CHEMICAL COMPOSITION OF ESSENTIAL OILS FROM FLOWERS OF
VERONICA LONGIFOLIA L., VERONICA INCANA L. AND VERONICA SPICATA L.

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In the Ukrainian flora, species of Veronica L. genus (Plantaginaceae Juss.) are classified into 8 sections. The phytochemical research into secondary metabolites of Veronica L. genus most related to the study of phenolic compounds and iridoids, while terpenoids of these species need further research. The chemical profiles of V. longifolia L., V. incana L. and V. spicata L. of Ukrainian flora are poorly studied. Phenolic acids, hydroxycinnamic acids, coumarins, flavonoids, tannins, iridoids, saponins, amino acids and organic acids have been reported for these species. Herbs harvested during the flowering stage are often used in the pharmaceutical industry, so the research into chemical composition of essential oils from Veronica species flowers are urgent.

The aim of this study was a comparative GC/MS study of the chemical composition of essential oils from V. longifolia L., V. incana L. and V. spicata L. flowers of Ukrainian flora.

Materials and methods. The objects of the research were flowers of Veronica spp. of Pseudolysimachium W.D.J. Koch section, namely V. longifolia L., V. incana L. and V. spicata L., harvested in the Botanical Garden of V. N. Karazin Kharkiv National University. The study of the chemical composition of essential oils was carried out by chromatography mass spectrometry on a 6890N MSD/DS Agilent Technologies chromatograph (USA) with a 5973N mass spectrometric detector. The components of essential oils were identified by comparison of the retention indices and mass spectra of phytochemicals in the studied essential oils with the data of NIST02 mass spectral library. The quantification of substances in the raw materials was carried out in comparison with a standard sample of menthol.

Results. As a result, 72 compounds were detected and quantified. The total content of essential oil in V. longifolia L. flowers was 0.17 % (39 components), the following compounds dominated: benzoacetalddehyde – 8.05, squalene – 5.17, palmitic acid – 15.73, butyl phthalate – 7.18. The total content of essential oil in V. incana L. flowers was 0.15 % (43 components), the following compounds prevailed: squalene 20.47, fatty acids, namely palmitic – 26.88, palmitoleic – 17.15, oleic – 11.61. The total content of the essential oil in V. spicata L. flowers was 0.11 % (43 components), the following compounds dominated: squalene – 5.53, fatty acids: palmitic – 22.78, linoleic – 6.72, carbohydrates: heptacosan – 12.27, hexacosan – 7.45. Among the identified compounds, mono-, norsesqui-, sesqui-, di- and triterpenoids, their oxidation products (aromatic compounds, aldehydes and alcohols, ketones), fatty acids, hydrocarbons and their derivatives were detected.

Conclusions. The chemical composition of essential oils from flowers of V. longifolia L., V. incana L. and V. spicata L. from Ukrainian flora was first studied by means of chromatography mass spectrometry. The yield of essential oil from V. longifolia L. flowers is higher (0.17 %) compared to those from flowers of V. incana L. (0.15 %) and V. spicata L. (0.11 %). Among the identified compounds terpenoids, aromatic compounds, their oxidation products, fatty acids and their esters, hydrocarbons were detected. The study of biologically active substances in essential oils from Veronica species flowers expands the scientific data on the chemical composition of these species and gives background for the further development of medicinal products, their standardization and understanding of their pharmacological activity.

Keywords: essential oil, flowers, GC-MS analysis, V. longifolia L., V. incana L., V. spicata L.

How to cite: Kovaleva, A., Osmachko, A., Ilina, T., Goryacha, O., Omelyanchik, L., Grytsyk, A., Koshovyi, O. (2022). Chemical composition of essential oils from flowers of Veronica Longifolia L., Veronica Incana L. and Veronica Spicata L. ScienceRise: Pharmaceutical Science, 4 (38), 69–79. doi: http://doi.org/10.15587/2519-4852.2022.263735

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1. Introduction

Veronica (Veronica L.) is the largest genus of the flowering plants in Plantaginaceae Juss. family [1] numbering about 500 species [2, 3]. Previously, Veronica L. genus was classified to Scrophulariaceae Juss. family, as well as Veronicaceae Durande. Family [4, 5]. In recent research articles, considering molecular phylogenetic data, the genus is classified to Plantaginaceae Juss. family [6, 7].

