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CHEMISTRY

Content and composition of essential oils in some Asteraceae species

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Abstract. The content and composition of the essential oils of five Asteraceae species from Estonia were studied. The oil yields ranged from traces up to 0.2%. By using GC-FID and GC-MS methods a total of 115 compounds were identified and significant qualitative and quantitative differences were observed among the studied species. The main constituents of the essential oils of the studied Asteraceae species were as follows: *Chamomilla recutita*: bisabolol oxide A (39.4%), bisabolone oxide A (13.9%), (*Z*)-en-yne-dicycloether (11.5%), bisabolol oxide B (9.9%), α-bisabolol (5.6%), and chamazulene (4.7%); *Chamomilla suaveolens*: (*Z*)-en-yne-dicycloether (37.2%), geranyl isovalerate (22.9%), (*E*)-β-farnesene (15.6%); *Anthemis tinctoria*: α-eudesmol (10.2%), γ-cadinol (8.7%), γ-cadinene (4.0%); *Matricaria perforata*: (*Z*,*Z*)-matricaria ester (77.9%), (*E*)-β-farnesene (3.5%), matricaria ester isomer (3.5%), and matricaria lactone (3.0%); and *Leucanthemum vulgare*: (*E*)-β-farnesene (7.3%), hexadecahydrocyclobuta[1,2:3,4]dicyclooctene (5.3%), decanoic acid (4.9%), and γ-eudesmol (4.5%). The number of compounds found in all plant oils studied was 14.

Key words: *Chamomilla recutita*, *Chamomilla suaveolens*, *Anthemis tinctoria*, *Matricaria perforata*, *Leucanthemum vulgare*, Asteraceae, essential oil.

INTRODUCTION

The Asteraceae family contains several species known as popular medicinal plants. The concept that plants can be classified also on the basis of their chemical constituents is not new [1,2]. According to an earlier study [3], the most popular medicinal plant in Estonia during the 20th century was *Chamomilla recutita* (L.) Rauschert (= *Matricaria recutita* L.), which was also very widely used in the Soviet Union, Russia, Germany, etc. In several publications (an overview in [3]) it is observed that the chemical composition of the essential oil of *Chamomilla recutita* is rather similar to that of *Chamomilla suaveolens* (Pursh) Rydb. (= *Matricaria suaveolens* (Pursh) Buch.; *M. discoidea* DC.; *M. matricarioides* (Less.) Porter). The chamomile inflorescence is anti-inflammatory and spasmolytic [4].

As many taxonomically related plants may contain structurally similar compounds [5], it could be useful to investigate also the composition of essential oils of other species of the Asteraceae family, morphologically and chemotaxonomically similar to the genus *Chamomilla*, such as *Anthemis tinctoria* L., *Matricaria perforata* Merat (= *M. inodora* L.; *Tripleurospermum inodorum* (L.) Sch. Bip.), and *Leucanthemum vulgare* Lam. (*Chrysanthemum leucanthemum* L.).

These three species are not yet known as medicinal plants of allopatic medicine. The antibacterial and bactericidal activity of extracts and their fractions of aerial parts of *Anthemis tinctoria* against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Enterococcus faecalis* was determined [6]. Mogosan et al. [7] mentioned that the tincture of *A. tinctoria* promotes potassium retention, the saponins of the same species increase urinary excretion of uric acid. According to the Patent No. RU 2311194, the extract of *Leucanthemum vulgare* is a constituent of a homeopathic agent possessing an antiviral effect [8].

The composition of the essential oils of two well-known species of the genus *Chamomilla*, especially of *Chamomilla recutita*, has been rather well investigated

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within the last 25 years [9–23]. At the same time, the composition of the essential oil of *Chamomilla suaveolens* has been the subject of rather limited phytochemical investigations [9, 24–33], realized basically in the former USSR (Russia, Estonia, and Lithuania). The main biologically active compounds in the oils of *Chamomilla recutita* and *C. suaveolens* were found to be (*E*)-farnesene, (*Z*)- and (*E*)-en-yne-dicycloether, and farnesole [3].

