The essential oil composition of *Artemisia jacutica* Drob. from the flora of Buryatia, Russia

E P Dylenova¹,², S V Zhigzhitzhapova¹, T E Randalova² and L D Radnaeva¹

¹ Baikal Institute of Nature Management SB RAS, Ulan-Ude, 670047 Russia
² Banzarov Buryat State University, Ulan-Ude, 670000 Russia

E-mail: edylenova@mail.ru

Abstract. This paper represents the results of the GC-MS analysis of the essential oil’s composition of *Artemisia jacutica* Drob. collected within the Republic of Buryatia in 2015-2020. *A. jacutica* is an East Siberian endemic plant which has been widely used in folk medicine of Yakutia for the treatment of gastrointestinal diseases. 59 compounds were identified in total, which were represented by mono- and sesquiterpenoids. Neryl-2-methylbutanoate, neryl-hexanoate, γ-eudesmol, and chamazulene were constant components of the oil, whereas γ-eudesmol and chamazulene predominated (the content reaches over 40%). Essential oils of *A. jacutica* collected in different years were characterized by a stable set of dominant constituents, while the content of sesquiterpenoids was over 92%. The samples of the 2018-2020 years of collection had a greater variety of constituents (31-36 compounds): derivatives of nerol, geraniol, 1,8-cineole, seline-4-diene, compared to the 2015-2017 samples.

1. Introduction

*Artemisia jacutica* Drob. is an endemic plant of Eastern Siberia. The low abundance of *A. jacutica* within the territory of Buryatia can be explained by the special growing conditions of forest-steppe on permafrost in the area with a sharply continental climate of the Yeravninsky district of Buryatia. This species has been widely used in the folk medicine of Yakutia for the treatment of gastrointestinal diseases. At present, there is a growing interest in essential oils and their components. Particularly due to the high content of chamazulene, the essential oil of *A. jacutica* has pronounced anti-inflammatory, antibacterial, wound healing properties [1, 2]. This paper represents the chemical composition of essential oils of *A. jacutica* growing within the territory of the Republic of Buryatia.

2. Materials and methods

2.1. Plant material

The object of the study was the aerial part of *Artemisia jacutica* Drob. collected in surroundings of the Shiringa village (Yeravninsky district, Buryatia) in 2015-2020, in a flowering stage. The voucher specimen of *A. jacutica* was deposited and stored in the Herbarium of the Laboratory of Chemistry of Natural Systems, Baikal Institute of Nature Management SB RAS (BINM SB RAS).
2.2. Isolation and analysis of essential oil

Essential oils were obtained by hydrodistillation method from the air-dried raw materials. The composition of the essential oil was analysed by GC/MS, using an Agilent HP 6890N gas chromatograph with a quadrupole mass spectrometer (HP MSD 5973) as a detector [3].

2.3. Statistical analysis

The obtained data were subjected to multivariate statistical analysis using the principal component analysis (PCA). All statistical analyses were conducted using the Sirius software ver. 7.0 (Pattern Recognition Systems, Bergen, Norway).

3. Results and Discussion

Essential oils (EO) of Artemisia jacutica, obtained from the whole aerial part, were dark blue with a specific odour. The yield of EO varied from 0.50% to 1.36% in terms of air-dry raw material. The analysis led to the identification of 59 compounds in total, which were represented by mono- and sesquiterpenoids. The content of sesquiterpene group (92.64-98.49%) was significantly higher than monoterpenes (1.51-7.06%). According to the results of previous studies, wormwoods of native phytocenoses of Buryatia (including endemic species), which are adapted to semi- and arid conditions, accumulate EOs with a stable set of dominant constituents. Such mono- and sesquiterpenoids as terpinolene, cis-p-menth-2-en-1-ol, 2-carene, borneol, geranyl acetate, neryl isobutanoate, β-elemene, α-bisabolol, eremoligenol, α-eudesmol, γ-costol, α-copaene, β-bourbonene, β-cubebene, β-copaene, allo-aromadendrene и copaborneol also were found in essential oils. The number of constituents varied over the years. The samples of the 2018-2020 years of the collection were characterized by a greater variety of constituents (31-38) in comparison with samples of 2015-2017 (8-22). The content of the same constituent changed over the years, but not significantly.