Up to 70 Veronica species grow on the territory of Ukraine [8, 9]. Veronica spp. are widely cultivated as fodder and ornamental plants, have many varieties and hybrids, which differ mainly in size of inflorescences and colour of flowers [10, 11].
Worldwide in folk medicine, tincture and juice from Veronica spp. herb were used in the treatment of the upper respiratory tract diseases as expectorant, emollient, and antibacterial agents [12, 13]. Decotions from Veronica spp. herb and rhizomes were used in the treatment of gastrointestinal tract disorders, genitourinary system disorders, and diabetes mellitus [14, 15]. The herbal tincture shows analgesic, sedative, hemostatic and cytotoxic properties cytotoxic properties [16]. Biologically active substances of flowering tops were used as traps for free radicals [17,18].

Species of Veronica L. genus are of scientific and practical interest as available sources of biologically active substances with a wide range of pharmacological activities, namely antimicrobial, antistaphylococcal, anti-inflammatory, antitumor, cytotoxic, antiradical and antioxidant [19–21].

The phytochemical research into secondary metabolites of Veronica L. genus is often related with taxonomy and chemotaxonomy studies. Iridoids and flavonoids are the best characterized phytochemicals of Veronica L. genus [22, 23]. The chemical profiles of V. longifolia L., V. incana L. and V. spicata L. of Ukrainian flora are poorly studied; phenolic acids, hydroxycinnamic acids, coumarins, flavonoids, tannins, iridoids, saponins, amino acids and organic acids were reported [24–26]. In microelements addition to iridoids, 22 other terpenoids have been detected in Veronica genus. Eight abietane-type diterpenoids have been isolated from V. sibirica and tested for anticancer activity. In addition, 1 bis-sesquiterpene, 12 steroidal saponins and 4 other terpenoids have been isolated from Veronica [27]. Based on literature data regarding to the phytochemical study of the genus Veronica, it could be resulted that the most part of the research are devoted to the study of phenolic compounds (flavonoids, hydroxycinnamic acids, etc.) and iridoids. Terpenoids composition of essential oils of Veronica species raw materials has hardly been studied, while the pharmaceutical industry uses flowering herb. The content of essential oil in flowers is usually significant and have influence on the pharmacological effect of the raw material, namely in terms of antimicrobial, anti-inflammatory and anti-tumor activity. Therefore, the study of the chemical composition of Veronica species essential oils is an urgent task of pharmacognostic and pharmaceutical science.

The aim of this study was a comparative GC/MS study of the chemical composition of essential oils from V. longifolia L., V. incana L. and V. spicata L. flowers of Ukrainian flora.

2. Planning (methodology) of the research

In Fig. 1 a graphical representation of the research planning process is shown.

![Planning of the research](image)

- Critical evaluation of literature data on the distribution of Veronica species, as well as data on their chemical composition
- Identification of Veronica species promising for the phytochemical research, and harvest of V. longifolia L., V. incana L. and V. spicata L. flowers
- Sample preparation and selection of chromatography conditions for GC-MS analysis
- GC-MS analysis of essential oils. Determination of the qualitative composition and quantitative content of the components of the studied essential oil
- Grouping of identified compounds acc. to classification groups and comparative analysis of identified substances in flowers of the Veronica species
- Selection of compounds as potential sources of medicines from the studied raw materials and prospects for further medicines creation

Fig. 1. Planning of the research

3. Materials and methods

Plant material.

