Comparative studies of essential oils from Matricaria recutita L.

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The aim of the work is to determine the component composition of the essential oil of medicinal chamomile, grown on the educational and research site of medicinal plants of Zaporizhzhia State Medical and Pharmaceutical University (ZSMPHU), and commercial essential oil that was purchased via the Internet.

Materials and methods. The object of the study was chamomile essential oil obtained by hydrodistillation and commercial oil. Qualitative and quantitative determination of the components of essential oils was established using the chromato-mass spectrometric method on a high-performance gas chromatograph "Agilent 7890B GC System" (Agilent, SantaClara, CA, USA) with a mass spectrometric detector "Agilent 5977 BGC/MSD" (Agilent, SantaClara, CA, USA).

Results. Dominant compounds of essential oil of chamomile, grown on the educational and research site of medicinal plants ZSMPHU were 2*H*-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)) – 7.54 %, chamazulene – 5.32 %, alpha-bisabolol – 4.30 %, 1*H*-cycloprop[e]azulen-7-ol, decahydro-3,1,7-trimethyl-4-methylene – 3.25 %, myrtenyl acetate – 3.03 %, azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl) – 2.16 %, bisabolol oxide B – 1.86 %. Commercial chamomile essential oil was dominated by 3-methoxy-3-methylbutanol (56.15 %), diethyl phthalate (17.46 %), linalyl acetate (6.99 %), linalool (4.41 %).

Conclusions. Industrial cultivation of chamomile in southern Ukraine shows a high biologically active substances content and can be in demand in the pharmaceutical industry's consumer market for raw materials.

Keywords: Matricaria recutita L., essential oil, chromatography-mass spectrometry.

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Порівняльні дослідження ефірних олій Matricaria recutita L.

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Мета роботи – встановлення компонентного складу ефірної олії ромашки лікарської, вирощеної на навчально-дослідній ділянці Запорізького державного медико-фармацевтичного університету (ЗДМФУ), та комерційної ефірної олії, яка придбана через мережу Інтернет.

Матеріали і методи. Об'єкт дослідження – ефірна олія ромашки, отримана методом гідродистиляції, та комерційна олія. Якісне та кількісне визначення компонентів ефірних олій здійснили з використанням хромато-мас-спектрометричного методу на високоефективному газовому хроматографі «Agilent 7890B GC System» (Agilent, SantaClara, CA, USA) з мас-спектрометричним детектором «Agilent 5977 BGC/MSD» (Agilent, SantaClara, CA, USA).

Результати. Сполуки, що домінували в ефірній олії ромашки, яка вирощена на навчально-дослідній ділянці лікарських рослин лікарських рослин ЗДМФУ: 2*H*-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl) – 7,54 %, chamazulene – 5,32 %, alpha-bisabolol – 4,30 %, 1*H*-cycloprop[e]azulen-7-ol, decahydro-3,1,7-trimethyl-4-methylene – 3,25 %, myrtenyl acetate – 3,03 %, azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl) – 2,16 %, bisabolol oxide B – 1,86 %. В комерційній ефірній олії ромашки лікарської переважали 3-methoxy-3-methylbutanol (56,15 %), diethyl phthalate (17,46 %), linalyl acetate (6,99 %), linalool (4,41 %).

Висновки. Промислове культивування ромашки лікарської в умовах півдня України сприяє високому вмісту біологічно активних речовин і може бути затребуваним для споживчого ринку сировини, що використовують у фармацевтичній промисловості.

Ключові слова: Matricaria recutita L., ефірна олія, хромато-мас-спектрометрія.

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Cultivation of medicinal plants contributes to the increase of the raw material base, the protection of rare and endangered species, and is a prerequisite for obtaining high-quality raw materials, primarily with a high content of pharmacologically active substances. The main task of selection is to breed species with a high yield of raw materials and an increased content of active substances, resistant to diseases and pests, and suitable for mechanized cultivation technology [1,2,3]. The qualitative composition and quantitative content of components may change due to the influence of various natural factors. Local geoclimate, seasonal changes, light, humidity, and soil type are the main parameters that affect the accumulation of biologically active substances in the plant. The cultivation of plants plays a major role in obtaining higher quality raw materials, which in turn contributes to the production of effective drugs, enabling appropriate therapy for patients [4].

The transition of domestic pharmaceutical production to international standards significantly increases the requirements for the cultivation and quality of medicinal raw materials [5]. The important factors affecting the content of active substances are environmental factors. They are the amount of precipitation and air humidity, soil composition, thermal and light energy [1,2].

