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# BIOMORPHOLOGICAL AND PHYTOCHEMICAL STUDY OF SOME PROMISING AROMATIC PLANT SPECIES FROM THE *Lamiaceae* FAMILY INTRODUCED IN THE REPUBLIC OF MOLDOVA

**Maricica COLȚUN, Alina BOGDAN**

"Alexandru Ciubotaru" National Botanical Garden (Institute), 18 Pădurii Street, Chişinău, Republic of Moldova

Corresponding author email: maricicacoltun@gmail.com

***Abstract***

*The article summarizes the results of the biomorphological and phytochemical study of some introduced species of aromatic plants from the Lamiaceae family under the pedoclimatic conditions of the Republic of Moldova: Elsholtzia stauntonii Benth., Koellia virginiana (L.) MacM., Agastache urticifolia (Benth.) Kuntze, Monarda fistulosa L., Perovskia atriplicifolia Benth. The biomorphological peculiarities of these species have been highlighted and the content and phytochemical composition of the volatile oil have been revealed. The species E. stauntonii accumulates 0.43% volatile oil and is characterized by a rich content in cinerone (50.8%) and rosefuran (20.6%). K. virginiana contains 1.00 -1.05% volatile oil, the main compounds being pulegone (84.6%) and menthol (2.5%). A. urticifolia plants contain 1.65-1.70% volatile oil with the basic compounds estragole (41.1%), pulegone (20.4%), limonene (15.3%). In the species M. fistulosa, the volatile oil content is noted at 0.75-0.80%, the basic components being carvacrol (54.83%), p-cymene (23.15%). P. atriplicifolia contains 0.54-0.65% volatile oil, rich in limonene (40.13%) and α-pinene (17.87%). The highlighted species can serve as sources of indigenous raw materials for the production and diversification of the range of natural cosmetic and pharmaceutical products.*

***Key words****: aromatic plants, biomorphology, cosmetics, essential oil, perfumery.*

## INTRODUCTION

Aromatic plants of the Lamiaceae family contain different proportions of biologically active substances, especially essential oils, which accumulate in secretory tissues located either outside the vegetative organs or inside them. The pharmacological value of the plants derives from the chemical compounds and their ratio in the volatile oil. The antibacterial, expectorant, diuretic, anti-inflammatory, spasmolytic, choleretic, carminative and sedative actions are some of the most common effects of the frequently used volatile oils (Ștefănescu et al., 2018). They are the most promising sources of antimicrobial drugs with low toxicity (Marino et al., 2001). The demand for such preparations, as well as directly for natural essential oils is constantly growing. In this regard, expanding the base of raw material obtained from plants with a high and qualitative content of essential oil, studying the biochemical characteristics of new promising essential oil bearing plants, as well as researching the seasonal dynamics of the accumulation of biologically active substances depending on organ, phase and age, remains a current issue. The study of native aromatic and medicinal plants, as well as those introduced from the flora of other geographical regions into the pedoclimatic conditions of our country constitutes a research priority within the Botanical Garden. In the process of introducing new species, for a given cultivation area, the complexity of the interaction of different vegetation factors is taken into account, so as to ensure an optimal balance between pedoclimatic conditions and the biological requirements of the plants. This avoids situations in which natural conditions may cause an increase in plant biomass production to the detriment of the content of active principles. The exploitation of new plant species expands the range of volatile oils, opens up new ways of identifying effective measures to promote health and prevent diseases naturally (Goncearuc, 2008).

The medicines derived from non-toxic plant matter have a healing effect and exert a complex action on the body, boosting the immune system. The cultivation of medicinal and aromatic plants is favored by the

pedoclimatic conditions of our country. The variety of natural conditions gives rise to a diverse range of species, which represent a source of plant material for medicine, cosmetics and food.

The collection of aromatic plants of the "Alexandru Ciubotaru" National Botanical Garden (Institute) brings together over 160 native and non-native aromatic taxa, with strong fragrance, perfect taste and unique flavor. Among the study subjects, the following aromatic plant species with a high content of high-quality volatile oil, introduced in recent years, were selected, researched and acclimatized: *Elsholtzia stauntonii* Benth., *Koellia virginiana* (L.) MacM., *Agastache urticifolia* (Benth.) Kuntze, *Monarda fistulosa* L., *Perovskia atriplicifolia* Benth. (Colțun et al., 2022). The therapeutic action of these plants is based on the high content of volatile oils, which are pleasantly smelling, effective in the prevention or prophylaxis of infectious diseases caused by bacteria or parasites, and as a treatment for people allergic to antibiotics. Aromatherapy, over the years, has become a branch of phytotherapy, which explains and shows how to use volatile oils from aromatic plants to prevent and cure many diseases.