The objects of the research were flowers of Veronica spp. of Pseudolysimachium W.D.J. Koch section, namely V. longifolia L., V. incana L. and V. spicata L., harvested in the Botanical Garden of V. N. Karazin Kharkiv National University (50°01′45.1″N, 36°13′50.3″E) in the flowering stage (mid-June) in 2019. Previously, we studied raw materials of V. longifolia “Blaubart” harvested in the flowering stage in Lyubotyn, Kharkiv region (49°56′54″ 35°55′46″) in June–July 2013, and in the Botanical Garden of V. N. Karazin Kharkiv National University in 2014. In contrast to V. longifolia (the species is 120–150 cm high, flowers blue-purple), V. longifolia “Blaubart” is 50 cm high, bearing 25 dark blue flowers on a dense inflorescence.

Analyses of the essential oil.

The study of the chemical composition of essential oils was carried out by chromatography mass spectrometry on a 6890N MSD/DS Agilent Technologies chromatograph (USA) with a 5973N mass spectrometric detector. The study of the chemical composition of essential oils was carried out according to the previously described technique used for the chemical characterization of many other essential oils [28, 29].

To obtain and study essential oils components from medicinal plant raw materials, Vinogradov’s method was used, which enables to isolate volatile compounds using small amounts of raw materials, and fully extract their components for further qualitative and quantitative analysis, what is of great importance for preliminary chemical characterization of raw materials.

For the distillation of essential oils from raw materials, 22 mL Agilent vials (part number 5183-4536) with open lids, silicone sealant, equipped with a reflux condenser 50 cm long and 5–7 mm in diameter were used. 2.00 g of the raw materials (acc. weighed) were put in the vial, water was added to its’ half level, screwed with the
The suitability of the chromatographic system was determined in comparison with a standard sample of menthol [30, 33]. According to literature data and preliminary analysis of the essential oils, menthol was not found in the studied essential oils. Therefore, it was used as internal standard for the preliminary calculation of the content of essential oil components. The choice of menthol as an internal standard due to the same class of determined substances, that allows to significantly reduce detection errors in the quantitative determination of substances.

Calculation of components content \( C \) (mg/kg) was carried out by the formula:

\[
X = \frac{P_1 \times 50 \times 1000}{P_2 \times m},
\]

where \( P_1 \) – a peak area of tested compound; \( P_2 \) – a peak area of standard compound; 50 – mass of internal standard (μg), injected into the sample; \( m \) – sample mass (mg).

Statistical properties of random variables with n-dimensional normal distribution are given by their correlation matrices, which can be calculated from the original matrices. Statistical assessment data are reported as mean ± SEM and were analyzed using STATISTICA 6 software. \( P \) values less than 0.05 were assumed to be statistically significant [34, 35].

4. Research results

The GC-MS technique used in the preliminary study enables to identify the main components of essential oils. The aim of the selection and definition of chromatographic conditions is to achieve a proper separation of the components of the oil, both for the qualitative analysis, as also for the proper quantification. To do so, well resolved peaks and not distorted ones, good relation signal-noise and horizontal base line with absence of drift, must be obtained for each one of the components. To accomplish this objective, a correct selection of the column is key. In general, for the development and selection of stationary phases, it must be considered, among other things, the thermal and chemical stability of the column, the selectivity in the separation of the components, the lining or coating surface, the diameter of the column, as well as the incorporation of more specific components to the stationary phase, or the use of different technologies to optimize the phase available to the specific regions of analyses that require better resolution. The variable that the analyst most frequently handles at the time of separation of the components of essential oils is perhaps the working temperature [36].

For the selection of chromatographic conditions some methods were analysed [28–30, 36–38]. The results of comparison are presented in Table 1.

The analyzed methods differ in the columns which were used for the analysis and the temperature interval of the thermostat. The used carrier gas in most methods was helium and its velocity is the same and amounts to 1 ml/min.