Among the great variety of medicinal plants, a special place is occupied by the medicinal chamomile (*Matricaria recutita* L.) [6]. In its wild form, species similar in appearance are found next to it, which are unacceptable impurities [7,8].

Chamomile medicinal flower baskets (*Matricariae* flores) are widely utilized in medicine owing to their substantial content of essential oils, flavonoids, and other biologically active metabolites. These compounds exhibit a wide range of therapeutic properties, including anti-inflammatory, antiseptic, antispasmodic, antioxidant, emollient, choleretic, astringent, antipyretic, soothing, and antimicrobial effects [9,10].

Chamomile flowers are key components of numerous preparations, with the majority being manufactured in Ukraine [11]. *Matricaria recutita* L. is classified as a priority medicinal plant, with its raw materials in high demand. These flowers are harvested from wild *Matricaria recutita* L. in their natural habitats and from cultivated sources across various regions of Ukraine.

The novelty of this study lies in several key aspects. First, it involves a comprehensive comparison of essential oils from various sources, considering diverse factors such as the growing conditions of the raw materials, the vegetation phase during harvesting, the processing methods, and the plants' geographical origin. Additionally, the study employs multiple analytical techniques to assess these variables. This multi-faceted approach provides valuable insights into the stability and quality of chamomile essential oils. Consequently, these findings contribute to the enhancement of scientific knowledge and the overall quality of essential oil production.

Aim

The purpose of the work is to determine the component composition of the essential oil of medicinal chamomile, grown on the educational and research site of medicinal plants of Zaporizhzhia State Medical and Pharmaceutical University, and commercial essential oil that was purchased via the Internet.

Materials and methods

The object of the study was chamomile essential oil, obtained by the method of hydrodistillation, and commercial oil. The essential oil was obtained in the laboratory of the Department of Pharmacognosy, Pharmacology and Botany of Zaporizhzhia State Medical and Pharmaceutical University (ZSMPHU). Qualitative and quantitative determination of the components of essential oils was established using the chromato-mass spectrometric method in the laboratory of gas chromato-mass chromatospectrometry of the Educational and Scientific Medical Laboratory Center with a vivarium.

The essential oil was obtained from dry medicinal plant material by the standard method of hydrodistillation (reference to the State Pharmacopoeia of Ukraine) [12].

The research was carried out using standard methods for determining chemical compounds on a high-performance gas chromatograph "Agilent 7890B GC System" (Agilent, SantaClara, CA, USA) with a mass spectrometric detector "Agilent 5977 BGC/MSD" (Agilent, SantaClara, CA, USA) [13,14]. Chromatographic column DB-5ms length 30 m × 250 µm × 0.25 µm. The speed of the carrier gas (helium) is 1.3 ml/min. Injection volume – 0.5 µl. Flow division – 1:5. The temperature of the sample input unit is 200 °C → 12°C/s → 265 °C. Thermostat temperature: programmable, 70 °C (1 min delay) → 10 °C/min → 270 °C (4 min delay). The temperature of the GC/MS interface is 275 °C; ion sources – 230 °C; of a quadrupole mass analyzer – 150 °C. Type of ionization: EI at an electron energy of 70 eV. 30–700 m/z. The NIST14 mass spectrum library was used to identify the components.

Results

The essential oil of medicinal chamomile, grown on the educational and research site of medicinal plants of ZSMPHU, was intensely blue, oily to the touch with a pleasant characteristic smell [15,16]. The commercial essential oil was yellow, oily to the touch with a faint odor.

According to the results of the chromatographic-mass-spectrometric study, 48 compounds were identified in the essential oil of chamomile, grown on the educational and research site of medicinal plants of ZSMPHU, taking into account agrotechnical methods *(Fig. 1, Table 1)* and 18 compounds in the essential oil purchased through the Internet *(Fig. 1, Table 2)*.