However, drastically little is known about the composition of the essential oil of other Asteraceae species mentioned above [34–38]. The main constituents of the essential oil of *Anthemis tinctoria* from Creece have been found to be spathulenol, caryophyllene oxide, and T-cadinol [37], but 1,8-cineole (8%), β-pinene (7%), decanoic acid (5%), and α-pinene (4%) in a sample from Slovakia [35,38].

The essential oil of *Matricaria perforata* from Germany is dominated by 2*Z*,8*Z*-matricaria ester (75%), accompanied by several other characteristic polyines, such as 8*Z*-2,3-dihydro-matricaria ester, 2*E*- and 2*Z*-lachnophyllum ester, 2*E*-dehydro-matricaria ester, and 5*E*,9*Z*-matricaria lactone [34]. The major constituents of the oil of *Leucanthemum vulgare* from Georgia include nerolidol, α-bisabolol, farnesol, and farnesene [36].

The current paper presents the content and the results of GC-FID and GC-MS analyses of the essential oils of inflorescences of *Chamomilla recutita*, *Chamomilla suaveolens*, *Anthemis tinctoria*, *Matricaria perforata*, and *Leucanthemum vulgare* growing in Estonia.

EXPERIMENTAL

Plant material

The plant material – samples of herbs of wild-growing *Anthemis tinctoria*, *Matricaria perforata*, *Leucanthemum vulgare*, and *Chamomilla suaveolens* – was collected in July 2007 from North Estonia (Harjumaa, Virla). The sample of *Chamomilla recutita* was from a cultivated plant and it was collected in June 2007 in the experimental garden of the University of Tartu. All collected fresh samples were dried at room temperature in a well-ventilated room. The dried drug samples were preserved in tightly closed bumper bags at room temperature in the absence of light. Voucher specimens and drug samples are deposited at the Department of Pharmacy, University of Tartu, Estonia.

Isolation of essential oil

The essential oils were isolated from dried samples of Asteraceae species by the distillation method described in the European Pharmacopoeia [39] for *Matricariae flos* by using the Clevenger-type apparatus. A 1000 mL round-bottomed flask, 30 g of plant material, and 300 mL of water as the distillation liquid were used. Cyclohexane (1 mL in a graduated tube) was added to take up the essential oil. The distillation time was 4 h at a rate of 3–4 mL/min. The oils were stored prior to analysis in ampoules and were analysed within a week.

Gas chromatography with FID

The essential oils were analysed using a Chrom-5 chromatograph with FID on two fused silica capillary columns with two stationary phases: poly(5% diphenyl–95% polydimethyl siloxane) (SPB^{TM}-5, 30 m × 0.25 mm, Supelco, Switzerland) and polar polyethylene glycol (SW-10, 30 m × 0.25 mm, Supelco, Switzerland). Film thickness of both stationary phases was 0.25 μm. Helium with the split ratio 1 : 150 and the flow rate 30–35 cm/s was applied as the carrier gas. The temperature program was from 50 to 250 °C at 2 °C/min, the injector temperature was 250 °C. A Spectra-Physics SP4100 integrator was used for data processing.

The identification of the oil components was accomplished by comparing their retention indices (RI) on two columns with the RI values of reference standards, our RI data bank, and with literature data [40–43].

The percentage composition of the oils was calculated in peak areas using the normalization method without correction factors. The relative standard deviation of percentages of oil components of three repeated GC analyses of a single oil sample did not exceed 5%.

Gas chromatography–mass spectrometry

GC/MS analysis was carried out using GCMS-QP2010 (Shimadzu, Japan) on a fused silica capillary column (30 m × 0.32 mm) with a bonded stationary phase: poly(5% diphenyl–95% dimethyl siloxane) (ZB-5, Zebron). The film thickness of the stationary phase was 0.25 μm. The carrier gas was helium with the split ratio of 1 : 8 and flow rate 44.4 cm/s. The temperature program was 1 min at 60 °C and then from 60 to 300 °C at 8 °C/min. The injector temperature was 280 °C. The MS source temperature was 200 °C. The MS detector was operated in the EI mode 70 eV at a scan rate 2 scans/s with an acquisition mass range of 40–500 u.

