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OF THE REPUBLIC OF KAZAKHSTAN
of the Institute of Plant Biology and Biotechnology

БИОЛОГИЯ ЖӘНЕ МЕДИЦИНА СЕРИЯСЫ

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ESSENTIAL OILS FROM PLANTS OF THE GENUS *THYMUS L.* OF KAZAKHSTAN FLORA: CHEMICAL COMPOSITION AND PROSPECTS OF APPLICATION

Abstract. The in-house data on chemical composition of essential oils from 14 plants pecies of *Thymus* L. genus of the family *Lamiaceae Lindl*. in Kazakhstan flora have been generalized. The author conducted a comparative analysis of the obtained results with the published materials on essential oils from *Thymus* L. species. The article discusses biosynthetic pathways of the main components of *Thymus* L. species which have been confirmed by the results of chemical analysis of essential oils undertaken by the author. The screening data of essential oils from thymes for the biological activity are provided.

Keywords: *Thymus* L., essential oils, mono- and sesquiterpenoids, gas chromatography-mass spectrometry, biosynthesis.

Introduction. Nowadays, the arsenal of a pharmaceutical market has considerably expanded with highly effective natural medicines. Over 1000 species of essential oil-bearing plantsgrow in the flora of Kazakhstan. Some species from the families *Lamiaceae, Apiaceae* and *Asteraceae*are of great interest, they used to be overlooked earlier, or else there are only minor data on their chemical composition and biological properties. From this viewpoint, the family *Lamiaceae L.* is worth mentioningas it is one of the leaders in Kazakhstan flora. Thus, this family incorporates 233 species combined in 45 genera in the territory of Kazakhstan [1].

Plants of the genus *Thymus*L. are the most popular among them because they are a rich source of essential oils which is very widespread. The genus*Thymus* L.ranks first on a species diversitywith27 species growing in Kazakhstan [1]. The contemporary studies have shown that essential oil from thymes is active against many poly-resistant pathogens due to the presence ofa monoterpenic phenol thymol in their composition [2]. Taking into account a high antimicrobial, antioxidant, and antiviral activity of essential oils from thymes [2-5], plants of this genus can be considered as a prospective source of herbal raw materials for the medicines with a wide range of pharmacological activity, low toxicity, and high efficiency against strains, viruses, and microbes resistant to the main classes of antibiotics.

The aim of the research is to study the chemical composition of essential oils from *Thymus* L.species growing in Kazakhstan.

Objects of research aretheessential oils from *Thymus crebrifolius* Klok., *Thymus Dmitrivae* Gamajun., *Thymus karatavicus* A. Dm., *Thymus Lavrenkoanus* Klok., *Thymus Marschallianus* Willd., *Thymus minussinensis* Serg., *Thymus mugodzharicus* Klok. et Schost., *Thymus petraeus* Serg., *Thymus rasitatus* Klok., *Thymus roseus* Schipz., *Thymus serpyllum* L., *Thymus stepposus* Klok. et Schost., *Thymus sibiricus* (Serg.) Klok. et Schost., and*Thymus vulgaris* L.

Research methods. Plant material was collected in 2011-2017 in the East Kazakhstan, South Kazakhstan regions, and in Central Kazakhstan.

Essential oils were extracted by a hydrodistillation method on Klevendzher’s apparatus from the air-dry mass of plant raw materials [6]. The weight of dry plant material varied from 20 to 100 g depending on a sample. The hydrodistillation of each sample was carried out within 3 hours with hexane used as a solvent to collect essential oil. The quantitative content of essential oils was calculated in volume-weight percentage per the air-dry mass of plant material. The obtained essential oil was placed in amber glass bottles, hermetically sealed and stored at a temperature of +1-4 °C. The research was done on the organoleptic and physico-chemical properties of the extracted essential oils.

The chemical composition was investigated by the gas chromatography-mass spectrometry method on the Gas Chromatograph with Mass Selective Detector Agilent 7890/5975C (Table 1). HP-5MS 5% Phenyl Methyl Silox (30 m × 0,25 mm) column with a speed of helium carrier gas of 1ml/min was used. Evaporator temperature was 2300˚C. The gas chromatography column was maintained at a temperature of 40 ˚C within 10 min. with the temperature programmed up to 240 ˚C,and a temperature change speed of 2 ˚C/min, then it was sustained in the isothermal mode for 20 min. The sample input mode wasstream division 100:1. Sample volume was 0,2 µL. Conditions of mass spectrarecordwere 70 eV, the massrange was 10-350m/z. The quantitative content of constituents was calculated automatically based on the peakareas of the general ion chromatogram. The quantitative analysis was carried out by means of the internal normalization method on the peakareas without the correcting coefficients. The components were identified as per the mass spectra and the retention time using Wiley GC/MS library.

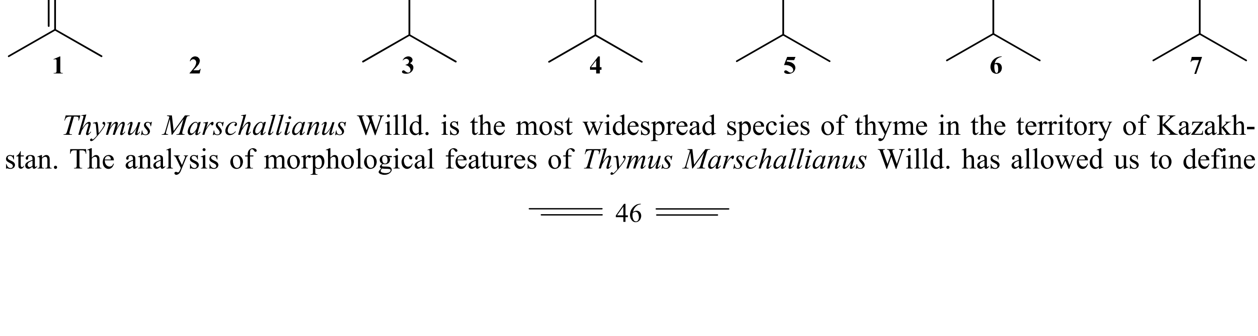
Research results. The genus *Thymus* L. (a thyme) is one of the largest and taxonomically complex in the family *Lamiaceae* Lindl. All studied species of *Thymus* L. grow in Kazakhstan [1].

Thymus crebrifolius Klok. isa semi-bush up to 4 cm high with a pleasant lemon scent. It is found on the precipices of temporary water way currents and rocks in regions of the Western Kazakh Uplands (Melkosopochnik) and Ulytau. It is an endemic plant. The raw material reserves of this species are noticed in the territory of Karaganda region [7]. The chemical composition of its essential oil has not been studied. The essential oil that we investigated for the first time represents the mobile liquid of a light yellow color with a pleasant lemon fragrance. Among the identified 74 components, the main are (in %) in *Thymus crebrifolius* Klok essential oil:linalool 31.9 (**1**), borneol – 9.6 (**2**).

Thymus Dmitrivae Gamajun. represents a dwarf semishrub up to 14 cm high, the distinctive features of this plant are thickish curved ligneous stipes sometimes with additional roots and also reddish leaves. It is encountered on the open stony slopes, on rockslides, andgravelfrom the mountains forest belt to the Alpine highlands of Zailiysky Alatau, the Kyrgyz Alatau, and the Western Tien Shan. We have studied the essential oil of this plant for the first time, the main component of which is 4-methyl-4-isopropylphenol 57.7% (**3**) among 17 identified.

Thymus karatavicus A. Dmitr. ex Gamajun. is an endemic plant. It grows on stony slopes and taluses of low mountains. It is found in Karatau and the Talas Alatau [1]. The are no data on the chemical composition of its essential oil. The investigated essential oil represents the yellowliquid with a pleasant scent andyield of 1.49%. We have identified 19 constituents, the main of them in*Thymus karatavicus* essential oil are (in %): thymol - 39.5 (**4**), *p*-cymene – 18.5 (**5**), thymol acetate– 13.0 (**6**) [8].