Among substances of terpenoid nature, the dominant compounds of chamomile essential oil grown on the educational and research site of medicinal plants of ZSMPHU were 2*H*-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl) – 7.54 %, chamazulene – 5.32 %, alpha-bisabolol – 4.30 %, 1*H*-cycloprop[e]azulen-7-ol,

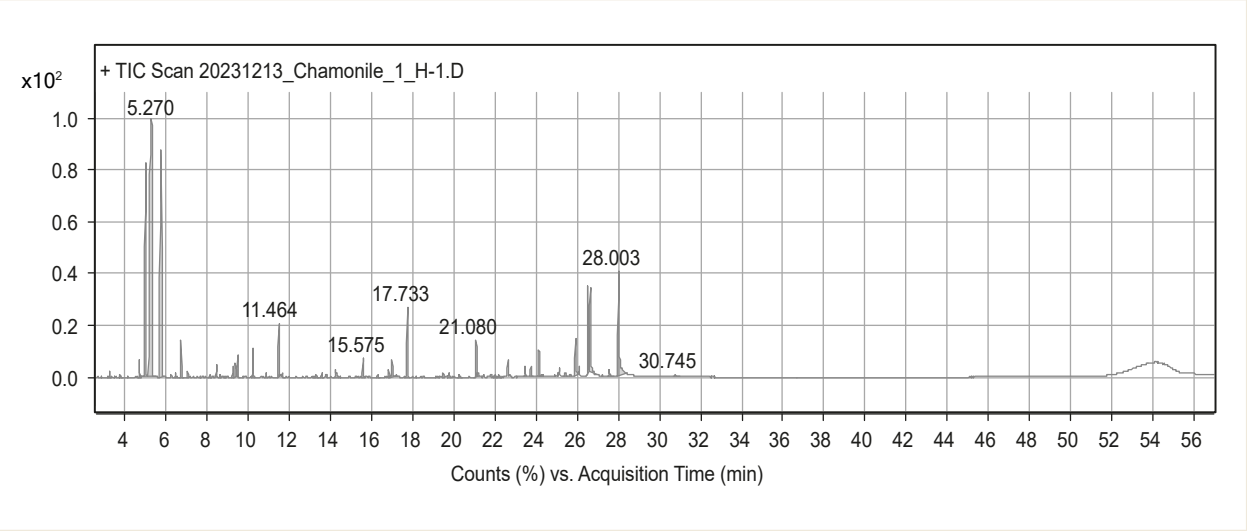

Fig. 1. Chromatogram of essential oil of chamomile, grown at the educational and research area of medicinal plants of ZSMPHU.

Table 1. Qualitative and quantitative content of chamomile essential oil of medicinal flowers grown at the educational and research site of medicinal plants of ZSMPHU

No.	RT	Compound name	Area Sum %
1	3.232	Toluene	0.19
2	3.745	Hexanal	0.10
3	4.695	Butanoic acid, 2-methyl-, ethyl ester	0.64
5	5.27	3,5-Octadiyne	28.99
7	6.448	Benzene, (1-methylethyl)	0.16
8	6.717	3-Carene	1.12
9	7.034	Butanoic acid, 2-methyl-, propyl ester	0.20
10	8.113	5-Hepten-2-one, 6-methyl	0.10
11	8.434	3,6-Heptadien-2-ol, 2,5,5-trimethyl	0.42
12	9.235	o-Cymene	0.36
13	9.368	D-Limonene	0.47
14	9.47	Eucalyptol	0.81
15	10.211	1,5-Heptadien-4-one, 3,3,6-trimethyl	1.11
16	10.863	1,5-Heptadien-4-ol, 3,3,6-trimethyl	0.14
17	11.464	Linalool	1.84
18	11.638	Bicyclo[3.1.0]hexan-3-one, 4-methyl-1-(1-methylethyl)	0.13
19	13.299	4-Hexen-1-ol, 5-methyl-2-(1-methylethenyl)	0.09
20	13.561	endo-Borneol	0.14
21	13.793	Terpinen-4-ol	0.11
22	14.234	α-Terpineol	0.65
23	15.575	D-Carvone	0.76
24	16.277	4,8-Dimethylnona-3,8-dien-2-one	0.09

Count of Table 1.