The phytochemical compounds and their ratio in the volatile oil of species of the genus *Elsholtzia* determine their pharmacological effect, which frequently includes antibacterial, expectorant, diuretic, anti-inflammatory, spasmolytic, carminative, choleretic and sedative action (Tucker et al., 1995). Due to its antimicrobial and antifungal properties, the volatile oil of *Koellia virginiana* (L.) MacM. has been appreciated in the pharmaceutical industry as a remedy with antimicrobial and antifungal action, necessary in the treatment of diseases caused by pathogenic bacteria (Prisacaru et al., 2010). According to the data from the specialized literature, the volatile oil of the species *Agastache urticifolia* (Benth.) Kuntze due to its compounds, exert antimicrobial, antidiabetic, anticancer, anti-inflammatory, antioxidant and immunomodulatory activities (Wilson et al., 2023).

Interesting studies have also been conducted on the volatile oil of *Monarda fistulosa* L. In several literature sources, it is recommended for skin rashes and dermatitis, insect bites and sunburns. This study reports on the chemistry and biological activity of the essential oil and hydroalcoholic extracts obtained from flowers and aerial parts of plants, which exhibited high levels of p-cymene, thymoquinone and decreased levels of thymol, γ-terpinene in senescent flowers. (Tiffany et al., 2013, Colțun et al., 2018, Berthalia et al., 2022).

*Perovskia atriplicifolia* Benth. has long been used in Pakistan as a traditional herbal medicine, against anti-inflammatory processes. The phytochemical compounds present in *Perovskia* volatile oil include rosmarinic acid and other hydroxycinnamic acids, monoterpenes, diterpenoids, mainly from the abietane class - carnosol, rosmanol, which give Russian sage volatile oil a number of therapeutic properties, namely: antibacterial, antiviral, anti-inflammatory and antitumor (Pourmortazavi et al., 2003, Ijaz et al., 2015). According to some studies, the main compounds of the essential oil from the flowering branches of *Elsholtzia stauntonii* Benth. are rosefuran (41.73%) and rosefuran epoxide (40.36%) (Tusker, 1995). Pharmacological investigations on extracts and pure compounds from *E. stauntonii* cover antiviral, antibacterial, antimicrobial, anti-inflammatory, antioxidant, as well as other protective activities (Zhiqin et al., 2012).

## MATERIALS AND METHODS

The research carried out covers the period 2018-2024, the experiences being set on the territory of the Collection of Aromatic Plants of the NBGI. The species included in the research: *Elsholtzia stauntonii* Benth., *Koellia virginiana* (L.) MacM., *Agastache urticifolia* (Benth.) Kuntze, *Monarda fistulosa* L., *Perovskia atriplicifolia* Benth. were mobilized and preserved as promising species, introduced from other geographical areas under the local pedoclimatic conditions. The seed material was received through the International Seed Exchange program, traditionally conducted with various specialized botanical institutions. The second stage included the study of the bioecological and morphological peculiarities of the plants grown under the new conditions. The experiments were focused on testing different reproduction methods and identifying

the peculiarities of the seasonal development and biological potential of plant growth. The phase, organ, age and seasonal dynamics of the accumulation of raw materials and volatile oil were established, and the best harvesting period was determined. Thus, aromatic plant species that possess a high potential for adaptability and accumulation of volatile oil were selected. The plants were grown in an open field, under ecologically balanced conditions, on a general agrotechnical background. Phenological observations and biomorphological studies were carried out every 3 days, throughout the entire growing season (Sparks, 2009). The volatile oil content of plants was determined by the method of steam distillation (Gosudarstvennaia, 1968). The chemical composition of the volatile oil was determined by gas chromatography-mass spectrometry (GC-MS) using the Agilent Technologies 6890N gas chromatograph coupled to the (MSD) 5975 inert XL Mass Selective Detector. The phytochemical research was conducted at the "Stejarul" Biological Research Center, Piatra Neamț, Romania.