Thymus Lavrenkoanus Klok. represents a dwarf subshrub with a height of 3-12 cm and short corollasof pink-violet color. It grows on stony and steppe tall-grass slopes, and on the hill tops. It is found in Karaganda and the East Kazakhstan regions. It is an endemic plant. In the composition of*Thymus lavrenkoanus* Klok essential oil 100 components have been identified, the main of which are (in %): *p*-cymene - 32.2 (**5**), γ-terpinene - 7.5 (**7**), thymol - 26.0 (**4**).



1 **2** **3** **4** **5** **6** **7**

Thymus Marschallianus Willd. is the most widespread species of thyme in the territory of Kazakhstan. The analysis of morphological features of *Thymus Marschallianus* Willd. has allowed us to define the following characteristic signs: the oblong sessile elliptic leaves pubescent with rare cilia, more seldom - glabrous; the inflorescences are extended, short-verticillate; the corolla is pale violet with a short tube. It grows in steppes, edges, and ravineslopes. This species can be a substitute for *Thymus serpyllum* L. and *Thymus vulgaris* L. Besides, *Thymus Marschallianus* Willd. is widespread in the conditions of Central Kazakhstan. It also grows in steppes, on hillslopes, in the river floodplains in the European part of Russia, in the Caucasus, in Western and Middle Siberia, and in Central Asia. According to the performeddistribution and raw material stocks analysis of *Thymus Marschallianus* Willd.herb in the territory of Karaganda region, the overallarea of its thickets is estimated as 85,8 hectares withtheexploitable reservesof 40,6 tons, andthe volume of potential annual harvestingof raw materials of 17,52 tons. It is pertinent to collect plant materials once in 3 years in onearea [21].

There are numerous data on the chemical composition of *Thymus Marschallianus* Willd. essential oil in literature (table 1) which confirm its complex constituent structure [9-19].

Table 1 – Major components of *Thymus Marschallianus* Willd. essential oil.

Place of growth	Essential oil components	Reference
China	γ -terpinene (18.0% to 22.4%), thymol (28.0% to 32.9%), *p*-cymene (7.7% to 25.4%)	9
Hungary	thymol - 32.9%	10
Kazakhstan	*p*-cymene, thymol,γ-terpinene	11
Caucasus	geraniol – 30.3%	12
China	thymol – 32.9%, γ-terpinene – 22.4%, carvacrol – 8.0%, *p*-cymene – 7.7%	13
Germany	caryophyllene, cadinene, nerolidol	14
Russia, Saratovregion	*p*-cymene -20.9%,thymol - 54.6%	15-16
Russia	borneol – 30.0%, α-pinene – 10.7%, sabinene –9.9%, thymol – 5.5%	17
Russia, Voronezh region	thymol – 16,5%, p-cymene 9.6%	18
Russia, Altai territory, Burlinregion	α-terpinenol acetate, *p*-cymene	19
Russia, Altai territory, Loktevsky region, 220 m above the sea level	*p*-cymene, limonene, γ-terpinene	19
Russia, Altai territory, Ust-Koksin region	*p*-cymene, γ-terpinene, thymol	19
Russia, Altai territory, Ust-Pristan region	γ-terpinene , *p*-cymene, thymol	19
Russia, Altai territory, Loktevsky region, 430 m above the sea level	geraniol, geranyl acetate	19
East-Kazakhstan region, Zyryanovsk region	γ-terpinene, *p*-cymene, thymol	19

As is seen from table 1, the chemical composition of *Thymus Marschallianus* Willd. essential oil can be divided into 3 groups. The majority of the studied essential oils had a high content of the sum of thymol and carvacrol up to 80% and a noticeable content of borneol up to 13%, at the same time a high content of monoterpene hydrocarbons was also observed up to 45%. The second group of essential oils contained a rather low content of phenols (7.0-38.8%) in their structure, and α-terpineol (14.1-45.9%) and monoterpene hydrocarbons were identified as the major components. The third group of essential oil samples were marked by a high content of geraniol (33.7-70.2%) and geranyl acetate (5.5-13.3%), a small content ofneral (0.7-6.4%) and geranial (1.7-10.1%), as well as a low content of monoterpene hydrocarbons [20]. In the investigated essential oil we identified 111 components, the major ones are thymol 19.3 (**4**) and *p*-cymene 18.2 (**5**).

Thymus minussinensis Serg. is a plant with floriferous sprouts of 1(2)-6 cm high, with reddish, short, down-directed hairs, and a pink corolla5-6 mm long. It grows on dry-steppehillslopes and granite rocks. It is encountered in Akmola region, in the East Kazakh Uplands and Bektau-Ata Mountains. We have studied the chemical composition of *Thymus minussinensis* Serg. essential oil by the GC-MS method for the first time. Twenty-three components have been found, the main of them are (%): *p*-cymene 22.5 (**5**), thymol 19.3 (**4**), γ-terpinene 18.0 (**7**).

Thymus mugodzharicus Klok. et Schost. is anundershrub growing on stony slopes, steppe hills, and dry slopes of river valleys. We collected *Thymus mugodzharicus* Klok. et Schost in the Mugodzhar Hills during blossoming period in 2014. *Thymus mugodzharicus* essential oil contains 25 components of which the following prevail (in %): thymol - 37.6 (**4**), borneol 8.3 (**2**), γ-terpinene 7.5 (**7**) [22].

Thymus petraeus Serg. is a mountain-steppe plant representing a prone vegetatively motionless subshrub of stlanictype. It is found in steppes of Altai and Krasnoyarsk regions, the Tyva Republic and a North-West part of China, with huge populations marked in the Republic of Khakassia [23]. In Kazakhstan it grows in mountain steppes and on the crushed rock slopes. It is seen in the Tarbagatai and Dzungarian Alatau. It is an endemic plant. There are scarce data in literature on the essential oil composition,of which the main components are linalyl acetate, γ-terpinene, *p*-cymene, thymol, andmyrcene [19,24]. In the researched oil we have found 59 components, the major of them are (in %)*o*-cymene 46.3 (**8**) andthymol 13.2 (**4**).

Thymus rasitatus Klok. is an endemic plant which grows on stony and steppe slopes, low mountains peaks, on granite taluses, and in the rockcracks of the Dzungarian Alatau, in Karkaraly, in the Irtysh and Balkhash-Alakulsk floristic regions, the East Kazakh Uplands [23]. We have studied the chemical composition of its essential oil for the first time, the main constituents are (in %): thymol 23.6 (**4**), *p*-cymene 21.2 (**5**), γ-terpinene 11.1 (**7**).

Thymus roseus Schipz. is a tinydwarf semishrub withviolet-rose or white floretshavinga pleasant fragrance. It grows on stony tops and slopes of mountainsand low-mountains, on granite rocks and rockslides. It is common in Western Siberia, Kazakhstan, and Mongolia. The data on its essential oil are sporadic. A.V. Tkachev investigated theessential oil from *Thymus roseus* Schipz growing in the Altai Republic (Russia) where the major constituents arethymol, *p*-cymene, γ-terpinene [19]. In the investigated essential oil we have defined 66 compounds, the major ones are (in %) *o*-cymene 14.1 (**8**), linalool 12.7 (**1**).

Thymus sibiricus (Serg.) Klok. et Schost. is a plant with floriferous branches 1,5-10 cm high, densely pubescent under the inflorescence with long and short downward hairs. It grows on the southern stony slopes, dry meadows, in pine woods on the sand. It is spread in Western Siberia, the Tarbagatai, and the Dzungarian Alatau. The main components of oil from*Thymus sibiricus* (Serg.) Klok. et Schost harvested in Buryatia are thymol (20.9%), γ-terpinene (14.0%), *o*-cymene (42.3%) [26]. The major components of the researchedessential oil from *Thymus sibiricus*(Serg.) Klok. et Schost (in %) are linalool 25.2 (**1**) andgeranyl acetate 18.0 (**9**).