No.	RT	Compound name	Area Sum %
25	16.823	Safrole	0.33
26	16.976	Thymol	0.82
27	17.199	Thymol	0.12
28	17.733	Myrtenyl acetate	3.03
29	19.477	Bicyclo[5.3.0]decane, 2-methylene-5-(1-methylvinyl)-8-methyl	0.17
30	19.745	Methyleugenol	0.17
31	20.258	Caryophyllene	0.12
32	21.08	cis-beta-Farnesene	1.46
33	21.163	1,4,7,-Cycloundecatriene, 1,5,9,9-tetramethyl	0.16
34	21.796	(1R,2S,6S,7S,8S)-8-Isopropyl-1-methyl-3-methylenetricyclo[4.4.0.02,7]decane	0.09
35	21.999	1,1,4a-Trimethyl-5,6-dimethylenedecahydronaphthalene	0.14
36	22.164	Azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl)	2.16
37	23.45	Cyclohexanemethanol, 4-ethenyl-4-trimethyl-3-(1-methylethenyl)	0.44
38	23.739	1,6,10-Dodecatrien-3-ol, 3,7,11-trimethyl	0.37
39	24.13	1*H*-Cycloprop[e]azulen-7-ol, decahydro-1,1,7-trimethyl-4-methylene	3.25
40	24.247	Alloaromadendrene oxide-(1)	0.10
41	25.411	2-Naphthalenemethanol, 1,2,3,4,4a,5,6,7-octahydro,4a,8-tetramethyl	0.22
42	25.638	tau-Muurolol	0.10
43	25.911	Bisabolol oxide B	1.86
44	26.509	(S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl)dihydro-2*H*-pyran-3(4*H*)-one	3.80
45	26.619	α-Bisabolol	4.30
46	27.556	Chamazulene	5.32
47	28.003	2*H*-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)	7.54
48	30.745	(Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6-dioxaspiro[4.4]non-3-ene	0.24

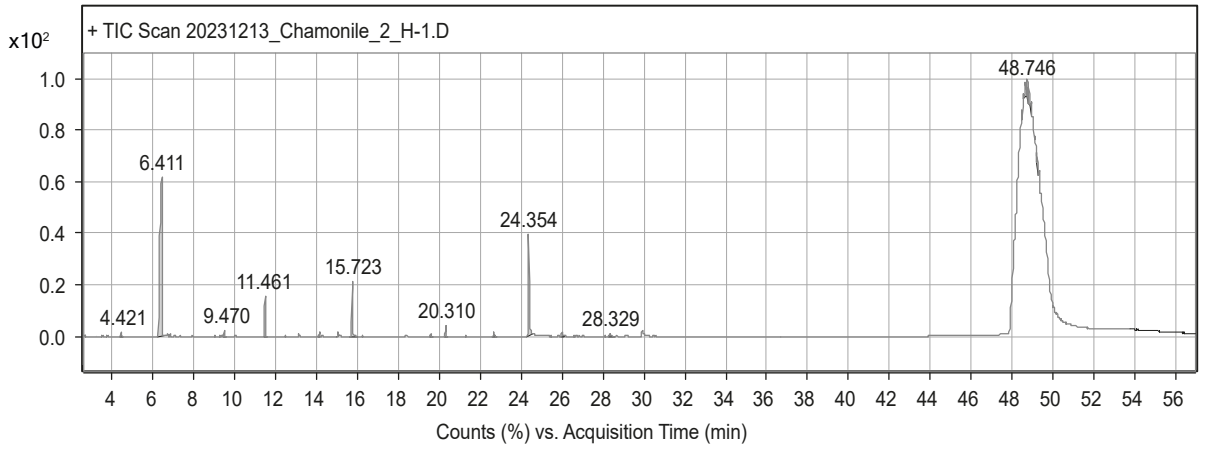

Fig. 2. Chromatogram of commercial chamomile medicinal flowers essential oil.

Table 2. Qualitative and quantitative content of commercial chamomile essential oil

No.	RT	Compound name	Area Sum %
1	4.421	Butanoic acid, 3-hydroxy-3-methyl	0.32
2	6.411	3-Methoxy-3-methylbutanol	56.15
3	9.47	Eucalyptol	0.59
4	11.461	Linalool	4.41
5	14.129	1,3-Dioxolane, 2-heptyl	0.42
6	15.047	2,6-Octadien-1-ol, 3,7-dimethyl	0.44
7	15.723	Linalyl acetate	6.99
8	19.57	beta.-Phenylethyl butyrate	0.44
9	20.31	Nopyl acetate	1.36
10	22.644	2-Phenoxyethyl isobutyrate	0.60
11	24.354	Diethyl Phthalate	17.46
12	25.997	Ethanone, 1-(2,3,4,7,8,8a-hexahydro-3,6,8,8-tetramethyl-1H-3a,7-methanoazulen-5-yl)	0.73
13	28.329	Cyclopenta[g]-2-benzopyran, 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethyl	0.57
14	48.648	Hexadecanoic acid, 2-methylpropyl ester	2.41
15	48.746	1-Methylbutyl hexadecanoate	2.54
16	48.826	1-Methylbutyl hexadecanoate	2.15
17	48.924	1-Methylbutyl hexadecanoate	1.02
18	49.212	1-Methylbutyl hexadecanoate	1.39

decahydro-3,1,7-trimethyl-4-methylene – 3.25 %, myrtenyl acetate – 3.03 %, azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl) – 2.16 %, bisabolol oxide B – 1.86 %, linalool – 1.84 %, cis-beta-farnesene – 1.46 %, 3-carene – 1.12 %.