## RESULTS AND DISCUSSIONS

The species *Elsholtzia stauntonii* Benth. from the Lamiaceae family, introduced in the Botanical Garden in 2018, researched to date as an aromatic and medicinal plant, is of particularly high value for introducing and exploiting new aromatic species. In the wild, it occurs mostly in China and Pakistan. In the NBGI, the initial material was received by international seed exchange – Hortus Botanicus Latvia. Under the climatic conditions of the Republic of Moldova, it behaves as a perennial plant, which develops a typical shrub reaching a height of 60-90 cm, with a diameter of 60 cm, made up of shoots up to 65-70 cm long. The leaves are opposite, oblong-oval, reaching a length of 9-12 cm and a width of 4-5 cm, falling off at the end of the growing season, in November. The inflorescences are large spikes. The length of the central inflorescence is 4-17 cm. There are more flowers in the lower whorl and fewer in the upper one. The flowers reach a length of 6-9 mm and a diameter of 2.5-3.0 mm. The weight of 1000 seeds is 0.2 g (Figure 1).

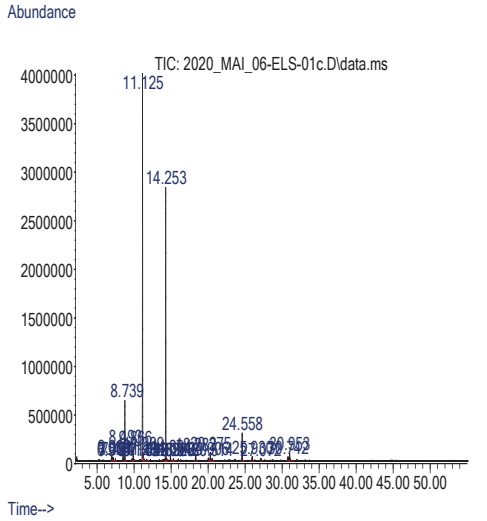
Figure 1. General appearance of the species *Elsholtzia stauntonii* Benth.

The plants are able to complete the full development cycle in the first year of life, however, the onset of phenological phases is delayed, so the fruits do not reach the full ripening phase. The plants grow the fastest in the second half of June. In late August - early September, inflorescences emerge at the top of the main and lateral buds. In the second and subsequent years, the growing season usually starts at the end of March. A plant develops up to 50 perennial 35-70 cm long shoots, the fastest growth occurs in May. The full flowering stage occurs at the end of July and lasts 31-42 days. From aesthetic point of view, the plants are the most attractive at the time of flowering, when they are completely covered with spike inflorescences of purple flowers, located at the ends of the branches. The fruits ripen at the end of September. The growing season lasts 125-145 days, depending on the weather conditions.

*E. stauntonii* prefers sunny areas with slightly fertile soils. Lands with groundwater located close to the surface and heavy clay soils are unsuitable for its cultivation. The bush is usually shaped by annual pruning, which plays a key role in increasing the productivity of the plant. The bush load should not exceed 35-40% of the shoots, with a nutrition area of 80 x 40 cm. Plants can be pruned annually in spring, starting from the second year after planting. Once every five years, the plant needs to be rejuvenated, by cutting it at a height of 15-20 cm above the soil surface. The biologically active substance contained by this plant is its volatile oil, the content of which increases

before the start of flowering, reaching a maximum in this phase and then begins to decrease. A similar tendency was observed in previous years. The maximum content of volatile oil is found in the early flowering stage and constitutes 0.5-1.65%. The perfume note of the essential oil is 4.5 points and it is characterized by a rich content of cinerone (50.8%) and rosefuran (20.6%). Other important compounds, of the 25 identified, are eucalyptol (6.3%) and β-caryophyllene (6.2%) (Figure 2). The volatile oil is a thin, orange-colored fluid that harmonizes with all plant fragrances. Literature data and investigations on the chemical compounds of the volatile oil have confirmed a pronounced antibacterial activity against pathogenic bacteria. The dried raw material contains a number of vital micro- and macronutrients: iron, manganese, molybdenum, which makes it possible to use it in the treatment of anemia, as a diuretic and stimulant for digestion, as well as in the treatment of respiratory diseases. In conclusion, the allochthonous species *Elsholtzia stauntonii*, introduced and researched in the NBGI, can be recommended for cultivation, as an aromatic and medicinal species with aromatic and therapeutic potential. This plant has not yet revealed all its secrets. It is still very promising for study – there are great prospects for researchers and lovers of new organic herbal products.