After analysing the given methods, the choice was made in favour to the method given in the first column, as experimental results have shown that it provides a good separation of essential oil components. HP-5ms is a medium polar column, widely used in laboratory analysis, a standard one with a standard sorbent. This makes it easy to reproduce the technique with its use in different laboratories. Previously, it was used for the analysis of many other essential oils [29, 30]. Split ratio 1/50 required to avoid column overloading. The analysis time of this technique is optimal and is 42.5 minutes. The technique used enables to compare components in essential oils, it separates them well, and enables to identify the main components, what is the basis for the further development of validated methods for the standardization of raw materials and essential oil. It meets the recommended requirements for essential oil analysis methods and can be used for routine analysis [39].

As a result, 72 compounds were detected and quantified, 4 of which were not identified. Among the identified compounds, mono-, norsesqui-, sesqui-, di- and triterpenoids, their oxidation products (aromatic compounds, aldehydes and alcohols, ketones), fatty acids, hydrocarbons and derivatives of compounds of these classes (Table 2, Fig. 2–4) were detected.
### Table 1

The review of existing methods for essential oil analyses

| Conditions       | [29, 30] | [28] | [37] | [38] | [36] |
|------------------|----------|------|------|------|------|
| Chromatograph    | 890N MSD/DS Agilent Technologies (USA) with a 5973N mass-spectrometer detector | Agilent Technologies 6890 with 5973 mass-spectrometer detector | GC 7890A with a flame ionization detector (FID) | Hewlett Packard GCD system | HIMADZU GC 14B |
| Chromatographic column | HP-5MS (30 m×0.25 mm, 0.50 µm) | DB-5 (30 m×0.25 mm, 0.50 µm) | HP-5MS (60 m×0.25 mm, 0.25 µm) | HP-Innowax FSC column (60 m×0.25 mm, 0.25 µm) | Mega Bore DB-WAX P/N 125-7032 column (30 m×0.53 mm, 1 µm) |
| The carrier gas  | helium | helium | helium | helium | nitrogen |
| The carrier gas velocity | 1 ml/min | 1.2 ml/min | 1 ml/min | 1 ml/min | – |
| Sample volume    | 2 µL | 2 µL | – | – | – |
| Split ratio      | 1/50 | 1/100 | 1/50 | – | – |
| The temperature of the thermostat | 50 to 220 °C at a rate of 4 °C/min | 50 to 320 °C at a rate of 4 °C/min | 60 to 240 °C at a rate of 4 °C/min | 60 to 220 °C at a rate of 4 °C/min | 60 to 200 °C at a rate of 5 °C/min |
| Evaporator detector temperature | 250 °C | 250 °C | 250 °C | 220 °C | – |

### Table 2

Component composition of essential oils of *V. longifolia L.*, *V. incana L.* and *V. spicata L.* flowers