RESULTS AND DISCUSSION

Content of essential oils

The content of essential oils in the investigated plants of Asteraceae species ranged from traces up to 0.2% based on dry weight (Table 1). The highest oil content was found in *Matricaria perforate* (0.2%) and the lowest in *Anthemis tinctoria* (only in traces). As it was shown in [38], the content of essential oil in the individual

floral parts of *A. tinctoria* from Slovakia ranges from 0.02% to 2.78%. The highest content of essential oil was found in the tongue-shaped flowers in the second development stage.

A very low yield of essential oil (0.03%) was found also in the sample of *Leucanthemum vulgare* of Estonian origin. The essential oil of *L. vulgare* from Georgia made up 0.4–0.5% of the air-dried mass [36].

The extremely low concentrations of essential oil in *A. tinctoria* and *L. vulgare* can probably be explained by the origin of the investigated samples. Our earlier experience shows that there may exist a significant difference between the minimum and maximum yield of essential oil in other plants: 10-fold difference in *Chamomilla recutita* [23], 11-fold in *Achillea millefolium* [44] and *Salvia officinalis* [45], 16-fold in *Levisticum officinale* [46], 14-fold in *Thymus serpyllum* [47], 5-fold in *Pimpinella anisum* [48], and 6-fold in *Valeriana officinalis* [49] collected or obtained as commercial samples from different retail pharmacies of various countries.

The *Chamomilla* species – *C. recutita* and *C. suaveolens* – contained 0.15% and 0.12% essential oil, respectively. According to the standards of the 10th edition of the *U.S.S.R Pharmacopoeia* [50], the inflorescences of *C. recutita* and *C. suaveolens* should contain at least 0.3% and 0.2% essential oil. Consequently, the oil yield in the investigated Asteraceae species was rather low although the distillation method corresponded to the monograph of Matricariae flos (inflorescences of *C. recutita*) in the *European Pharmacopoeia* [39] and the distillation time (4 h) was quite long.

Composition of essential oils

Essential oil components of five Asteraceae species and their percentages and mode of identification are reported in Table 1. A total of 115 compounds were identified in the studied samples, which accounted for 49.1–98.5% of the total amount of oil. The largest number of compounds were identified in the oil of *Matricaria perforata* (84). In other oils 52–62 compounds were identified. From the essential oil of the flower heads of *M. perforata* growing in Germany about 50 compounds were found [34]. The amount of polyacetylenes in the oil of *M. perforata* from Estonia (88.6%) was practically equal to their concentration found in Germany (88.8%) [34].

In the oil of *Leucanthemum vulgare* we succeeded in identifying only 49.1% of the total oil. The mass spectra of 23 incompletely identified peaks are presented in Table 2. The oil of *L. vulgare* contained much more aliphatic acids and esters than the oils of the other investigated Asteraceae species [9–36] but had a very low concentration of polyacetylenes (Table 1).

The main constituents found in the essential oils of the studied Asteraceae species were bisabolol oxide A, bisabolone oxide A, (*Z*)-en-yne-dicycloether, bisabolol oxide B, α-bisabolol, and chamazulene in the essential oil of *Chamomilla recutita*; (*Z*)-en-yne-dicycloether, geranyl isovalerate, and (*E*)-β-farnesene in *C. suaveolens*; (*Z*,*Z*)-matricaria ester, (*E*)-β-farnesene, matricaria ester isomer, and matricaria lactone in *Matricaria perforata*; α-eudesmol, γ-cadinol, and γ-cadinene in *Anthemis tinctoria*; and (*E*)-β-farnesene in *Leucanthemum vulgare* (Table 1).

Chamazulene is the typical constituent of the essential oil of *C. recutita*. It has been found in the range from 0.7% to 15.3% in samples of *C. recutita* [19,23] and from 0% to 42% in *Achillea millefolium* growing wild and/or cultivated in different countries [44], but was not found in the oil of *C. suaveolens* [33]. The presence of chamazulene in the essential oil of *C. suaveolens* may depend on its chemotypes or growing places.