| RT (min) | | Kovats index | Compounds | Area % |
|---|---|---|---|---|
| 7.03 | | 978 | 1-Octen-3-ol | 0.3 |
| 7.19 | | 985 | 3-Octanone | 0.3 |
| 7.47 | | 996 | 3-Octanol | 0.2 |
| 8.49 | | 1025 | *p*-Cymene | 1.4 |
| 8.74 | | 1032 | Eucalyptol | 6.2 |
| 9.71 | | 1060 | γ-Terpinene | 0.2 |
| 9.86 | | 1064 | Acetophenone | 1.6 |
| 11.12 | | 1099 | (Z)-Cinerone | 43.3 |
| 14.25 | | 1178 | Rosefuran epoxide | 33.2 |
| 14.35 | | 1180 | 4-Terpineol | 0.2 |
| 14.89 | | 1194 | α-Terpineol | 0.6 |
| 18.28 | | 1272 | Geranial | 1.0 |
| 24.56 | | 1421 | β-Caryophyllene | 3.9 |
| 25.93 | | 1456 | α-Humulene | 0.6 |
| 27.07 | | 1484 | α-Curcumene | 0.4 |
| 30.95 | | 1583 | Spathulenol | 1.5 |
| | | | *Other compounds* | *5.1* |




***1*** ***2***

Figure 2. The chemical composition of the *Elsholtzia stauntonii* Benth. volatile oil by GC-MS
1- identified chemical compounds; 2- chromatogram

*Koellia virginiana* (L.) MacM. native to North America, is another promising species. It has been researched in the Botanical Garden as an aromatic and medicinal plant (Figure 3).

In the first year of vegetation, under the conditions of our country, the plants develop a single stem and do not reach the germination phase. After the first autumn frosts, the aerial organs die. The perennial plants start the growing season at the beginning of March. From the rhizomes, 30-60 annual shoots appear on the soil surface. The plants bloom between July 20 and August 30.

The seeds ripen by the end of September. *K. virginiana* plants synthesize volatile oil in all organs: the maximum is produced in inflorescences 2.00-2.10% of the absolute dry matter. The content of volatile oil varies depending on the plant development stage, the maximum is noted at the end of the flowering stage: 1.41-1.52% (Figure 4).

Figure 3. General appearance of the species *Koellia. virginiana* (L.) MacM.

25 chemical compounds were identified in the volatile oil, the main ones being pulegone (84.6%), menthol (2.5%) and limonene (8.4%). The volatile oil, having a strong and pleasant fragrance, was appreciated by the specialists of the "Viorica-Cosmetic" company with a perfumery rating of 4.6 points out of 5. The menthol aroma is due to the presence of menthol and limonene among its compounds, therefore, and is of interest in the manufacture of fragrances for cleaning and laundry products. The research conducted in collaboration with the "Nicolae Testemițanu" State University of Medicine and Pharmacy, within the Epidemiology Laboratory, demonstrated that the volatile oil obtained from *K. virginiana* plants in the full flowering phase exhibits antimicrobial properties due to the high content of its main component – pulegone (84.6%) and can be used as an antimicrobial and antifungal substance in the production of preparations for the treatment of mycoses and other diseases caused by some gram-positive and gram-negative bacteria.