Thymus serpyllum L. is a dwarf subshrub up to 13 cm high usually with petiolate,elliptic leaves pubescent with long cilia on the edge; the inflorescences are of a densecephalanthium form; thecorolla is bright pink with a long tube. It is widespread in the whole territory of the CIS countries including Armenia, Kazakhstan, the Russian Federation, Ukraine,it is also found in the foothills of Tibet, in the north of India, and in North America. The aerial parts of *Thymus serpyllum* L. are widely used both in traditional and folk medicine of many countries of the world as a valuable herb. The plant therapeutic effects are due to the presence of various biologically active agents (flavonoids, tannins, macro- and minor constituents, essential oil)in its raw material. It is included as a medicinal raw material in the State Pharmacopoeia of Kazakhstan [8]. *Thymus serpyllum* L. is an extremely polymorphic genus related to the Siberian and Central Asian thymes which is split to a number of minorspeciesthat are geographically isolated or peculiar for certain localities. In this regard, the chemical composition of essential oils is also very diverse. For instance, as is seen from Table 2 thymol (**4**) and carvacrol (**10**) are the main components of essential oil from *Thymus serpyllum* L. growing in Albania, Armenia, Hungary, India, China, Pakistan, and Ukraine. Thymol (**4**) is the main component of the essential oil from*Thymus serpyllum* L. growing in Egypt, Japan, Iran, and Serbia, whereascarvacrol (**10**) is commonfor the essential oil from Italy, Poland, and Russia. Thymol (**4**) and carvacrol (**10**) are absent in the essential oils of *Thymus serpyllum* L. chemotypes growing in Belarus, Estonia, Finland (*T. serpyllum* L. ssp. *serpyllum* and *T. serpyllum* L. ssp. *tanaensis* (Hyl.) Jalas), Lithuania (*T. serpyllum* L. ssp. *Serpyllum* and *T. serpyllum* L. ssp. *serpyllum* var. *serpyllum*), Turkey, Sweden, and Poland (the Central part) (table 2).

Table 2 – Major constituents of *Thymus serpyllum* L. essential oil and its subspecies

Place of growth	Constituents	Reference
1	2	3
Albania	phenols (47-74%), *p*-cymene (8.5-36.5%)	[27, 28]
Armenia	(1) thymol (81.5/76.1%), *p*-cymene, carvacrol, β-caryophyllene, α-terpineol, (2) carvacrol (49.0-62.0%), thymol (21.5-29.7%), *p*-cymene, β-caryophyllene, α-terpineol	[27, 29]
Belorussia	γ-terpinene (21.4%), *p*-cymene (19.0%), thymol	[27, 30]
	camphene (1.75-12.62%), β-myrcene (2.26-14.61%), 1,8-cineole (up to 23.12%), camphor (4.24-27.59%), β-caryophyllene (1.12-22.64%), (-)-borneol (2.02-33.39%), caryophyllene oxide (3.79-28.7%), thymol (3.59%), carvacrol (up to 3.69%)	[31]
China	*T. serpyllum* L. var. *mongolicus* Ronn. *p*-cymene (30.3%), thymol+carvacrol (20.0%), β-phellandrene (14.0%);	[27, 33-34]
	T. serpyllum L. var. *mongolicus* Ronn. thymol (23.9%), 2,4,5-trimethyl benzyl alcohol (16.9%), *p*-cymene (16.3%), carvacrol (10.6%)	[27, 34]
Croatia	thymol (30.0%), carvacrol (49.4%), γ-terpinene (5.3%),	[35]
Egypt	thymol (62.02%), β-phellandrene (13.50%)	[36]
Estonia	(E)-nerolidol (70.1%), caryophyllene oxide (45.0%), myrcene (20.2%), (E)-β-caryophyllene (13.3%), germacrene D (12.4%)	[37]
	geranyl acetate (up to 46.4%), linalyl acetate (up to 31.4%), geraniol (up to 30.3%), myrcene (up to 20.2%)	[37]
Finland	*T. serpyllum* L. ssp. *serpyllum* (1) monoterpene hydrocarbons (33%), 1,8-cineole (12.5-15.0%), germacra-1(10),5-dien-4-ol (3-12%), germacrene D (10.0-12.0%) (2) monoterpene hydrocarbons (30%), 1,8-cineole (26%)	[27,38]
	T. serpyllum L. ssp. *tanaensis* (Hyl.) Jalas (1) linalool (21.9-43.8%), linalyl acetate (8.9-17.6%), (2) 1,8-cineole (17.2-27.6%), myrcene (15.4-22.4%), β-caryophyllene (6.8-19.1%)	[27,39-40]
	T. serpyllum L. ssp. *tanaensis* (Hyl.) Jalas (1) linalool (52.2%), monoterpene hydrocarbons (13%) (2) linalyl acetate (58.3%), monoterpene hydrocarbons (15%) (3) monoterpene hydrocarbons (33%), 1,8-cineole (12.5-15.0%)	[27,38]
Hungary	carvacrol (39.5/45.9%), thymol, p-cymene (25.0%), linalool, nerol	[27, 41]
India	carvacrol (49.4%), *p*-cymene, thymol, zingiberene	[27, 42]
	thymol (57.6%), *p*-cymene (20.0%)	[27, 43]
	Uttarakhand Hills thymol (19.4-60.1%), γ-terpinene (0.3-13.8%), *p*-cymene (3.5-10.4%)	[44]
	Uttarakhand Himalaya thymol (37.27–55.56%), thymyl methyl ether (3.26–12.93%)	[45]
Iran	carvacrol (48.8%), thymol (13.8%), *p*-cymene (12.3%)	[46]
	γ-terpinene (22.7%), *p*-cymene (20.7%), thymol (18.7%), germacrene D (5.1%)	[47]
Italy	North East Italy carvacrol + carvacrol methyl ether (44.9%)	[48]
Lithuania	*T. serpyllum* L. s. l.: 1,8-cineole (16.3-19.0%), β-caryophyllene (9.6-11.3%), myrcene (9.7-10.7%)	[27, 49]
	T. serpyllum L.: α-pinene (6.3-25.6%), camphene (23.6-48.9%), β- myrcene (1.6-51.5%), 1,8-cineole (6.3-33.3%)	[50]
	T. serpyllum L. ssp. *Serpyllum* 1,8-cineole, germacrene B, (E)-β-ocimene, α-cadinol	[51]
	T. serpyllum L. ssp. *serpyllum* var. *serpyllum* 1,8-cineole (8.9-13.9%), caryophyllene oxide (6.5–12.5%), borneol (7.4–10.5%)	[52]
Pakistan	thymol (42.6%), *p*-cymene, carvacrol, borneol,	[27, 53]
	carvacrol (44.4%), *o*-cymene (14.0%), α-terpineol (6.47%), α-pinene (6.06%), β-caryophyllene (5.25%)	[54]
	thymol (53.3%), carvacrol (10.4%), *p*-cymene (8.8%)	[55]
	Muzaffarabad, the State of Jammu and Kashmir thymol (16.5-18.8%), borneol (1.6-3.1%), ledol (0.2-7.3%), safrole (1.1%), 1,8-cineole (14.0-18.0%),	[56]

Continuation of table 2

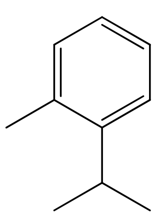
1	2	3
Poland	Central Poland: camphene (8.07-13.91%), β-myrcene (6.53-17.97%), cyneole (1.41-11.64%), β-caryophyllene (1.06-9.02%), borneol (0.15-16.91%)	[57]
	the North-Western Poland: carvacrol (30.90–46.16%), γ-terpinene (5.72–9.09%), *p*-cymene (4.51–13.46%)	[58]
Russia	*T. serpyllum* L. s. l. village Kolyvan' (Kurijnski area, 150 m above sea-level) β-myrcene (4.0%), *p*-cymene (3.8%), 1,8-cineole (14.0%), cis-β-terpineol (8.2%), camphor (4.0%), *trans*-nerolidol (29.8%)	[59]
	T. serpyllum L. s. l. village Mendur-Sokkon (Ust-Kanski area, 500-750 m above sea-level) *p*-cymene (14.5%), 1,8-cineole (5.6%), γ-terpinene (17.2%), carvacrol (29.6%)	[59]
Serbia	*trans*-nerolidol (24.2%), germacrene D (16.0%), thymol (7.3%), δ-cadinene (3.7%), β-bisabolene (3.3%)	[60, 61]
	trans-caryophyllene (27.7%), γ-murolene (10.5%), α-humulene (7.5%), α-pinene (6.9%), 3-octanon (6.6%), thymol (5.6%), camphor (3.6%)	[61, 62]
Turkey	2,4,6-trimethylanisol (73.41%), 3,5-dimethyl benzoic acid (5.38%), β- bisabolene (3.67%)	[63]
Ukraine	(1) thymol (50.0/35.1%), γ-terpinene (12.7/18.0%), *p*-cymene (8.6/14.1%), (2) carvacrol (48.4/55.2%), γ-terpinene (10.1/27.1%), *p*-cymene (8.0/7.1%)	[64]

We have investigated in detail the composition of *Thymus serpyllum* L. essential oil., collected in 8 various regionsof Kazakhstan. The composition is mainly presentedbythymol (5.1-58.2%) and carvacrol (1.2-55.2%) and depends on the place of growth [64]. It is known that in the wild there are populations and even certain plants which essential oil has a distinctive composition very unlikethe typical one for this species.