| #   | Compound/BAS group      | RI   | Content, mg/kg | V. longifolia L. | V. incana L. | V. spicata L. |
|-----|-------------------------|------|----------------|------------------|--------------|---------------|
|     |                         |      |                | mg/kg* | %** | mg/kg* | %** | mg/kg* | %** |
| 1   | *trans*-Linalooloxide   | 1160 | 27.97±0.51     | 2.60   | 0.17±0.01 | 0.01 | – | – | – |
| 2   | *cis*-Linalooloxide     | 1068 | 10.69±0.23     | 1.00   | 0.23±0.01 | 0.02 | – | – | – |
| 3   | Linalool                | 1093 | 24.98±0.36     | 2.33   | 0.51±0.02 | 0.03 | – | – | – |
| 4   | *p*-Ment-8-en-1-ol      | 1131 | 33.23±0.65     | 3.09   | 0.30±0.01 | 0.02 | – | – | – |
| 5   | Carvone                 | 1220 | –              | –      | –      | –    | 7.9±0.28 | 0.73 | – |
| 6   | Piperitone              | 1232 | –              | –      | –      | –    | 1.30±0.05 | 0.12 | – |
| 7   | Safranil                | 1167 | 5.86±0.17      | 0.55   | 2.27±0.10 | 0.15 | – | – | – |
| 8   | Terpinyl acetate        | 1351 | –              | –      | –      | –    | 1.51±0.05 | 0.14 | – |
| 9   | Geraniol                | 1243 | –              | –      | –      | –    | 0.33±0.01 | 0.02 | – |
| 10  | Dihydrodrolulanate      | 1286 | –              | –      | 1.40±0.04 | 0.09 | – | – | – |
| 11  | Eugenol                 | 1341 | 21.21±0.44     | 1.97   | 0.96±0.02 | 0.06 | – | – | – |
| 12  | *β*-Damascenon          | 1360 | 9.99±0.27      | 0.93   | 0.84±0.02 | 0.06 | 1.89±0.07 | 0.18 | – |
| 13  | *trans*-Caryophyllene   | 1420 | –              | –      | –      | –    | 1.41±0.05 | 0.13 | – |
| 14  | Geraniol acetate        | 1751 | 3.91±0.12      | 0.36   | 1.41±0.05 | 0.09 | 8.59±0.31 | 0.8 | – |
| 15  | Ionon-5,6-epoxide       | 1977 | 5.48±0.20      | 0.51   | 0.96±0.03 | 0.06 | – | – | – |
| 16  | *β*-Ionone              | 1474 | 7.58±0.29      | 0.71   | 1.48±0.05 | 0.1  | – | – | – |
| 17  | *trans*-*β*-Ionon       | 1927 | –              | –      | –      | –    | 6.21±0.19 | 0.58 | – |
| 18  | *cis*-β-Ionon           | 1661 | –              | –      | –      | –    | 8.89±0.22 | 0.83 | – |
| 19  | Dihydroactiniodiolide   | 2331 | –              | –      | –      | –    | 2.98±0.13 | 0.28 | – |
| 20  | Myristicin              | 1494 | –              | –      | –      | –    | 10.8±0.44 | 0.99 | – |
| 21  | Leden oxide             | 1890 | –              | –      | –      | –    | 2.92±0.10 | 0.27 | – |
| 22  | Caryophyllene oxide     | 1560 | –              | –      | –      | –    | 3.09±0.11 | 0.29 | – |
| 23  | Dihydroisocalamenediol  | 1745 | –              | –      | –      | –    | 24.15±1.04 | 2.24 | – |
| 24  | *trans*-Methylidihydroasmonate | 1657 | – | – | – | 14.45±0.53 | 1.34 | – | – |
| 25  | Apiole                  | 1682 | –              | –      | –      | –    | 8.56±0.38 | 0.8 | – |
| 26  | 1,4-*cis*,-1,7-trans-acorenone | 1694 | – | – | – | 42.01±1.65 | 3.9 | – | – |
| 27  | Neophytadiene           | 1908 | –              | –      | –      | –    | 29.54±1.07 | 2.74 | – |
| 28  | Phytol                  | 2122 | 28.57±1.15     | 2.66   | 12.27±0.49 | 0.81 | – | – | – |
| 29  | Squalene                | 2829 | 55.56±1.67     | 5.17   | 309.73±8.67 | 20.47 | 59.50±1.91 | 5.53 | – |
| Sum: |                        |      | 235.03         | 21.88  | 332.86 | 21.99 | 235.69 | 21.89 | – | – |
### Carboxylic acids