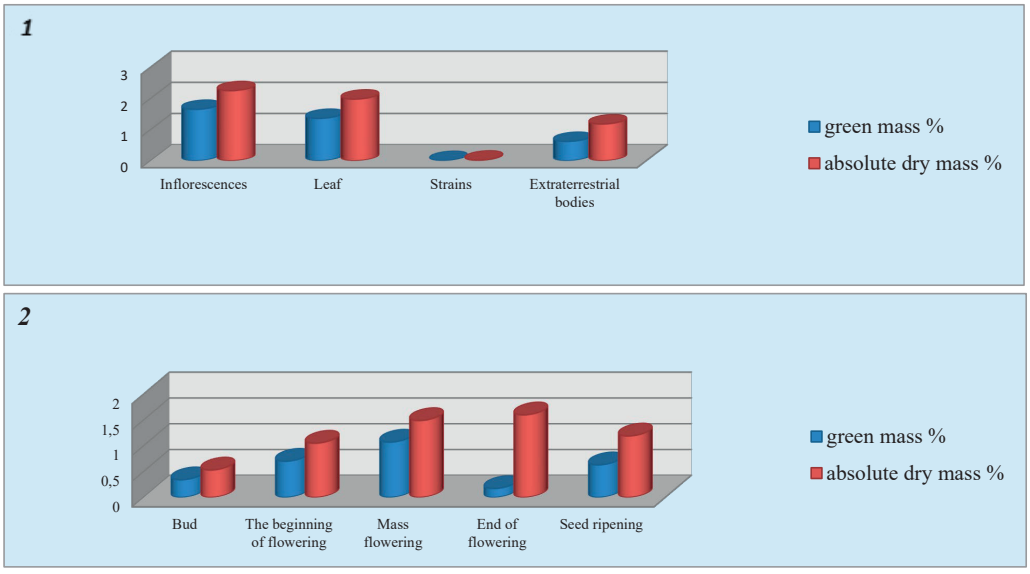



Figure 4. Dynamics of volatile oil accumulation in the species *Koelllia virginiana* (L.) MacM. :1- volatile content depending on the aboveground organs; 2- volatile oil content depending on the phenological phase.

Another promising aromatic and spice species is *Agastache urticifolia* (Benth.) Kuntze native to western North America, from California to Colorado, where it occurs in the wild flora. It is cultivated in Japan, China and some European countries. Under the conditions of the Republic of Moldova it behaves as a perennial plant, growing about 1.1-1.3 m in height (Figure 5). It may not tolerate temperatures below -18º C for a long time, prefers southern exposure, warm,

sunny places with well-drained soils. In recent years, the species has tolerated well the weather conditions, completing its entire development cycle and forming viable seeds.

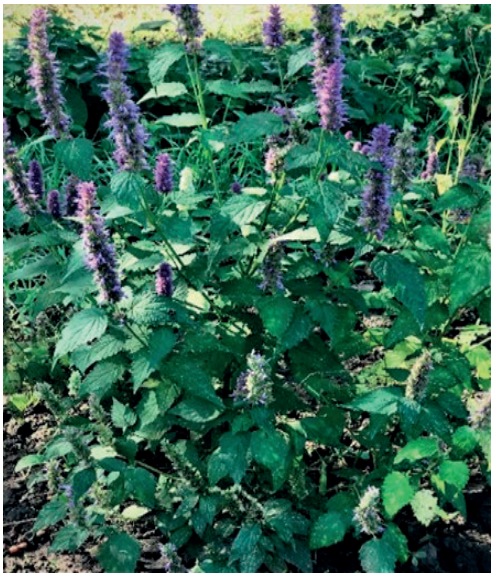


Figure 5. General appearance of the plant *Agastache urticifolia* (Benth.) Kuntze

The species was propagated by seeds sown directly into the soil in early spring and by seedlings stored initially indoors and then transplanted in the field, by division conducted in spring and, less often, by young rooted basal cuttings. The plants complete a full development cycle in the first year of vegetation. They start active growth at the end of April. During the summer, the plants develop slowly, forming 1-2 stems bearing 4-6 pairs of first-order branches, 4-5 pairs of leaves with a blade length of 4.5-6.5 cm and width of 3-4 cm. The plants reach a height of 50-55 cm at the end of August. In September, the first buds appear, some reaching the beginning of flowering. Under the local pedoclimatic conditions, *A. urticifolia* develops a bush composed of 4-6 erect, branched stems. Each branch ends with a compact spike inflorescence. It blooms from July to the end of summer, the flowers are small, the corolla ranging from lilac to blue-violet. It accumulates volatile oil throughout the entire growing season, which lasts 200-220 days. The maximum content is found in the full flowering phase, in 2-year-old plants, in inflorescences: 1.65-1.70% of the absolute dry matter. In the volatile oil of *A. urticifolia*, 17 chemical compounds were identified, the main ones being estragole (41.1%), pulegone (20.4%), limonene (15.3%), iso-menthone (12.0%), methyl eugenol (5.1%), menthone (1.7%) (Figure 6). Estragole determines the strong antibacterial and antifungal effect of the oil. Its presence brings the anise-like smell. Pulegone gives the volatile oil the insecticidal property, so that it can be recommended for the biological protection of plants.