For example, the so-called lemon *Thymus serpyllum* L. form belongs to such a group, which oil has a peculiar fragrance different from other samples dueto the present of a considerable amount of geraniol (to 60-70%). We can assume that a sample collected in the neighborhood ofAkmola region belongs to the lemon form. Trans-geraniol (55.9%) and lavandulyl acetate (28.5%) are biosynthesized in this essential oil.

Thymus stepposus Klok. et Schost. generally has linear leaves on very short leafstalks; the in florescence is elongated, verticillate; the corolla is violet with a longer tube. A.V. Tkachev considers that *Thymus stepposus* Klokov & Des. - Shost. is a synonym of *Thymus Marschallianus* Willd [19]; however, in the Flora of Kazakhstan it is included as a separate specieswith a number of distinctive morphological features [1]. The main components ofthe essential oil from this plant harvestedin Buryatia are thymol (20.9%), γ-terpinene (14.0%), *p*-cymene (42.3%) [26]. In the plant essential oil from the north of Kazakhstan, the main constituents are trans-nerolidol (21.5%), 1,8-cineole (16.0%), camphor (10.3%), trans-β-ocimene (6.1%), camphene (4.2%), and borneol (2.9%) [66].

According to our data, the main components of *Thymus stepposus* Klok. et Schost. are (in %): thymol 57.7 (**4**), α–terpineol 25.2 (**11**), 1,8-cineole (**12**) – 8.9.



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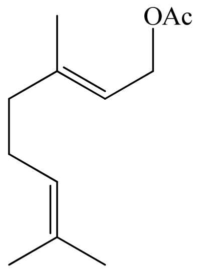

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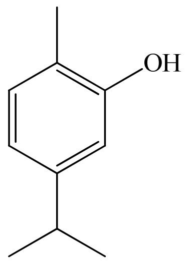

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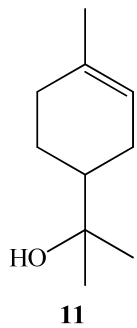

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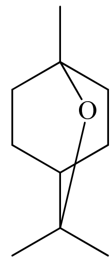

12

Thymus vulgaris L. is a typical representative of the vegetatively-fixed subshurbs remaining the main root system during the whole life cycle. It is widespread in the Western part the Mediterranean: on the Iberian Peninsula, in Southern France, in the North-West of Italy. The main commercial product is the essential oil produced from *Thymus vulgaris* L. cultivars. The oil composition is rather well studied and is subjectto a variability. Literature data confirm that the genus *Thymus* L. features a considerable intraspecies and cultivarpolymorphism both in regards to the morphological characteristics and the mass fraction of essential oil and its compositional structure which serves as a basis when determining the chemotype. The existence of several chemotypes within its world geographic rangehas been revealed.

Over 20 various chemotypes of *Thymus vulgaris* L. are described in the literature. [26]. Usually it contains more phenols: up to 60% of thymol and 2-10% of carvacrol; *p*-cymene (up to 20%), γ-terpinene (12%), and caryophyllene (2-10%), etc. are also present[67-73]. The essential oil that we have extracted from *Thymus vulgaris* L. contains 100 components, the main of them are (in %): thymol 58.6 (**4**), *o*-cymene 11.2 (**8**).

The majorityof terpenoid volatiles that we have found in the essential oils from the genus *Thymus* L. belongs to the monoterpene group. The essential oils from thymes usually contain over 90% of monoterpenes with aminor content of sesquiterpenes. About 300 mono- and sesquiterpenes are observed in *Thymus* L.essential oils., of which 34 were chosen as the most significant volatile components [27,74]. Thymol (**4**) is found in the essential oils of 77 taxons of *Thymus* L. Over a half of thyme taxons (89 taxons or 55%) belong to the phenolic and 73 (45%) - to the non-phenolic group [27]. As a matter of fact, thymol (**4**) and carvacrol (**10**) are also found in other plants but in a meagre amount. That is what makes the genus *Thymus* L. the most rich source of monoterpenoid phenols interesting for the search of thymol (**4**) and carvacrol (**10**).

Plants of the genus *Thymus* of Kazakhstan flora also accumulatethe aromatic alcohols of thymol (**4**) and carvacrol (**10**). The essential oils of the studied 10 speciescontainthymol (**4**) from 0.09% to 50.1%. Thymol (**4**) has been found in small amounts in the essential oilsfrom *Thymus Dmitrivae* Gamajun., *Thymus stepposus* Klok. et Schost., *Thymus crebrifolius* Klok. and in rather high amounts in *Thymus petraeus* Serg., *Thymus minussinensis* Serg., *Thymus Marschallianus* Willd., *Thymus rasitatus* Klok., *Thymus karatavicus* A. Dm., *Thymus mugodzharicus* Klok. et Schost.

A high content of monoterpene hydrocarbons *p*-cymene (**5**) in 56 taxons and γ-terpinene (**7**) in 38 taxons of *Thymus* L. has also been noted irrespective of the presence of thymol (**4**) and carvacrol (**10**). All four monoterpenes are closely related by the biogenetic processes.

A number of researchers [26, 74-77] offered biogenetic schemes according to which the components of essential oils are formed by successive transformations, starting from geranyl pyrophosphate (figure 1) where the conversion of one terpene component to another is controlled by one gene coding the synthesis of the corresponding enzyme. If the required enzyme is absent, the sequence of the biosynthetic chain stops and the precursor accumulates. The primary accumulation of a precursor in the essential oil of thyme species determines the diversity of the biochemical composition of various representatives of the genus *Thymus* L., which is confirmed by the results of our studies of the chemical compositions of the extracted essential oils.

Among the monoterpene compounds, the dominant components are linalool, borneol, γ-terpinene, α-terpineol, 1,8-cineole.

The sesquiterpene fraction is represented by caryophyllene, γ-murrolene, germacrene D, β-bisabolene, γ-cadinene, σ-cadinene, α-bisabolene, caryophyllene oxide, but their content is minor. Moreover, all studied essential oils samples from 14 species contain caryophyllene (0.49-3.07%) and caryophyllene oxide (0.74-2.1%). All the actual data indicate the interrelation of these components in the biosynthetic process which proceeds according to the known scheme of geranyl diphosphate with the predominant formation of *p*-menthaneand pinane types. The predominant biosynthetic pathway of sesquiterpenes is the cyclization of farnesyl diphosphate with the subsequent formation of a germacryl cation followed by branching to caryophyllanes, humulans, etc.

Despite the fact that in general the oil composition of all samples is similar, some samples containt components in significant amounts that are absent in other samples. For instance, 1,8-cineole (**12**) is present only in the essential oilsamples from *Thymus stepposus* Klok. et Schost, *Thymus minussinensis* Serg, *Thymus mugodzharicus* Klok. et Schost., linalool is found in the essential oils of *Thymus Marschallianus* Willd, *Thymus roseus* Schipz., *Thymus crebrifolius* Klok., etc.