Figure 1. PCA biplot (Comp. 2 – Comp. 3) for the components of essential oils of Artemisia jacutica.
Special attention should be devoted to the sesquiterpene group of EO, which content was over 92%. Analysis of the obtained long-term data (from 2015 to 2020) showed that EOs of *A. jacutica* contained the following constant components: neryl-2-methylbutanoate (3.40-10.10%), neryl-hexanoate (1.06-6.45%), γ-eudesmol (25.39-46.90%), and chamazulene (23.56-47.77%), whereas γ-eudesmol and chamazulene were predominant (the content exceeded 40%). Thus, the sum of bicyclic sesquiterpenoids varied from 56.04 to 79.76%. Particular attention should be given to the significant content of acyclic sesquiterpenoids (11.21-41.12%) – derivatives of nerol (neryl-2-, neryl-3-methylbutanoate, neryl hexanoate), and its isomer geraniol (geranyl-2-, geranyl-3- methylbutanoate, etc.) (table 1).

Table 1. The yield and major constituents of the essential oils of *Artemisia jacutica* Drob. growing in Buryatia.

| Year of collection | Yield of EO, % (in terms of air-dried material) | Name of component | Content (in % of the sum of the components) |
|--------------------|-----------------------------------------------|------------------|------------------------------------------|
| 2020 | 0.66 | β-myrcene | 991 | – | 0.18 | 0.64 | – | 0.88 | – |
| 2019 | 1.36 | linalool | 1,100 | 0.26 | – | 0.44 | – | – | – |
| 2018 | 1.00 | ∑ Acyclic monoterpenoids | 0.26 | 0.18 | – | 1.08 | – | 0.88 | – |
| 2017 | 0.50 | ∑ Bicyclic monoterpenoids | 2.64 | 1.54 | 2.80 | – | 2.52 | 1.72 | – |
| 2016 | 0.67 | ∑ Sesquiterpenoids | 14.60 | 15.22 | 11.21 | 27.05 | 27.52 | 18.68 | – |
Table 1 Continued

| RI | Year of collection | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 |
|----|-------------------|------|------|------|------|------|------|
| Yield of EO, % (in terms of air-dried material) | 0.66 | 1.36 | 1.00 | 0.50 | 0.67 | 0.53 |

| Name of component | Content (in % of the sum of the components) | Monocyclic sesquiterpenoids | Bicyclic sesquiterpenoids | Tricyclic sesquiterpenoids |
|-------------------|---------------------------------------------|-----------------------------|---------------------------|---------------------------|
| β-elemene         | 1,392                                       | 0.20                        |                           |                           |
| γ-curcumene       | 1,482                                       | –                           | 0.25                      | –                         |
| germacrene D      | 1,484                                       | 0.23                        | –                         | 1.82                      |
| ar-curcumene      | 1,485                                       | 0.41                        | –                         | –                         |
| β-curcumene       | 1,513                                       | –                           | 0.05                      | –                         |
| elemol            | 1,553                                       | 0.66                        | 0.89                      | 1.24                      |
| α-bisabolol       | 1,688                                       | –                           | –                         | 1.53                      |
| ∑ Monocyclic sesquiterpenoids | 1.30                              | 1.19                        | 4.79                      | 1.83                      |
| Caryophyllene     | 1,422                                       | 0.91                        | –                         | –                         |
| Humulene          | 1,456                                       | –                           | 0.06                      | 0.18                      |
| Caryophyllene, 9-epi | 1,469                     | –                           | 0.61                      | 1.41                      |
| Sesquicinol, dehydro- | 1,471                               | 1.21                        | 0.40                      | 0.69                      |
| Selina-4,11-dien  | 1,477                                       | 2.95                        | 0.96                      | 1.71                      |
| Cadina-1,4-diene, cis- | 1,496                               | 0.15                        | 0.08                      | 1.20                      |
| Bicyclogermacrene | 1,500                                       | 0.08                        | 0.15                      | 0.30                      |
| Amorphone, delta- | 1,553                                       | 0.16                        | 0.12                      | –                         |
| ∑ Bicyclic sesquiterpenoids | 78.46                              | 76.24                      | 75.72                      | 71.44                      |
| ∑ Tricyclic sesquiterpenoids | 78.46                              | 76.24                      | 75.72                      | 71.44                      |
| ∑ Monoterpenoids  | 4.84                                        | 4.14                        | 7.06                      | 1.51                      |
| ∑ Sesquiterpenoids| 95.14                                       | 93.18                      | 92.64                      | 98.49                      |