Commercial chamomile essential oil was dominated by 3-methoxy-3-methylbutanol (56.15 %), diethyl phthalate (17.46 %), linalyl acetate (6.99 %), linalool (4.41 %).

In the essential oil of chamomile, grown on the educational and research site of medicinal plants of ZSMPHU and commercial, 2 components – linalool (1.84 % and 4.41 %, respectively) and eucalyptol (0.81 % and 0.59 %, respectively) were identified.

Discussion

Azulene-containing compounds, which cause its blue color, are markers of the quality of essential oil of medicinal chamomile (*Matricaria recutita* L.) [11]. Hamazulene was identified only in the essential oil of chamomile grown at the medicinal plant research area of ZSMPHU.

The composition of biologically active substances in the essential oil of medicinal chamomile (*Matricaria recutita* L.), grown at the educational and research site of medicinal plants of Zaporizhzhia State Medical and Pharmaceutical University, and commercial essential oil purchased over the Internet may differ due to several key factors.

Firstly, the lower component composition of the commercial essential oil can be attributed to the fact that the plants were grown in different regions with varying climatic conditions. These environmental differences significantly impact plant metabolism and, consequently, the composition of biologically active substances (BAS).

Secondly, the methods of collection and processing used for the essential oils can vary. Commercial processes may involve high temperatures or chemical solvents that can alter the BAS composition. These methods can potentially degrade sensitive components or change the overall chemical profile of the essential oil.

Thirdly, the timing of harvesting plays a crucial role in the quality and quantity of essential oil extracted from the plant material. Harvesting raw materials at the incorrect time can reduce the total amount of essential oil available. The accumulation of essential oils in chamomile occurs gradually, reaching its peak during the full flowering phase. Essential oil components such as chamazulene, α-bisabolol, bisabolol oxide, and linalool achieve their optimal concentrations during this phase. If the harvesting is done either too early or too late, the concentrations of these active substances can be significantly lower, impacting the efficacy and quality of the essential oil.

The use of different distillation methods can affect the composition of the oil, including the loss or change of certain components. Unknown conditions of storage and

transportation can lead to changes in the composition of the oil, including the loss of volatile components. Inadmissible impurities are possible during the procurement of raw materials or adulteration, such as the addition of synthetic components or dilution with other oils, which affects the final composition of BAS.

Conclusions

1. The results of the chromatographic-mass spectrometric study revealed the presence of 48 compounds in the essential oil of chamomile grown at the educational and experimental site of medicinal plants of ZSMPHU. Among these compounds, the following components were predominant: 2*H*-pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl) – 7.54 %, chamazulene – 5.32 %, alpha-bisabolol – 4.30 %, 1*H*-cycloprop[e]azulen-7-ol, decahydro-3,1,7-trimethyl-4-methylene – 3.25 %, myrtenyl acetate – 3.03 %, and azulene, 1,2,3,3a,4,5,6,7-octahydro-1,4-dimethyl-7-(1-methylethenyl) – 2.16 %.

2. The commercial chamomile essential oil, obtained through an online purchase, was predominantly composed of 3-methoxy-3-methylbutanol (56.15 %), diethyl phthalate (17.46 %), linalyl acetate (6.99 %), and linalool (4.41 %).

3. The components common to both essential oils were linalool (1.84 % and 4.41 %, respectively) and eucalyptol (0.81 % and 0.59 %, respectively).

4. The absence of the characteristic blue color and the insignificant component composition of the commercial essential oil may indicate that the chamomile raw material was harvested during the wrong phase of vegetation or that the incorrect type of chamomile was utilized as the source of oil, thus impacting the essential oil's quality.

5. The studies have demonstrated the viability of industrially cultivating chamomile in the conditions of southern Ukraine, given its high content of biologically active substances and potential demand in the raw material market for the pharmaceutical industry.

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