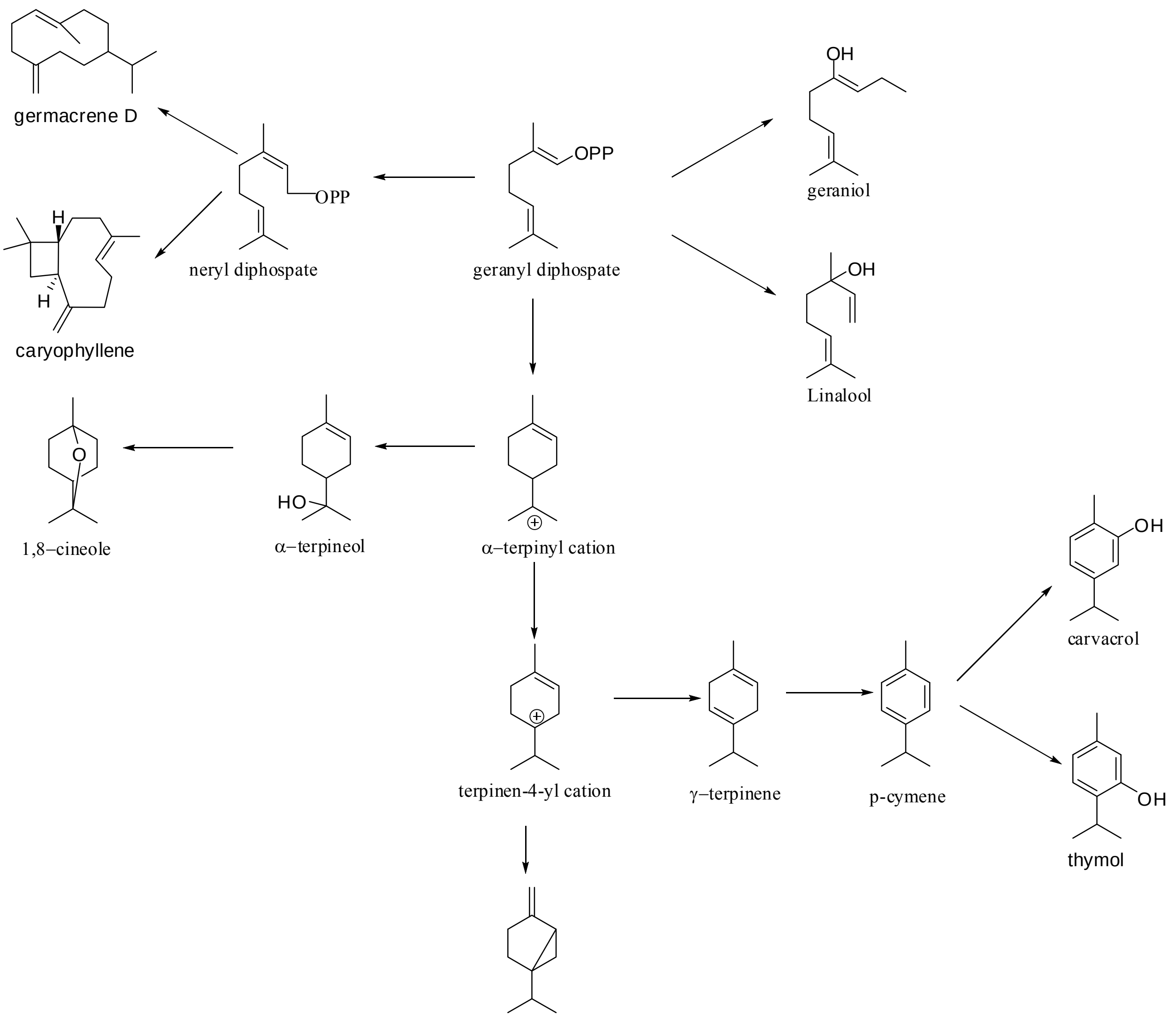

Figure 1 – The alleged scheme of biogenesis of the essential oils components in thymes

Thymus Lavrenkoanus Klok., *Thymus crebrifolius* Klok, *Thymus karatavicus* A. Dm. *Thymus rasitatus* Klok., and *Thymus petraeus* Serg. are the endemic species. *Thymus sibiricus* (Serg.) Klok.et Schost. is a plant that is difficult to identify by botanical features, as there are its hybrids with *Thymus Marschallianus* Willd. and other species. In the essential oil of *Thymus sibiricus* (Serg.) Klok. et Schost. monoterpenoids linalool (**1**) and geranyl acetate (**9**) have beendetermined. These monoterpenoids can be proposed as chemotaxonomic markers for *Thymus sibiricus* (Serg.) Klok. et Schost. The major component of essential oil from *Thymus Marschallianus* Willd., growing in different locations, is thymol (**4**), therefore, the species can be differentiatedby chemical composition of their essential oils, i.e. based on the chemotaxonomic markers.

Promising for isolation of new compounds are the essential oils of *Thymus crebrifolius* Klok., *Thymus Dmitrivae* Gamajun., *Thymus Lavrenkoanus* Klok., *Thymus petraeus* Serg., and *Thymus serpyllum* L. Based on the results of gas chromatography-mass spectrometry, in all thyme species were detected compounds witha functional hydroxyl group (borneol, terpineol-4, etc.) in their structure, molecules that have double bonds, and a system of conjugated bonds (thymol, cymene, etc.) in their structure which are responsible for the antioxidant activity. For the targeted search of new biologically active compounds, we have screened the essential oils extracted from *Thymus* species for analgesic, antioxidant, antimicrobial, antifungal, antiviral, and cytotoxic activities.

When screening samples of essential oils from plants of this species, it was revealed that they all exhibita weak and moderate antimicrobial activity against gram-positive and gram-negative strains [3,78]. The study of antimicrobial activity was carried out on the strains of gram-positive bacteria *Staphylococcus aureus, Bacillus subtilis*, gram-negative strain of *Escherichia coli*, and yeast fungus *Candida albicans* by the agar diffusion method (wells). Comparator drugsare Cefazolin for bacteria and Nystatin for yeast *Candida albicans*.

The results that we have obtained are in alignment with data on the antimicrobial activity of essential oil in the research of S.V. Kushnarenko [79], in which the intrinsic antimicrobial activity of the essential oil from *Thymus Marschallianus* Willd. is due to the high content of monoterpene phenols such as thymol and carvacrol. In theinvestigated sample of *Thymus Marschallianus* Willd., harvested in the Southern Altai, the content of thymol was 37.1%, carvacrol - 2.2% of the total essential oil mass.

We have studied the effect of essential oils on the larvae of marine crustaceans *Artemia salina* (Leach) under *in vitro*culture conditions to determine the cytotoxic activity potential. The cytotoxic activity range based on the median lethal doseLD_{50}, expressed in μg/ml, is as follows:all essential oilsamples subjectedto the research of cytotoxic activity revealedtheir activity against the larvae of marine crustaceans *Artemia salina*.

Essential oils of *Thymus petraeus* Serg, *Thymus rasitatus* Klok., *Thymus serpyllum* L. were screened for the analgesic activity. The investigated essential oils were studied at a dose of 50 mg/kg with intragastric injection. The comparator drug Metamizole sodium (Diclofenac) was tested at a dose of 50 mg/kg. The researched objects and the comparator were introduced 30 minutes prior to the injection of 0.75% solution of acetic acid. As a result of the study it was found that *Thymus rasitatus* Klok.E. sample has an analgesic effect, besides the changes are reliable compared to the control. The remaining samples did not reveal an analgesic activity.

The antioxidant properties of thymol, essential oils from *Thymus Marschallianus* Willd. and *Thymus petraeus* Serg. were evaluated by*in vitro* experiments on rat liver microsomes. The research results showed that all samples have pronounced antioxidant properties.

When comparing the antioxidant properties of the tested samples with the antioxidant effect of α-tocopherol, it was shown that thymol, essential oils of *Thymus Marschallianus* Willd. and *Thymus petraeus* Serg. have a more pronounced antioxidant activity which exceeds the action of vitamin E by almost 90% [4]. The conducted experiments show that all investigated objects had a dose-dependent antioxidant effect on the processes of peroxidation, with the highestantioxidant effect observed in thymol which inhibited LPO processes by 83% at a protein concentration of 2 μg/mg.

The screening of essential oils for the antiviral activity was carried out on the model of influenza virus (strain A/Almaty/8/98 (H3N2). In the research, a comparative study of the virus-inhibiting and virucidal activities of the investigated drugs with the commercial preparations Amizon and Geviran was made. It was shown that Amizon and Geviran cannot inhibit the replication of the virus A/Almaty/8/98 (H3N2) in a dose range up to 3.2 mg/kg. When studying the ability to suppress the infectious activity of the virus A/FPV/Rostock/34 (H7N1), it was found that essential oils from *Thymus rasitatus* Klok. And *Thymus petraeus* Serg. exceed the activity of commercial drugs Amizon and Geviran by over 1.0 lg [5].