As shown in Table 1, the oil composition of the studied species was quite different. Only 14 compounds were found in all plant oils studied: decanoic acid, (*E*)-β-farnesene, germacrene D, caryophyllene oxide, geranyl isovalerate, γ-eudesmol, bisabolol oxide A, hexahydrofarnesyl acetone, (*Z*)-en-yne-dicycloether, *n*-nonadecane, *e*-eikosane, γ-palmitolactone, *n*-tricosane, and *n*-pentacosane.

CONCLUSION

In this study the content and composition of inflorescences of five Asteraceae species were investigated. The oil yield in the investigated Asteraceae species was rather low. The composition of the essential oils of these five species was compared. Only 14 compounds were found in all analysed oils. The composition of the oils of *Chamomilla recutita*, *C. suaveolens*, and *Matricaria perforata* was relatively similar; however, the oil of *Leucanthemum vulgare* was quite different from the other oils studied.

Table 1. Composition of the essential oils from some species of Asteraceae. The main components are indicated in bold. Identification methods: 1 – RI(SPB-5), 2 – RI(SW-10), 3 – mass spectra

Compound	RI		Percentage composition					Identification method
	SPB-5	SW-10	*Chamomilla recutita*	*Chamomilla suaveolens*	*Anthemis tinctoria*	*Matricaria perforata*	*Leucanthemum vulgare*	
α-Pinene	927	1025	tr	tr	0.1	–	–	1,2,3
Sabinene	966	1120	–	–	0.9	–	tr	1,2,3
β-Pinene	969	1116	0.2	0.2	**1.8**	–	–	1,2,3
6-Methyl-5-hepten-2-one	984	1344	0.1	tr	tr	tr	–	1,2,3
Myrcene	988	1168	0.1	**2.9**	0.2	–	0.2	1,2,3
2-Pentylfuran	990	1236	–	tr	0.2	tr	–	1,2,3
n-Octanal	1002	1278	0.2	tr	0.1	–	tr	1,2,3
α-Terpinene	1012	1181	tr	tr	0.2	–	–	1,2,3
p-Cymene	1018	1272	0.2	tr	0.3	–	0.1	1,2,3
Limonene	1023	1202	tr	0.5	0.4	–	tr	1,2,3
1,8-Cineol	1026	1208	0.2	tr	**3.6**	–	0.4	1,2,3
(*E*)-β-Ocimene	1044	1254	0.2	tr	–	tr	tr	1,2,3
γ-Terpinene	1054	1246	0.2	–	0.5	–	–	1,2,3
Artemisia ketone	1058	1353	0.8	–	–	tr	–	1,2
cis-Limonene hydrate	1065	1257	–	–	0.1	–	–	1,2,3
Terpinolene	1084	1283	–	–	0.1	–	–	1,2,3
Perillene	1100	1507	–	0.1	–	–	–	1,2,3
2-Methylbutyl 2-methylbutyrate	1100	1300	0.2	–	0.3	tr	0.1	1,2,3
n-Nonanal	1103	1400	0.2	0.1	0.4	–	0.2	1,2,3
Isoamyl isovalerate	1110	1309	–	tr	0.1	tr	0.2	1,2,3
1-Octenyl acetate	1113	1386	–	–	–	–	1.1	1,2,3
n-Pentyl isovalerate	1129	1382	–	tr	0.2	tr	0.4	1,2,3
Pinocarvone	1162	1565	–	–	0.1	tr	–	1,2,3
Octanoic acid	1172	2093	–	–	tr	–	0.2	1,2,3
Terpinen-4-ol	1172	1606	0.1	tr	0.5	–	tr	1,2,3
p-Cymen-8-ol	1178	1846	–	tr	0.2	–	–	1,2
α-Terpineol	1187	1704	0.1	tr	1.8	–	tr	1,2,3
cis-3-Hexenyl isovalerate	1234	1454	tr	–	tr	tr	–	1,2,3
Nonanoic acid	1290	2190	–	–	1.1	–	0.1	1,2.3
n-Undecanal	1304	1600	–	tr	0.5	–	tr	1,2,3
(*E*)-Carvyl acetate	1330	1756	–	–	0.1	–	–	1,2,3
δ-Elemene	1334	1462	–	–	0.2	–	–	1,2
2H-2,4a-Ethanonaphthalene,1,3,4,5,6,7-hexa-hydro-2,5,5-trimethyl-	1334	1493	–	–	–	0.1	–	1,2,3
(*E*,*E*)-2,4-Decadienal	1334	1816	–	–	tr	–	0.1	1,2,3
α-Cubebene	1343	1454	–	–	0.2	–	0.1	1,2,3
α-Copaene	1367	1485	tr	–	1.3	–	tr	1,2,3
Isoeugenol	1367	2213	–	–	–	0.1	–	1,2,3
Geranyl acetate	1380	1764	–	tr	–	–	0.8	1,2,3
(*Z*)-Jasmone	1390	1935	–	–	tr	–	–	1,2,3
Decanoic acid	1398	2292	0.2	0.8	**3.6**	0.3	**4.9**	1,2,3
(*E*)-β-Caryophyllene	1408	1588	0.1	–	0.6	0.2	1.3	1,2,3
Aromadendrene	1440	1590	–	–	0.1	0.1	tr	1,2,3
β-Gurjunene	1442	1600	–	–	tr	–	–	1,2,3
α-Humulene	1449	1626	–	–	0.4	tr	0.1	1,2,3
Geranyl acetone	1450	1876	–	–	0.1	–	–	1,2,3
(*E*)-β-Farnesene	1455	1668	**2.3**	**15.6**	**3.3**	**3.5**	**7.3**	1,2,3