| 1   | 2     | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
|-----|-------|------|------|------|------|------|------|------|
| 49  | 1- (2-Hydroxy-1-methylethyl) -2,2-dimethylpro- | 1154 | 50.15±2.32 | 4.67 | 0.78±0.02 | 0.05 | –   | –   |
|     | pyl-2-methylpropionate                      | 1389 | –       | –    | 0.55±0.02 | 0.04 | –   | –   |
| 50  | 3-Hydroxy-2,4,4-trimethylpentyl 2-methylpropionate | 1331 | –       | –    | 0.34±0.01 | 0.02 | –   | –   |
| 51  | Capric acid                                  | 1345 | 8.55±0.35 | 0.80 | 2.35±0.17 | 0.16 | –   | –   |
| 52  | Lauric acid                                  | 1344 | 8.32±0.32 | 0.77 | 13.32±0.51 | 0.88 | –   | –   |
| 53  | Tridecanoic acid                             | 1668 | –       | –    | 7.48±0.35 | 0.49 | –   | –   |
| 54  | Myristic acid                                | 1748 | 18.17±0.81 | 1.69 | 84.45±3.42 | 5.58 | 22.26±0.92 | 2.07 |
| 55  | Isopropyl myristate                          | 1836 | –       | –    | –         | –    | 11.89±0.49 | 1.1  |
| 56  | Pentadecanoic acid                           | 1840 | 26.32±1.03 | 2.45 | 62.26±2.76 | 4.11 | –   | –   |
| 57  | Methylpentadecanoic acid                     | 1598 | –       | –    | –         | –    | 26.49±1.24 | 2.46 |
| 58  | Palmitoleic acid                             | 2223 | 18.88±0.91 | 1.76 | 259.67±10.53 | 17.15 | 13.12±0.51 | 1.22 |
| 59  | Palmitic acid                                | 2204 | 168.99±7.72 | 15.73 | 406.85±19.34 | 26.88 | 245.25±10.78 | 22.78 |
| 60  | Ethyl palmitate                              | 1979 | –       | –    | –         | –    | 9.61±0.46 | 0.89 |
| 61  | Heptadecanoic acid                           | 2042 | 20.38±0.90 | 1.90 | 7.86±0.23 | 0.52 | –   | –   |
| 62  | Linolenic acid                               | 2443 | 10.02±0.47 | 0.93 | 32.54±1.34 | 2.15 | 6.05±0.27 | 0.56 |
| 63  | Linoleic acid                                | 2490 | 18.06±1.79 | 1.68 | 56.84±2.67 | 3.75 | 72.3±3.05 | 6.72 |
| 64  | Oleic acid                                   | 2040 | 21.69±0.92 | 2.02 | 175.71±6.78 | 11.61 | 5.12±0.22 | 0.48 |
| 65  | Stearic acid                                 | 2188 | 17.72±0.75 | 1.65 | 30.28±1.31 | 2    | 3.74±0.15 | 0.35 |
| 66  | Sum:                                        | 387.25 | 36.05 | 1141.28 | 75.39 | 415.83 | 38.63 |

### Higher hydrocarbons

| 67  | Tricosan                                     | 369  | 6.49±0.25 | 0.4 | 3.04±0.12 | 0.2 | 9.77±0.41 | 0.91 |
| 68  | Tetracosan                                   | 402  | –         | –   | –         | –   | 2.05±0.07 | 0.19 |
| 69  | Pentacosane                                  | 396  | 13.92±0.62 | 0.84 | 3.15±0.12 | 0.21 | 3.60±0.12 | 0.33 |
| 70  | Hexacosan                                    | 415  | 23.78±1.06 | 1.44 | 4.84±0.18 | 0.32 | 80.08±3.65 | 7.45 |
| 71  | Heptacosan                                   | 426  | 26.01±1.26 | 1.57 | 9.44±0.42 | 0.62 | 132.09±5.11 | 12.27 |
| 72  | Nonakosan                                    | 454  | 20.02±0.92 | 1.21 | 8.19±0.38 | 0.54 | 111.57±5.01 | 10.36 |
| Sum:                                       | 90.22 | 8.40 | 28.66 | 1.89 | 339.16 | 31.51 |

**Note:** *– mg per 1 kg of raw material; **– from the sum of the identified compounds; –– – Compound not found
Fig. 2. Chromatographic profile of essential oil components from *V. longifolia* L. flowers

Fig. 3. Chromatographic profile of essential oil components from *V. incana* L. flowers
5. Discussion of the results

The total content of the essential oil in *V. longifolia* L. flowers was 0.17 %, previously in “Blaubart” variety, the yield of essential oil was reported as 0.82 %; in the flowers of *V. incana* L. and *V. spicata* L. the content of the essential oil was 0.15 %, and 0.11 %, respectively. As a result of the research, in the essential oil from *V. longifolia* L. flowers 39 constituents were quantified (in the variety “Blaubart” 38), 38 were identified; 12 of which were terpenoids [31, 40].