The most interesting for further research and isolation of individual components with an antimicrobial effect are the essential oils from *Thymus vulgaris* L., *Thymus Dmitrivae* Gamajun., *Thymus sibiricus* (Serg.) Klok. et Schost., *Thymus crebrifolius* Klok., *Thymus roseus* Schipz.exhibiting the pronounced antibacterial action against gram-positive strains (*St. aureus, Ba. subtilis*). Whereas, samples of essential oils from *Thymus lavrenkoanus* Klok., *Thymus vulgaris* L., and *Thymus sibiricus* (Serg.) Klok. et Schost. showed a pronounced antibacterial activity against gram-negative bacteria (*E. coli*).

In addition, the essential oils from *Thymus vulgaris* L., *Thymus Dmitrivae* Gamajun., and *Thymus crebrifolius* Klok. have a pronounced cytotoxicity and are promising substances for these archof compoundswith potential antitumor activity. As a result of conducted research it was confirmed that a sample of essential oil from *Thymus rasitatus* Klok. has an analgesic effectwith thereliable changes as compared to the control.

Conclusions. The majoressential oilcomponents of the studied 14 species of*Thymus* L. are thymol (**4**), carvacrol (**10**), *p*-cymene (**5**), γ-terpinene (**7**), linalool (**1**), geraniol and its acetate (**9**), and other components that can be viewed as a renewable material for the synthesis of new compounds.

Thymol (**4**), carvacrol (**10**), *p*-cymene (**5**), and γ-terpinene (**7**) are the main ones in 12 studied essential oils. This fact evidences the interrelation of these components in the biosyntheticprocess. As is shown in Figure 2, γ-terpinene (**7**) is a precursor of *p*-cymene (**5**), and with further addition of the OH group, either thymol (**4**) or carvacrol (**10**) is formed depending on the position. The study of chemical composition of *Thymus* L. essential oils has also a theoretical value since it gives opportunity toinvestigate the biosynthesis of mono- and sesquiterpenoids in nature.

The obtained results significantly expand the knowledge of chemical composition and biological activity of the extracted essential oils from plants of the genus *Thymus* L.,updateinformation on the dynamics of mono- and sesquiterpenoids accumulation and show the dependence of their content on the growth conditions. Essential oils from the following species are considered prospective for isolation of new compounds: *Thymus crebrifolius* Klok., *Thymus Dmitrivae* Gamajun., *Thymus lavrenkoanus* Klok., *Thymus petraeus* Serg., and *Thymus serpyllum* L.

Thus, the essential oils from*Thymus* L. plants of the family *Lamiaceae*of the flora of Kazakhstan, which contain a complex of biologically active substances and exhibit a wide spectrum of pharmacological action, are undoubtedlyof interest for further study and creation of new effective drugs on their basis.

REFERENCES

[1] Pavlov N.V. Flora of Kazakhstan. Almaty: Publishing House of the Academy of Sciences of the Kazakh SSR. 1964. Vol. 7. 497 p.

[2] Reyes-Jurado F., Franco-Vega A., Ramı'rez-Corona N., Palou E., Lo'pez-Malo A. Essential oils: antimicrobial activities, extraction methods, and their modeling // Food eng. rev. 2015. N 7. P. 275-297.

[3] Sadyrbekov D.T., Ryazantsev O.G., Akhmetova S.B., Seidakhmetova R.B., Kenesov B.N., Atazhanova G.A., Adekenov S.M. Thymes: composition and biological activity of essential oils // In book: Innovative development and the relevance of science in modern Kazakhstan. Almaty, 2011. P. 153-158.

[4] Kazbekova A.T., Atazhanova G.A., Seitembetova A.Zh., Seitembetov T.S., Niyazova R.E., Adekenov S.M. The relationship between the level of polyphenols and the antioxidant activity of essential oils of thyme distributed in the territory of Kazakhstan // In book: Phenolic compounds: Fundamental and applied aspects. M., 2012. P. 75-78.

[5] Atazhanova G.A., Ryazantsev O.G., Adekenov S.M. Innovative patent of the Republic of Kazakhstan № 27863. Antiviral agent. Appl. 12/18/2013.

[6] State Pharmacopoeia of the Republic of Kazakhstan. First edition. Astana, 2008. 230 p.

[7] Akhmetalimova A.M., Ishmuratova M.Yu., Ivasenko S.A., Loseva I.V. Anatomical structure of the aerial organs of *Thymus eremita* Klok // Proceedings of IV (XII) International Botanical Conference of Young Scientists. SPb., 2018. P. 35.

[8] Jia H.L., Ji Q.L., Xing S.L., P.H. Zhang, Zhu G.L., Wang X.H. Chemical composition and antioxidant, antimicrobial activities of the essential oils of *Thymus Marschallianus* Will. and *Thymus proximus* Serg. // Journal of food science. 2010. Vol. 75, N 1. P. E59-E65.

[9] Gaal B. The essential oils and oil content of native Hungarian thyme // Magyar Gyogyszeresztudomanyi Tarsasag Ertesitoje. 1926. Vol. 2. P. 217-247.

[10] Dembitskii A.D., Yurina R.A., Krotova G.I. Composition of Thymus Marschallianus essential oil // Chemistry of natural compounds. 1985. N 4. P. 477-481.

[11] Kasumov F.Yu. Component compositions of the essential oils of the genus Thymus // Chemistry of natural compounds. 1987. N 5. P. 637-638.

[12] Jia H., Ji Q., Ai L., Zhang P., Zhu G., Wang X. Analysis of volatile oil of *Thymus Marschallianus* Willd from Xinjiang by gas chromatography-mass spectrometry. Zhongguo Tiaoweipin. 2008. N 6. P. 60-63.

[13] Schratz E., Hirster H. Zusammensetzung des Ttherischen ales von *Thymus vulgaris* und *Thymus Marschallianus* in Abhangigkeit von Blattalter und Jahreszeit // Planta medica. 1970. Vol. 19. P. 160-176.

[14] Berezutsky M.A., Durnova N.A., Vlasova A.V. New data on the distribution and chemical composition of thyme species (*Thymus* L.) in the flora of Saratov region // In book: Development, research and marketing of new pharmaceutical products. Pyatigorsk, 2009. P. 13-14.

[15] Durnova N.A., Romanteeva Yu.V., Kovtun A.N. Chemical composition of essential oil from *Thymus Marschallianus* Willd. and *Thymus Pallasianus* H.B. growing in the territory of Saratov region // Chemistry of Plant Raw Material. 2014. N 2. P. 115-119.

[16] Spiridonova S. I. Essential oil of Thymus Marschallianus Willd. // Zhurnal Obshchei Khimii. 1936. Vol. 6. P. 1510-1513.

[17] Korenskaya I.M., Izmalkova I.E., Slivkin A.I., Falaleyev A.V., Maltseva A.A. Pharmacognostic and gas chromatography-mass-spectrometric study of the aerial parts of *Thymus satureioides* and *Thymus marschallianus* Willd. // Bulletin of VSU, series: Chemistry, Biology, Pharmacy. 2016. N 4. P. 137-141.

[18] Tkachev A.V., Prokusheva D.L., Domrachev D.V. Wild-growing essential oil-bearing plants of Southern Siberia. Novosibirsk: Offset-TM LLC, 2017. 575 p.

[19] Sur S.V. Composition of essential oils from thyme herbs // Chemical and Pharmaceutical Journal. 1988. N 11. P. 1361-1366.

[20] Akhmetalimova M., Orazbayeva P.Z., Ishmuratova M.Yu., Ivasenko K., Glowniak S.A. Study of raw material resources of *Thymus Marschallianus*in the territory of the Central Kazakhstan // Bulletin of Karaganda University. Series: Biology. Medicine. Geography. 2017. N 4(88). P. 8-14.