Table 1. *Continued*

Compound	RI		Percentage composition					Identification method
	SPB-5	SW-10	*Chamomilla recutita*	*Chamomilla suaveolens*	*Anthemis tinctoria*	*Matricaria perforata*	*Leucanthemum vulgare*	
8-Methylcoumarin	1461	2308	–	–	–	0.9	–	1,2,3
Alloaromadendrene	1464	1632	0.1	0.1	tr	–	–	1,2,3
Germacrene D	1470	1696	0.2	0.5	0.5	0.1	0.1	1,2,3
α-Amorphene	1479	1744	–	tr	0.4	tr	tr	1,2,3
α-Muurolene	1485	1725	0.2	–	1.2	–	tr	1,2,3
Geranyl isobutanoate	1488	1882	–	0.1	–	tr	tr	1,2,3
Isopentyl phenyl acetate	1488		–	–	2.1	–	–	1,3
Bicyclogermacrene	1490	1720	tr	–	0.2	tr	–	1,2
$C_{15}H_{24}$ (1)	1490	1742	–	–	–	–	0.2	1,2,3
n-Undecanoic acid	1492	2350	0.2	tr	1.0	–	0.8	1,2
n-Tridecanal	1500	1795	tr	–	0.3	–	1.2	1,2,3
***Z*-Lachnohyllum methyl ester**	1500	2250	–	–	–	**2.9**	–	1,2,3
Isofaurinone	1503	1900	0.2	1.4	0.4	–	0.5	1,2
δ-Cadinene	1510	1750	0.1	0.4	**2.2**	–	0.1	1,2,3
$C_{15}H_{26}O$ (2)	1510	1935	–	–	**3.2**	–	–	1,2,3
Matricaria ester*	1511	2256	–	–	–	**3.5**	–	1,2,3
(*Z*,*Z*)-Matricaria ester	1516	2321	–	–	–	**77.9**	–	1,2,3
γ-Cadinene	1523	1752	0.1	0.2	**4.0**	–	tr	1,2,3
E-Lachnohyllum methyl ester	1528	2248	–	–	–	0.1	–	1,3
$C_{15}H_{24}O$ (3), hotrienol structure	1528	1938	–	1.0	–	–	–	1,2,3
Cadina-1,4-diene	1530	1798	–	–	0.2	–	–	1,2,3
Elemol	1543	2100	–	tr	0.2	–	0.2	1,2,3
NI (4), hotrienol structure, acetate?	1554	2035	tr	0.4	0.1	–	–	1,2,3
NI (5), farnesene epoxide?	1554		–	–	–	0.3	–	1,3
NI (6), isocaryophyllene oxide?	1563		–	–	–	–	0.5	1,3
Dehydromatricaria ester*	1563	2412	–	–	–	1.1	–	1,2,3
(*E*)-Nerolidol	1563	2032	0.3	0.7	0.9	–	–	1,2,3
Dendrolasin	1563	2044	tr	0.7	–	–	–	1,3
Lauric acid	1568	2495	–	–	tr	–	2.0	1,2,3
Spatulenol	1568	2120	**2.4**	1.4	**2.3**	0.5	–	1,2,3
Geranyl butanoate	1570	1883	–	0.2	–	–	–	1,2,3
Caryophyllene oxide	1572	1965	0.1	1.2	1.3	0.4	**5.0**	1,2,3
Matricaria lactone*	1578	2584	–	–	–	**3.0**	–	1,2,3
Dihydronerolidol	1580	2108	0.2	0.3	–	–	–	1,2,3
Humulene-1,2-epoxide	1580		–	–	–	–	0.5	1,3
trans-α-Bisabolene epoxide	1582	2108	–	–	0.3	0.1	–	1,2,3
NI (7), benzenemethanol, α-1-octenyl-?	1595	2324	–	–	–	–	**18.4**	1,2,3
Viridiflorol	1595	2044	tr	tr	0.5	0.1	–	1,2,3
NI (8)	1600	2051	0.1	0.7	–	0.3	–	1,2,3
NI (9), sesquiterpene acetate	1600	2057	–	–	**4.6**	–	–	1,2,3
Geranyl isovalerate	1608	1924	0.3	**22.9**	0.1	0.1	1.1	1,2,3
Cubenol	1619	2100	0.1	–	1.0	–	–	1,2,3
(*Z*)-α-Bergamotol	1619	2236	–	–	–	0.1	–	1,2,3
NI (10)	1620	2108	–	–	–	0.7	**5.7**	1,2,3
NI (11), dendrolasin isomer*	1622	2100	–	1.7	–	–	–	1,2,3
$C_{15}H_{24}O$ (12), nerolidol structure	1625	2127	–	0.3	–	–	–	1,2,3
γ-Eudesmol	1627	2157	0.3	0.2	1.4	0.2	**4.5**	1,2,3
γ-Cadinol	1635	2182	0.2	–	**8.7**	0.2	tr	1,2,3
T-Muurolol	1641	2200	–	0.5	**4.0**	–	–	1,2,3