The phytochemicals of the essential oil from *V. longifolia* L. flowers were represented by acyclic monoterpenoids: linalool, its derivatives trans-linalooloxide and cis-linalooloxide, geranyl acetone; monocyclic monoterpenoid p-ment-1-ene-8-ol; norterpenoids β-ionone and its oxidized form ionone-5,6-epoxide, β-damascenone; monocyclic aromatic terpenoid eugenol; acyclic diterpenoid alcohol phytol and triterpenoids squalene, safranal; aromatic compounds, aldehydes and alcohols, ketones. The stearotenic fraction was represented by aliphatic hydrocarbons and higher fatty acids. The content of terpenoids in the sum of the detected components in the essential oil from *V. longifolia* L. flowers was 21.88 %, aromatic compounds constituted 29.86 %, aldehydes, ketones and alcohols accounted for 2.98 %, fatty acids and their esters accounted for 36.05 %, hydrocarbons – 8.40 %, unidentified compounds constituted 0.83 %.

In the essential oil from *V. longifolia* L. flower, the following compounds dominated (constituted more than 5 %), %: benzoacetaldehyde – 8.05, squalene [41] – 5.17, palmitic acid – 15.73, butyl phthalate – 7.18.

In the essential oil from *V. incana* L. flowers 43 constituents were detected and quantified, 42 were identified; 14 of which belong to terpenoids. The content (%) of terpenoids in the sum of the detected compounds was 21.99, aromatic compounds constituted 0.56, aldehydes and alcohols accounted for 0.16, fatty acids and their esters constituted 75.39, hydrocarbons accounted for 1.89, unidentified compounds constituted 0.01. The chemical composition of the essential oil from *V. incana* L. flowers is like that from *V. longifolia* L. flowers. The characteristic components of *V. incana* L. essential oil distinguishing it from both *V. longifolia* L. and *V. spicata* L. are geraniol, dihydroedulan, 2,4-diter-t-butlyphenol, 1-(2-hydroxy-1-methylethyl)-2,2-dimethylpropyl-2-methylpropionate and 3-hydroxy-2,4,4-trimethylpentyl 2-methylpropionate. In the flowers of *V. incana* L. the following compounds dominated (%): squalene 20.47, fatty acids [42], namely palmitic – 26.88, palmitoleic – 17.15, oleic – 11.61.
In the essential oil from *V. spicata* L. flowers, 47 constituents were detected and quantified, 45 were identified; 18 of which were classified as terpenoids. The content (%) of terpenoids in the sum of the detected components was 21.89, aromatic compounds constituted 4.94, aldehydes and alcohols accounted for 1.09, ketones constituted 0.72, fatty acids and their esters accounted for 38.63, hydrocarbons constituted 31.51, unidentified compounds accounted for 1.22. The following compounds dominated (%): squalene – 5.53, fatty acids: palmitic [43] – 22.78, linoleic – 6.72, carbohydrates: heptacosan – 12.27, hexacosan – 7.45.

At the same time, it should be noted that the used column (HP-5ms) is not a specialized column for the analysis of chiral compounds. In the practice of pharmaceutical analysis, specialized columns are used for this purpose (for example, columns of the HP-Chiral β Columns series or similar containing specialized sorbents that are sharpened specifically for the analysis of enantiomers [44]. However, in this case, the efficiency of the chromatographic system (choice of the column, correctly selected chromatographic conditions, sensitivity of the detector) allows not only to effectively separate the various components of the mixture, but also to separate some enantiomers (for example, trans-linalooloxide and cis-linalooloxide, trans-β-Ionone, cis-β-Ionone, etc.). Which testifies to the ineffectively increasing quality of modern universal sorbents for gas chromatography, because of which using the standard for the laboratory pharmaceutical analysis of the column makes it possible to solve separations that are unique in their selectivity.