A biplot visualizing the correlation between the chemical composition of EOs and the year of the raw material collection was mapped using PCA-method (figure 1). The samples collected in 2018-2020 formed one locus in the central part of the biplot. These samples contained a greater variety of constituents (31-36 compounds) compared to the rest of the samples. They were characterized by the content of monoterpenic compounds, such as seline-4,11-diene, 1,8-cineole, and acyclic sesquiterpenoids: geranyl-2-, geranyl-3-methylbutanoate, neryl pentanoate, neryl hexanoate, neryl-2-methylbutanoate. Samples with the predominance of bicyclic sesquiterpenic compounds in EOs – 2015 (chamazulene), 2017 (γ-eudesmol), as well as 2016 were separated from the central part of the biplot.
Such distribution of samples can be explained by one of the significant factors of plant development in semiarid and arid ecosystems – the amount of precipitation during the vegetation period. There were low amounts of precipitation in Transbaikalia in 2015-2017 during the summer period (76-96% of normal rainfall in 1961-1990) in comparison with 2018-2020 years (103-121%). 2015 was the warmest on a global scale and with the lowest amount of precipitation (76%) [4-9].

4. Conclusion
Long-term study (over five years) of the essential oils of *A. jacutica* from natural populations within the surroundings of the Shiringa village, Yeravninsky district, Republic of Buryatia, made it possible to conclude that the chemical composition is characterized by a stable set of dominant constituents: neryl-2-methylbutanoate, neryl-hexanoate, γ-eudesmol, chamazulene. A specific feature is the accumulation of sesquiterpene group in all samples of EOs in significant amounts (more than 92%).

Acknowledgments
This research was financially supported by the Basic Scientific Research Programs of the State Academies of Sciences and the Grant of Banzarov Buryat State University 2021.

References
[1] Khanina M A, Serykh E A, Amelchenko V P, Pokrovsky L M and Tkachev A V 1999 *Chemistry of Plant Raw Material* [Khimiya Rastitel'nogo Syr'ya] 3 63–78
[2] Kershengolts B M, Anshakova V V, Filippova G V and Kershengolts E B 1999 *Chemistry of Plant Raw Material* [Khimiya Rastitel'nogo Syr'ya] 3 89–94
[3] Tykheev Zh A, Zhigzhizhapova S V, Zhang F, Taraskin V V, Anenkhonov O A, Radnaeva L D and Chen Sh 2018 Molecules 23 1496
[4] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2016 *A Report on climate features of the Russian Federation in 2015* (Moscow) p 68
[5] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2017 *A Report on climate features of the Russian Federation in 2016* (Moscow) p 70
[6] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2018 *A Report on climate features of the Russian Federation in 2017* (Moscow) p 69
[7] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2019 *A Report on climate features of the Russian Federation in 2018* (Moscow) p 79
[8] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2020 *A Report on climate features of the Russian Federation in 2019* (Moscow) p 97
[9] Russian Federal Service for Hydrometeorology and Environmental Monitoring 2021 *A Report on climate features of the Russian Federation in 2020* (Moscow) p 104