Table 1. *Continued*

Compound	RI		Percentage composition					Identification method
	SPB-5	SW-10	*Chamomilla recutita*	*Chamomilla suaveolens*	*Anthemis tinctoria*	*Matricaria perforata*	*Leucanthemum vulgare*	
NI (13)	1642	2108	–	–	–	–	**2.9**	1,2,3
$C_{15}H_{24}O$ (14), chamomillol	1642	2200	–	–	–	0.4	–	1,2,3
Bisabolol oxide B	1644	2125	**9.9**	0.2	–	0.1	–	1,2,3
α-Eudesmol	1646	2218	0.2	–	**10.2**	–	–	1,2,3
Alloaromadendrene epoxide	1657	2226	tr	tr	1.2	0.1	–	1,2,3
Hexadecahydrocyclobuta[1,2:3,4]di-cyclooctene	1673	1900	–	0.2	tr	–	**5.3**	1,2,3
Bisabolone oxide A	1675	2163	**13.9**	0.6	–	tr	–	1,2,3
α-Bisabolol	1688	2215	**5.6**	0.1	0.3	–	–	1,2
***cis*-α-Bisabolene epoxide**	1688	2212	–	–	**2.6**	–	–	1,2,3
(*Z*)-Lancelol (β-bisabolen-12-ol)	1690		–	–	–	0.1	0.5	1,3
Dimethylpentadecane	1700	1700	–	–	–	–	2.2	1,2,3
Aromadendrene oxide 2	1700	2421	–	1.2	2.4	0.7	–	1,3
Geranyl tiglate	1700	2184	0.5	–	–	–	–	1,2,3
n-Pentadecanal	1711	2024	–	–	0.2	–	0.2	1,2,3
Chamazulene	1713	2370	**4.7**	0.5	–	–	tr	1,2
Citronellyl hexanoate	1715	2321	–	–	2.0	–	–	1,2,3
Bisabolol oxide A	1748	2421	**39.4**	0.1	0.1	tr	0.4	1,2,3
Benzyl benzoate	1750	2630	–	–	tr	0.1	–	1,2,3
Myristic acid	1773	2713	–	–	0.4	–	0.1	1,2,3
NI (15) MW236	1775		–	tr	0.3	–	–	1,3
NI (16) MW234	1786		–	0.5	tr	tr	–	1,3
n-Octadecane	1800	1800	0.2	–	–	0.3	–	1,2
NI (17) MW232, benzenemethanol, α-1-decenyl-	1800		–	0.6	0.5	–	0.8	1,3
NI (18)	1807	2421	–	–	**4.2**	–	–	1,2,3
NI (19), indene structure	1826		–	–	–	–	1.3	1,3
Farnesyl acetate	1828	2265	–	0.2	tr	tr	–	1,2,3
Hexahydrofarnesyl acetone	1842	2160	0.1	0.5	0.4	0.1	0.2	1,2,3