| RT(min) | Kovats index | Compounds | Area% |
|---|---|---|---|
| 6.91 | 973 | Sabinene | 0.1 |
| 6.97 | 976 | 3-Cyclohepten-1-one | 0.7 |
| 7.19 | 985 | 3-Octanone | 0.1 |
| 7.39 | 993 | β-Myrcene | 0.5 |
| 8.67 | 1030 | Limonene | 15.3 |
| 11.21 | 1101 | Linalool | 0.2 |
| 11.68 | 1113 | 1-Octenyl acetate | 0.3 |
| 12.02 | 1122 | 1,3,8-ρ-Menthatriene | 0.2 |
| 12.59 | 1136 | *cis*-ρ-Mentha-2,8-dien-1-ol | 0.2 |
| 13.37 | 1155 | Menthone | 1.7 |
| 13.80 | 1166 | *iso*-Menthone | 12.0 |
| 14.26 | 1178 | *cis*-Linalool oxide (furanoid) | 0.4 |
| 15.24 | 1202 | Estragole | 41.1 |
| 16.93 | 1241 | Pulegone | 20.4 |
| 23.85 | 1404 | Methyl eugenol | 5.1 |
| 24.56 | 1422 | β-Caryophyllene | 0.7 |
| | | *Other compounds* | *1.0* |

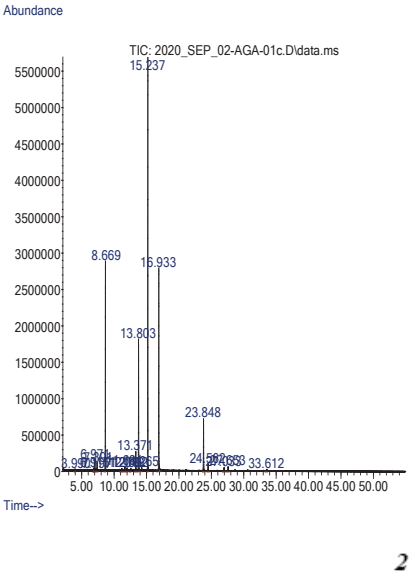



Figure 6. The chemical composition of the essential oil of *Agastache urticifolia* (Benth.) Kuntze by GC-MS22
1 – chemical compounds; 2 – chromatogram

*Monarda fistulosa* L. (wild bergamot, bee balm) is a perennial herbaceous species, cultivated as an aromatic, medicinal and spice plant (Figure 7). It occurs in the spontaneous flora of North America and Canada.

Figure 7. General appearance of the species *Monarda fistulosa* L.

In our country, wild bergamot is cultivated on small areas, in gardens of aromatic herbs and in flower beds. In the Botanical Garden, it has been researched as an aromatic and medicinal plant, with a rich content of biologically active substances, especially volatile oil. Under the local conditions, the plant develops a bush composed of 16-20 stems with a height of 65-120 cm, which lignify towards the end of the growing season. The leaves are cordate-lanceolate, toothed, with fine hairs. The flowering period is quite long, lasting from mid-summer to October. The flowers are small, connected to the axillary false whorls, located at the main ends of the lateral buds. On a stem there are 5-9 inflorescences with a diameter of 6-9 cm, in each inflorescence – 230 -292 purple flowers. All parts of the plant contain volatile oil, which gives it a lemony scent and a refined taste.

The fruit is a nutlet. Wild bergamot starts the growing season early, in the second half of February - early March. It blooms from the second year, in June - July. The full flowering stage usually occurs in the first half of July. Heavy, marshy and acidic soils are unsuitable for wild bergamot. It prefers sunny, open places, possibly with a slight shade. Monarda is