It is noteworthy that the content of squalene [45, 46] in the essential oil from *V. incana* L. flowers was 5.57 and 5.20 times higher than in *V. longifolia* L. and *V. spicata* L., respectively. The chemical composition of the essential oil from *V. spicata* L. flowers significantly differs from those from *V. incana* L. and *V. longifolia* L. flowers. In the essential oil from *V. spicata* L. flowers, carvone [47], piperitone, terpenyl acetate, trans-caryophyllene, trans-β-ionone, cis--ionone, dihydroactinidiolide, myristicin, caryophylen oxide, dihydroisocamalenediol, trans-methylylsidine, 1,4-methylidihydro,7-trans-acerenone, neophytadiene, vinylcyclohexacarboxylate, 1-allyl-2,3,4,5-tetramethoxybenzene, 2-(phenylmethylene) octanal, (1-methylundecyl) benzene, hexylbenzoate, dodecanal, octadec-3,15-act-1-ol, 9-di-tert-butyl-1-oxaspiro-[4,5]-deca-6,9-diene-2,8-dione, isopropyl myristate, methylpentadecanate, ethyl palmitate and tetracosan were detected, and these compounds were not detected in the essential oils from *V. incana* L. and *V. longifolia* L. flowers.

Common components of essential oils of all the studied species are geranyl acetone and β-damascenone, benzophenone, decanal, fatty acids, namely myristic, palmitoleic, palmitic, linoleic, linoleic, oleic, and stearic; tricosan, pentacosan, hexacosan, heptacosan and nonacosan. Terpenoids, aldehydes and ketones, as well as phenolic compounds present in the essential oil are of particular importance for understanding the pharmacological activity of the essential oil. Linalool [48], geraniol [49] and damascenon [50] and their derivatives show a sedative effect [51, 52]. The triterpenoid squalene shows anti-cancer, antioxidant, hypoglycemic and immunomodulatory properties [45, 46]. The raw materials contain lipophilic substances with pronounced antimicrobial activity – terpenoids, aromatic compounds, carboxylic acids, what gives background for the development of technologies for obtaining biologically active complexes.

**Study limitations.** During the GC-MS study, several compounds were not identified due to the absence of their characteristics in NIST05 mass spectra libraries, as well as in AMDIS and NIST programs.

**The prospects for the further research.** In future, it is reasonable to study a dependence of essential oils composition on plant development, season, and growth conditions. Also, since studied herbal materials contain phytochemicals with different activities, it is reasonable to obtain corresponding substances and study their potential activities.

**6. Conclusions**

The chemical composition of the essential oils from flowers of *V. longifolia* L., *V. incana* L. and *V. spicata* L. from Ukrainian flora was first studied by means of chromatography mass spectrometry. The yield of essential oil from the *V. longifolia* L. flowers is higher (0.17 %) compared to those from flowers of *V. incana* L. (0.15 %) and *V. spicata* L. (0.11 %).

In the essential oil from *V. longifolia* L. flowers, 39 compounds were detected and quantified; in the essential oil from *V. incana* L. flowers – 43 compounds; 47 compounds were detected and quantified in the essential oil from *V. spicata* L. flowers. Among the identified compounds terpenoids, aromatic compounds, their oxidation products, fatty acids and their esters, hydrocarbons were detected.

29 Terpenoids and their derivatives were identified. The content of terpenoids in the sum of the detected compounds was: 21.88 % in the flowers of *V. longifolia* L., 21.99 % in the flowers of *V. incana* L., 21.89 % in the flowers of *V. spicata* L.

The study of biologically active substances in essential oils from Veronica species flowers expands the scientific data on the chemical composition of these species and gives background for the further development of medicinal products, their standardization and understanding of their pharmacological activity.

**Conflicts of interest**

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

**Funding**

This work was supported by the Ministry of Health Care of Ukraine from the State Budget in the framework [grant number 2301020] “Scientific and scientific-technical activity in the field of health protection” on the topic “Modern approaches to the creation of new medicines for a correction of metabolic syndrome”.
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