[21] Sarsenbaeva L.A., Gering A.V., Mukasheva F.T., Atazhanova G.A., Adekenov S.M. Chemical composition of essential oils from *Thymus mugodzharicus* Klok. et Shost. and *Thymuskaratavicus* A. Dmitr. exGamajun. // In book: Development, research and marketing of new pharmaceutical products. Pyatigorsk: Pyatigorsk GFA, 2016. Issue 72. P. 66-68.

[22] Dutova S.V. Pharmacological and pharmaceutical aspects of the immunotropic action of extracts from the raw material of essential oil plants. Diss.doc. diss. in the speciality 14.03.06 Pharmacology, clinical pharmacology. Volgograd, 2016. 330 p.

[23] Myadenets M.A., Domrachev D.V., Vodolazova S.V. Investigation of the chemical composition of *Nepeta sibirica* L., *Thymus petraeus* L. and *Schizonepeta multifida* L., growing in the territory of the Republic of Khakassia // Chemistry of Plant Raw Material. 2012. N 4. P. 119-124.

[24] Akhmetalimova A.M., Ivasenko S.A., Ishmuratova M.Yu. Prospects for the use of endemic representatives of the genus *Thymus* L. as a medicinal plant raw material // Sechenov Bulletin. 2016. N 2(24). P. 35-36.

[25] Rabzhaeva A.N. Peculiarities of accumulation of the biologically active substances in *Thymus baicalensis* Serg. depending on the environmental factors, Diss. … cand. of biol. sci. in spec. 03.02.08 - Ecology, 03.02.01 - Botany. Ulan-Ude, 2011. 114 p.

[26] Stahl-Biskup E, Saez F. Thyme. The genus *Thymus*. London: Taylor and Francis, 2002. P. 85-124.

[27] Asllani U. Albanian Thyme varieties and their essential oils // Bulletin I Shkencave te Natyres. 1973. Vol. 27. P. 111-127.

[28] Abetisjan R.G., Aslanjaic C.K., Arutjunjan E.G., Akopjan C.W. The essential oils of Mentha longifolia (L.) Huds. and Thymus serpyllum L. (Armenian SSR). // Rast. Res. 1988. Vol. 24. P. 605-610.

[29] Popov V.I., Odynets A.I. Study on the chemical composition of the essential oil of the Ukrainian thyme grown in Belorussia (Thymus serpyllum) // Mater. S'ezda Farm. BSSR 3rd. 1977. P. 166-168.

[30] Buzuk A.G., Jurchenko R.A., Vinarskiy V.A., Buzuk G.N. Comparative pharmacognostical analysis of grass thyme // Newsletter of Pharmacy. 2011. Vol. 53, N 3. P. 19-24.

[31] Hong-ju F., Jing-hua N., Shou-quan L., Yu-xiu F. The chemical composition of Thymus mongolicus Ronn. and T. quinquecostatus. Celak oils of Chinese origin. // Flavor Fragr. Journal. 1988. Vol. 3. P. 73-77.

[32] Luo J., Song Y. Components of essential oil from Thymus mongolicus Ronn. // Linchan Huaxue Yu Gongye. 1989. Vol. 9. P. 53-58.

[33]Zhang H., Wang Y., Zhang Zh. Study on chemical constituents of essential oil from *Thymus mongolicus* Ronn. // Acta Bot. Boreal.-Occident. Sin. 1992. Vol. 12. P. 245-248.

[34] Kulisic T., Radonic A., Milos M. Antioxidant properties of thyme (*Thymus vulgaris* L.) and wild thyme (*Thymus serpyllum* L.) essential oils // Ital. J. Food Sci. 2005. Vol. 3. P. 315-324.

[35] Eweis M., Imhemmed A.A.-A., Gad A.S Influence of *Thymus serpyllum* essential oil on *Aspergillus parasiticus* morphology and aflatoxins production // Research journal of pharmaceutical, biological and chemical sciences. 2012. Vol. 3, N 2. P. 322-332.

[36] Raal A., Paaver U., Arak E., Orav A. Content and composition of the essential oil of *Thymus serpyllum* L. growing wild in Estonia // Medicina (Kaunas). 2004. Vol. 40, N 8. P. 795-800.

[37] Stahl-Biskup E., Laakso I. Essential oil polymorphism in Finnish *Thymus* species. // Planta Med. 1990. Vol. 56. P. 464-468.

[38] Ivars L. Kemotaxonomiska undersijkningar av *Thymus serpyllum* // Famz. Aikak. Famceutisk Notisblad. 1964. Vol. 73. P. 324-332.

[39] Von Schantz M., Ivars L. Über die Zusammensetzung des ätherischen Öles von *Thymus serpyllum* ssp. *tanaensis* (Hyl.) Jalas. // Ann. Univ. Turku. A. II., 1964. Vol. 32. P. 301-307.

[40] Varga E., Bardocz A., Belák A., Maráz A., Boros B., Felinger A., Böszörményi A., Horváth G. Antimicrobial activity and chemical composition ofthyme essential oils and the polyphenolic content of different thymus extracts // Farmacia. 2015. Vol. 63, N 3. P. 351-361.

[41] Razdan T.K., Koul G.L. Zur Zusammensetzung des Quendeloles (Thymian) // Riechstoffe, Aromen, Körperpflegemittel. 1975. Vol. 25. P. 166-168.

[42] Gulati B.C., Gupta R. Essential oil from *Thymus serpyllum*. // Indian Perfumer. 1977. Vol. 21. P. 162-163.

[43] Verma R.S., Verma R.K., Chauhan A., Yadav A.K. Seasonal Variation in Essential Oil Content and Composition of *Thyme*, *Thymus serpyllum* L. Cultivated in Uttarakhand Hills // Indian J Pharm Sci. 2011. Vol. 73, N 2. P. 233-235.

[44] Mohan M., Seth R., Singh P., Lohani H., Gupta S. Composition of the Volatiles of *Hyssopus officinalis* (L.) and *Thymus serpyllum* (L.) from Uttarakhand Himalaya // National Academy Science Letters. 2012. Vol. 35, N 5. P. 445-448.

[45] Rasooli I., Mirmostafa S.A. Antibacterial properties of *Thymus pubescens* and *Thymus serpyllum* essential oils // Fitoterapia. 2002. Vol. 73. P. 244-250.

[46] Sefidkon F., Dabiri M., Mirmostafa S.A. The composition of *Thymus serpyllum* L. oil // Journal of Essential Oil Research. 2004. Vol. 16, N 3. P. 184-185. DOI 10.1080/10412905.2004.9698691.

[47] Porto C., Decorti D. Analysis of the volatile compounds of aerial parts and essential oil from *Thymus serpyllum* L. cultivated in North East Italy by HS-SPME/GC-MS and evaluation of its flavouring effect on Ricotta Cheese // Journal of Essential Oil Bearing Plants. 2012. Vol. 15, N 4. P 561-571. DOI 10.1080/0972060X.2012.10644089.

[48] Ložienė K., Vaiciuniene J., Venskutonis P.R. Chemical composition of essential oil of creeping thyme (*Thymus serpyllum* L.) growing wild in Lithuania // Plant Medica. 1998. Vol. 64. P. 772-773.

[49] Kruma Z., Galoburda R., Balins A., Kausinieks J., Sabovics M., Alsina I., Zukauska I. Volatile compounds composition of thyme belonging to different genetic clones // International Conference on Food Innovation. 2010. P. 1-4.

[50] Ložionė K., Venskutonis P.R. Chemical composition of the essential oil of *Thymus serpyllum* L. ssp. *serpyllum* growing wild in Lithuania. // Journal of Essential Oil Research, 2006. Vol. 18, N 2. P. 206-211. DOI 10.1080/10412905.2006.9699067.

[51] Mockute D., Bernotiene G. 1,8-cineole-caryophyllene oxide chemotype of essential oil of *Thymus serpyllum* L. growing wild in Vilnius (Lithuania) // Journal of essential oil research. 2004. Vol. 16, N 3. P. 236-238. DOI 10.1080/10412905.2004.9698708.

[52] Sattar A., Malik M.S., Khan S.A. Essential oils of the species of *Labiatae* part IV. Composition of the essential oil of *Thymus serpyllum* // Pakist. J. Sci. Ind. Res. 1991. Vol. 34. P. 119-120.