a promising aromatic plant, which is recommended to be grown outside the crop rotation system with annual plants. The species can be planted again on the same area at least after 5-6 years. Soil preparation involves plowing to a depth of 22-25 cm. The seedbed is prepared 4-5 days before sowing or planting, by leveling and smoothing the soil as much as possible and then by compacting it. Wild bergamot is propagated by seeds sown directly in the field or by seedlings obtained in greenhouses, as well as by division. Sowing right before winter begins is more advantageous, considering that this work is carried out in a period less busy with other agricultural works. Wild bergamot seeds must have a physical purity of 95% and a germination of 70%. They are sown directly into the field right before the beginning of winter, late November - early December, when the average daily temperature drops below -5°C and there is no longer a risk that the seeds will germinate until spring. During winter, temperature, humidity and other factors have a positive impact on seeds, stimulating and maintaining the complex processes preceding germination in spring. To create 1 ha of wild bergamot plantation, 1.5-2.0 kg of seeds is needed. The optimum soil temperature for seed germination in spring is +13.-+15 °C. Using the moisture accumulated in the soil during the winter, they sprout in the first days of May. In some years, with mild winters, this sowing time is not favorable because of the high temperatures, which favor early seed germination, and the possible return of low temperatures, which may destroy the young plants. Seed germination, regardless of the time of sowing in the field, is 55-75%, under laboratory conditions 70-80%. Wild bergamot plants can also be propagated by seedlings, being grown in a substrate of chernozem and sand (1:1). Sowing is carried out at the end of February or the beginning of March. In order to obtain the required amount of seedlings for 1 ha, 500-700 g of seeds and a greenhouse area of 100 $m^2$ are needed. This species is responsive to organic and mineral fertilizers. One of the simplest and most effective methods of plant propagation is division. The perennial plants can be divided both in autumn and spring. The plant portions planted in autumn start vegetating in spring, 10-15 days earlier than those divided and planted in March. Wild bergamot, during the growing season, may be affected by rust (*Puccinia menthae* Pers.), which appears as rust spots, especially on the leaves, and consequently causes damage by reducing the quality of the leaves and by premature defoliation of the stems. Rust attacks on plants can be avoided by strictly following crop rotation, planting seedlings free from other plant debris and using healthy propagation material. Wild bergamot plants accumulate volatile oil throughout the entire growing season in all aboveground organs. Wild bergamot plantations intended for obtaining volatile oil are harvested starting from the second year of vegetation, for 5-6 years. The maximum volatile oil content is found in the full flowering stage, mainly in leaves and inflorescences, up to 0.75-0.80% of the absolute dry matter. In the volatile oil of *Monarda fistulosa* L., 15 chemical compounds were identified, the main ones being carvacrol (54.83%), p-cymene (23.15%), carvacrol methyl ether (5.90%) etc. (Figure 8). Due to the compounds present in the volatile oil, the species possesses antifungal properties and it can be recommended to be included in phytotherapeutic remedies with antifungal action. The oil is in demand in the food industry, as it is used to flavor wines, soft drinks and confectionery products. The optimal harvest time is during the full flowering stage of the crop. If the area to be harvested is large, it is recommended that harvesting begins when 50-60% of the plants have bloomed, so that the entire area can be harvested during the optimal period. To obtain seeds, harvesting is carried out at the stage of full maturation – at the end of October. On average, 2-3 kg of seeds is obtained from 1 ha. After 5-6 years of exploitation of a wild bergamot plantation, the herb yield decreases, thus, the volatile oil content decreases too. New plantations need to be established on a different plot.

To sum up, it is necessary to mention that perennial *Monarda fistulosa* plants go through an entire vegetation cycle, which lasts 185-190 days, accumulate a large amount of high-quality volatile oil and also are of high aesthetic value, being promising in landscaping as an ornamental species. It can be successfully

cultivated on industrial areas. Literature analysis and the investigations on the content and quality of the volatile oil demonstrate the need for further research on *Monarda* species, in order to establish their therapeutic effects. The research will allow for the diversification of effective and harmless antimicrobial preparations available in medical practice.

| TR(min) | Compounds | Area % |
|---|---|---|
| 5.59 | α-Thujene | 2.30 |
| 5.79 | α-Pinene | 0.59 |
| 6.92 | 3-Octenol | 2.44 |
| 7.33 | β-Myrcene | 0.35 |
| 8.19 | α-Terpinene | 2.54 |
| 8.45 | p-Cymene | 23.15 |
| 8.61 | Limonene | 0.87 |
| 9.65 | γ-Terpinene | 1.42 |
| 14.29 | 4-Terpineol | 0.66 |
| 17.09 | Carvacrol methyl ether | 5.90 |
| 17.28 | Thymoquinone | 1.50 |
| 19.60 | Carvacrol | 54.83 |
| 24.48 | β-Caryophyllene | 0.30 |
| 26.96 | Germacrene D | 0.47 |
| 29.80 | Thymohydroquinone | 1.33 |
| | *Other compounds* | *1.36* |

