% palmitic acid [17] and 1.3% capric acid has been identified in the *Z. absinthifolia* aerial parts [34].Chromatographic analysis of the oil obtained from plant fruits was determined 14 fatty acids- caproic, caprylic, capric, lauric, myristic, myristoleic, palmitic, palmitoleic, stearic, oleic, linolenic, linoleic, arachidic and behenic. The main component of *Z. absinthifolia* fruit oil is oleic acid (74.36%). Small amounts of caprylic and palmitic acids were also found to be 8.9% and 5.39%, respectively. The lowest percentage is palmitinoleic acid (0.07%) [44].

2.4 Antibacterial activity

Zosima absinthifolia, like other species belonging to the family *Apiaceae*, contains coumarins, furocoumarins, pyranocoumarins, flavonoids, terpene compounds-mono-, sesquiterpenes, etc. The various biologically active components isolated from *Z. absinthifolia*, have anti-inflammatory, highly antibacterial, phytotoxic, antifungal, antioxidant and other biological properties.

A study conducted in Iran found antibacterial activity of three coumarin derivatives derived from the fruit of the plant - imperatorin, aurapten and 7-preiloxicumarin and essential oil [35]. In numerous studies are also known other biological properties of the imperatorin [36-37]. In addition some pyranocoumarins (aegelinol, agacillin) derived from the plant roots also have moderate antibacterial activity [18]. A group of researchers found that the essential oil of the fruit has a high antibacterial effect against *Bacillus subtilis* and *Bacillus pumilus* [35]. At the same time, the ethanol extract of the aerial parts of *Z. absinthifolia* has antimycobacterial activity [38]. The methanol extract was found to have a important antibacterial avtivity against *Bacillus cereus* and *Staphylococcus epidermidis* [35]. Antimicrobial properties of the essential oils of the species *Z. absinthifolia* has been studied as well as it was as certained that essaential oils can be used as antifungal means [41].

2.5 Antioxidant activity

According to some studies, the methanol extract of the plant fruit has significant antioxidant activity [39]. Ethyl acetate extracts of *Z. absinthifolia* also have high antioxidant potential [40]. The highest antioxidant activity of the plant is characterized in dichloromethane extract of essential oil from fruits and flowers. For this reason, the flowers and fruits of plant may be a new potential source of natural antioxidant and anticholinesterase compounds [15]. In addition, the results of biological studies show that acetone extract and seeds (in the early stages of development) have high antioxidant properties [19]. Plant methanol extract showed that high antioxidant feature with an RC50 value of 143.5 μg mL^{-1} [35].

2.6 Anti-inflammatory and alleopathic activity

Some researchers have reported that alleopathic activity of some components-aurapten and 7-preniloxicumarin derived from *Z. absinthifolia* fruits [35]. Razavi and co authers found that the essential oil obtained from the fruit of the plant has an alleopathic effect against bacteria and fungi from the middle to the top [35]. The imperatorin, isolated from the plant and belonging to coumarins, also plays an alleopathic role for the plant and can protect the plant from various pathogens [21]. In addition, a number of studies have found that the imperatorin has anti-inflammatory activity [31]. Also, *Z. absinthifolia* aerial part extract exhibited significant anti-inflammatory activity in 75 mg/kg dose [24, 25].

2.7 Antifungal and cytotoxic activity

Biologically active substances isolated from the seeds and roots of *Z. absinthifolia*, in particular imperatorin, have antifungal activity against the fungus *Sclerotinia sclerotiorum* [21]. Pirano-coumarins derived from the root of the plant - aegelinol and agacillin also have antifungal activity [21]. According to research, the cytotoxic properties are manifested in acetone extracts of flowers [19] and methanol extract [39].

4. Conclusion

Different types of chemical constituents of *Z. absinthifolia* and their biological activities are reflected in the article. Many chemical compounds were isolated from the selected plant and identified. Among them, mono-, sesquiterpens, coumarins are the main bioactive components in *Z. absinthifolia.* Also, many components in the chemical composition were evaluated for their biological activity. Some of the chemical constituents have substantial pharmacological properties. It is clear that, a number of component obtained from *Z. absinthifolia* has significant potential as useful natural supplements in numerous diseases and can be used in various fields of medicine in the future.

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