[53] Hussain A.I., Anwar F., Chatha S.A.S., Latif S., Sherazi S.T.H., Ahmad A., Worthington J., Sarker S.D. Chemical composition and bioactivity studies of the essential oils from two *Thymus* species from the Pakistani flora // LWT - Food Science and Technology. 2013. Vol. 50. P. 185-192.

[54] Ahmad A.M., Khokhar I., Ahmad I., Kashmiri M.A., Adnan A., Ahmad M. Study of antimicrobial activity and composition by GC/MS spectroscopic analysis of the essential oil of *Thymus serphyllum* // Internet Journal of Food Safety. 2006. Vol. 5. P. 56-60.

[55] Aziz Sh., Habib-ur-Rehman, Irshad M., Asghar S.F., Hussain H., Ahmed I. Phytotoxic and antifungal activities of essential oils of *Thymus serpyllum* grown in the state of Jammu and Kashmir // Journal of Essential Oil Bearing Plants. 2010. Vol. 13, N 2. P 224-229. DOI 10.1080/0972060X.2010.10643816.

[56] Osińska E., Węglarz Z., Angielczyk M. Preliminary investigation on the variability of *Thymus serpyllum* L. growing wild in Central Poland // Proceed XVIth EUCARPIA Gen Res. 2002. P. 253-256.

[57] Wesołowska A., Jadczak D., Grzeszczuk M.Influence of distillation time on the content and composition of essential oil isolated from wild thyme (*Thymus serpyllum* L.) // Herba Polonica. 2012. Vol. 58, N 4. P. 40-50.

[58] nBanaeva Yu.A., Pokrovskiy L.M., Tkachev A.V. Chemical composition of the essential oil of *Thymus serpyllum* L.s.l. growing wild in Altai region // Proceedings of the International Conference on Natural Products and Physiologically Active Substances (ICNPAS-98). Russia, Novosibirsk, 1998. P. 145.

[59] Petrović S.S., Ristić M.S., Babović N.V., Lazić M.L., Francišković M., Petrović S.D. Chemical composition and antioxidative activity of essential oil of *Thymus serpyllum* L. // Hemijska industrija. 2013. OnLine-First (00): 51-51, doi 10.2298/HEMIND130513051P.

[60] Stanisavljević D.M., Zlatković B.P., Ristić M.S., Veličković D.T., Đorđević S.M., Lazić M.L. Hemijski sastav etarskog ulja (*Thymus serpyllum* L.) sa područja Kopaonika // Savremene tehnologije. 2012. N 1. P. 25-29.

[61] Jarit C., Mitrovit M., Pavlovit P. Review of Ethnobotanical, Phytochemical, and Pharmacological Study of Thymus serpyllum L. // Hindawi Publishing Corporation. Evidence-based complementary and alternative medicine. 2015. Article ID 101978. http://dx.doi.org/10.1155/2015/101978.

[62] Ummihan T., Mitsuru S., Motonobu G., Semih O. Chemical compositions and antioxidant properties of essential oils from nine species of Turkish plants obtained by supercritical carbon dioxide extraction and steam distillation. // IntJFoodSciNutr. 2008. Vol. 59. P. 619-634. DOI 10.1080/09637480701553816.

[63] Sur S.V., Tulyupa F.M., Tolok A.Ya., Peresypkina T.N. Composition of essential oils from the aboveground part of the Thyme // Khim. Farm. Zh. 1988. Vol. 22. P. 1361-1366.

[64] Kirillov V., Stikhareva T., Mukanov B., Chebotko N., Ryazantsev O., Atazhanova G., Adekenov S.. Composition of the Essential Oil of Thymus serpyllum L. from Northern Kazakhstan // TEOP. 2016. 19(1). P. 212-222.

[65] Suleimen E. M., Ibataev Zh. A., Iskakova Zh. B., Ishmuratova M. Yu. Constituent composition and biological activity of essential oil from Thymus stepposus // Chemistry of Natural Compounds. 2016. Vol. 52, N 1. P. 171-172. DOI 10.1007/s10600-016-1583-x.

[66] Satyal P., Murray B.L., McFeeters R.L., Setzer W.N. Essential oil Characterization of Thymus vulgaris from various geographical locations // Foods. 2016. N 5. Doi 10.3390/foods5040070 www.mdpi.com/journal/foods

[67] Soković M., Vukojević E., Marin P.B., Brkić D.D., Vajs V., Griensven L. Chemical composition of essential oils of Thymus and Mentha species and their antifungal activities // Molecules. 2009. N 14. P. 238-249; doi 10.3390/-molecules 14010238.

[68] Borugă O., Jianu C., Mişcă C., Goleţ I., Gruia A.T., Horhat F.G. Thymus vulgaris essential oil: chemical composition and antimicrobial activity // Journal of Medicine and Life. 2014. Vol. 7, N 3. P. 56-60.

[69] Kulpa D., Wesołowska A., Jadczak P. Micropropagation and composition of essentials oils in garden Thyme (Thymus vulgaris L.) // Not Bot Horti Agrobo. 2018. 46(2). DOI 10.15835/nbha46211020.

[70] Pirbalouti A.G., Hashemi M., Ghahfarokhi F.T. Essential oil and chemical compositions of wild and cultivated Thymus daenensis Celak and Thymus vulgaris L. // Industrial Crops and Products. 2013. Vol. 48. P. 43-48.

[71] Grosso C., Figueiredo A.C., Burillo J. Composition and antioxidant activity of Thymus vulgaris volatiles: Comparison between supercritical fluid extraction and hydrodistillation // J. Sep. Sci. 2010. Vol. 33, N 14. P. 2211-2218.

[72] Letchamo W., Marquard R., Hölzl J., Gosselin A. The selection of Thymus vulgaris cultivars to grow in Canada // Angewandte Botanik. 1994. Vol. 68. P. 83-88.

[73] Starchak Yu.A. Pharmacognostic study of plants of the genus *Thymus* L. as a promising source for phyto-drugs production. Diss. … doct. pharm. sci. – Kursk, 2016. – 470 p.

[74] Ramak P., Osaloo S.K., Sharifi M., Ebrahimzadeh H., Behmanesh M. Biosynthesis, regulation and properties of plant monoterpenoids // Journal of Medicinal Plant Research. 2014. Vol. 8(29). P. 983-991.

[75] Majdi M., Mashhady A.M., Maroufi A., Crocoll C. Tissue-specific gene-expression patterns of genes associated with thymol/carvacrol biosynthesis in thyme (Thymus vulgaris L.) and their differential changes upon treatment with abiotic elicitors // Plant Physiology and Biochemistry. 2016. DOI: 10.1016/j.plaphy.2017.03.016.

[76] Mikio Y, Taeko U. Biosynthesis of thymol // Chem. Pharmaceu. Bull. 1962. Vol. 10. P. 71-72.
[77] Sadyrbekov D.T., Ryazantsev O.G., Kenesov B.N. On theissue ofessential oils composition of some endomic thymes // In book: Innovative development and the relevance of science in modern Kazakhstan. Almaty, 2011. P. 111-114.
[78] Kushnarenko S.V., Utegenova G.A., Shegebayeva A.A., Ozek G., Ozek T., Abidkulova K.T., Kotukhov Yu.A., Danilova A.N. The antimicrobial activity of essential oils of some plantsof Kazakhstan // Bulletin of KazNU. Biological Series. 2016. N 2(67). P. 199-206.

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ЭФИРНЫЕ МАСЛА РАСТЕНИЙРОДА *THYMUS* L. ФЛОРЫ КАЗАХСТАНА: ХИМИЧЕСКИЙ СОСТАВ И ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ

Аннотация. Обобщены собственные данные по химическому составу эфирных масел 14 видов растений видов *Thymus* L. семейства *Lamiaceae Lindl*. флоры Казахстана. Проведен сравнительный анализ полученных автором результатов с опубликованными материалами по эфирным маслам видов *Thymus*. В статье обсуждаются пути биосинтеза основных компонентов в видах *Thymus* L, которые подтверждены результатами исследования автором компонентных составов эфирных масел. Приведены данные по скринингу эфирных масел тимьянов на биологическую активность.

Ключевые слова: тимьян, эфирные масла, моно- и сесквитерпеноиды, хромато-масс-спектрометрия, биосинтез.

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