NI (20), $C_{17}H_{16}O_2$, ester	1849	2265	–	–	–	–	**9.8**	1,2,3
(*Z*)-En-yne-dicycloether, MW200	1866		**11.5**	**37.2**	0.1	0.1	0.5	1,3
NI (21), indene structure?	1870	2412	–	–	–	–	**3.9**	1,2,3
(*E*)-En-yne-dicycloether, MW200	1882		0.4	0.8	–	–	–	1,3
n-Nonadecane	1900	1900	0.2	0.4	0.4	0.2	0.5	1,2,3
NI (22)	1914	2432	–	–	–	–	1.1	1,2,3
(*Z*)-En-yne-dicycloether, MW214	1933		0.4	0.3	–	–	–	1,3
Palmitic acid	1975	2920	tr	tr	1.5	–	1.7	1,2,3
n-Eicosane	2000	2000	0.1	0.2	0.2	0.1	0.1	1,2,3
13-Hexyloxacyclotridec-10-ene-2-one, MW280	2045	2432	–	tr	–	–	0.6	1,2,3
$C_{15}H_{14}O_2$ (23), benzhydryl acetate?	2063	2435	–	–	–	–	0.5	1,2,3
γ-Palmitolactone	2100		0.1	0.3	0.2	0.1	0.2	1,3
cis-Linoleic acid	2120		0.1	–	0.1	0.1	0.4	1,3
9,12-octadecadien-1-ol, (*Z*,*Z*)-	2123		–	–	0.2	–	–	1,3
n-Tricosane	2300	2300	0.1	0.2	1.2	0.1	0.2	1,2,3
n-Pentacosane	2500	2500	0.7	tr	1.4	tr	1.7	1,2,3
GROUPS OF COMPONENTS								
Monoterpenes			0.9	3.6	4.5	tr	0.3	
Oxygenated monoterpenes			1.5	23.2	8.6	0.2	2.3	
Sesquiterpenes			3.1	16.8	14.8	4.0	9.2	
Oxygenated sesquiterpenes			**73.4**	12.7	46.1	3.0	12.3	

Table 1. *Continued*

Compound	RI		Percentage composition					Identification method
	SPB-5	SW-10	*Chamomilla recutita*	*Chamomilla suaveolens*	*Anthemis tinctoria*	*Matricaria perforata*	*Leucanthemum vulgare*	
Polyacetylenes			12.3	**38.3**	0.1	**88.6**	0.5	
Aliphatic acid and esters			0.7	0.8	8.3	0.4	**12.0**	
Other compounds			6.6	2.0	7.4	1.8	12.5	
Not identified			0.1	1.8	5.0	1.4	**44.4**	
Total			98.6	99.2	94.8	99.4	93.5	
Oil volume, %			0.15	0.12	tr	0.2	0.03	

NI, not identified; * isomer not identified; tr, traces (<0.05%), – not found.

Table 2. Mass spectral data of unidentified compounds

No.	RI_{SPB-5}	MW	m/z (relative intensity)
1	1490	204	43(100), 118(60), 89(50), 136(25), 63(22), 90(20)
2	1516	222	43(100), 105(80), 41(60), 207(57), 161(55), 119(45), 91(40), 93(40), 79(38), 81(38), 55(35)
3	1529	220	71(100), 82(40), 43(35), 41(30), 107(20)
4	1552		43(100), 41(80), 71(80), 69(50), 79(45), 55(35), 93(35)
5	1554		43(100), 93(75), 120(48), 41(40), 79(40), 81(40)
6	1563		41(100), 96(98), 79(95), 83(78), 82(72), 67(62), 69(60), 109(60)
7	1595		43(100), 115(75), 128(58), 130(55), 147(53), 77(35), 129(35), 91(30)
8	1600	220	123(100), 81(70), 41(45), 69(30), 93(20)
9	1600	220	43(100), 177(50), 41(35), 91(30), 79(25), 107(25), 93(20)
10	1619		172(100), 101(88), 87(80), 86(45), 63(43), 144(40), 141(38), 115(36), 113(30)
11	1622		69(100), 41(70), 81(23), 67(17), 55(15)
12	1628	220	71(100), 69(65), 107(58), 43(55), 41(50), 94(30)
13	1641		43(100), 117(28), 115(25), 145(20)
14	1641	220	54(100), 82(40), 41(25), 67(25), 55(25)
15	1775	236	81(100), 41(90), 43(70), 55(55), 69(52), 95(45), 105(40), 123(30), 147(30)
16	1787	234	117(100), 57(60), 41(58), 91(52), 149(50), 77(35)
17	1800	232	115(100), 130(90), 57(82), 128(68), 129(65), 41(55), 147(50), 77(45)
18	1807	220	41(100), 55(85), 81(82), 79(70), 93(68), 110(57), 95(55), 43(45), 67(42), 197(42), 91(40)
19	1826		81(100), 41(50), 55(47), 147(45), 93(43), 123(37), 69(35)
20	1849	252	84(100), 95(95), 138(85), 94(60), 41(52), 55(45), 67(42), 109(42)
21	1870		128(100), 115(60), 129(52), 41(45), 141(40), 143(40), 91(35), 77(30)
22	1914		115(100), 41(65), 141(35), 167(30)
23	2063	226	165(100), 43(98), 166(50), 183(35), 152(25)

MW – molecular weight.

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Eeterliku õli sisaldus ja koostis mõnedes Asteraceae sugukonna taimeliikides

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On uuritud eeterliku õli sisaldust ja koostist viie Eestis kasvava Asteraceae sugukonna taimeliigi korvõisikutes. Eeterliku õli sisaldus nendes taimedes varieerus alates jälgedest kuni 0,2%-ni. Kasutades selleks GC-FID- ja GC-MS-meetodit, on eeterlikes õlides kokku identifitseeritud 115 koostisainet ning tehtud erinevates taimeliikides kindlaks märkimisväärsed kvalitatiivsed ja kvantitatiivsed erinevused. Uuritud Asteraceae sugukonna liikides olid eeterlike õlide põhikomponentideks järgmised koostisained: *Chamomilla recutita*: bisabolooloksiid A (39,4%), bisaboloonoksiid A (13,9%), (*Z*)-en-in-ditsükloeeter (11,5%), bisabolooloksiid B (9,9%), α-bisabolool (5,6%) ja hamasuleen (4,7%); *Chamomilla suaveolens*: (*Z*)-en-in-ditsükloeeter (37,2%), geranüülisovaleraat (22,9%) ja (*E*)-β-farneseen (15,6%); *Anthemis tinctoria*: α-eudesmool (10,2%), γ-kadinool (8,7%) ja γ-kadineen (4,0%); *Matricaria perforata*: (*Z*,*Z*)-matrikaariaester (77,9%), (*E*)-β-farneseen (3,5%), matrikaariaestri isomeer (3,5%) ja matrikaarialaktoon (3,0%); *Leucanthemum vulgare*: (*E*)-β-farneseen (7,3%), heksadekahüdrotsüklobuta[1,2:3,4]ditsüklookteen (5,3%), dekanoolhape (4,9%) ja γ-eudesmool (4,5%). Kõikide uuritud taimede õlides leiti 14 ühist komponenti.