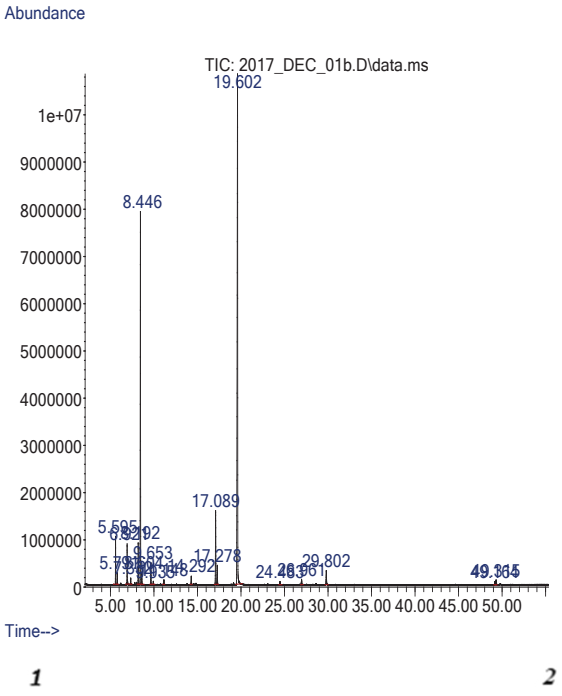



Figure 8. Chemical composition of the volatile oil of *Monarda fistulosa* L. by GC-MS
1- chemical compounds; 2 - chromatogram

Figure 9: General appearance of the species *Perovskia atriplicifolia* Benth.

A complex study was also conducted on the species *Perovskia atriplicifolia* Benth., obtained from seeds received from Russia in 2018. Research shows that, under the climatic conditions of the Republic of Moldova, it behaves as a perennial plant, developing a bush of 17-18 whitish stems and lobed, deeply toothed, silver-gray leaves (Figure 9).

Mature stems are woody at the base and young stems are herbaceous. The plant exudes a specific sage scent when crushed. It is a quite undemanding plant in terms of growing conditions. It thrives on poor soils and, once established, it is able to tolerate rather long periods of drought. It prefers alkaline soils, not the acidic or swampy ones. It withstands low temperatures down to -15 °C, as well as high ones. It reacts favorably to large amounts of

precipitation. It is a light-loving species. In early spring, last year's branches are cut at a height of 5-10 cm above the ground. Perennial plants start growing in early April. The flowering stage is long-lasting, sometimes until early October, which offers the possibility of including the species in the landscaping of green spaces of a curative-prophylactic and decorative type, as well as being used as a honey plant. *P. atriplicifolia* plants accumulate volatile oil throughout the growing season, in all aboveground organs. The maximum content is noted in the mass flowering phase 0.54-0.65%. Investigations on the chemical composition of the volatile oil of *P. atriplicifolia* resulted in the identification of 28 compounds that have a concentration above 0.5%. The compounds identified with the highest values are: d-limonene – 21.47%, eucalyptol – 16.19 %, α-pinene – 8.17%, caryophyllenes (α and β) - 11.91% (Figure 10). The above suggests us that the species *P. atriplicifolia* can be successfully cultivated under the local conditions, thus increasing the assortment of aromatic plants with a potential therapeutic effect in inflammatory diseases.

| Nr. crt. | Kovats Index | Retention Time | Compound | Area % |
|---|---|---|---|---|
| 1 | 914 | 5.16 | α-Thujene | 0.20 |
| 2 | 923 | 5.29 | α-Pinene | 8.17 |
| 3 | 939 | 5.51 | Camphene | 3.87 |
| 4 | 969 | 5.94 | β-Pinene | 3.93 |
| 5 | 980 | 6.09 | β-Myrcene | 0.98 |
| 6 | 1011 | 6.53 | Δ-3-carene | 0.23 |
| 7 | 1020 | 6.66 | *p*-Cymene | 0.89 |
| 8 | 1028 | 6.76 | D-Limonene | 21.47 |
| 9 | 1031 | 6.80 | Eucalyptol | 16.19 |
| 10 | 1043 | 6.98 | *cis*-β-Ocimene | 0.23 |
| 11 | 1057 | 7.17 | γ-Terpinene | 0.55 |
| 12 | 1099 | 7.76 | Linalool | 0.53 |
| 13 | 1146 | 8.41 | Sabinol | 0.56 |
| 14 | 1176 | 8.84 | Borneol | 4.34 |
| 15 | 1187 | 8.99 | 4-Terpineol | 0.51 |
| 16 | 1200 | 9.18 | alfa-Terpineol | 0.54 |
| 17 | 1299 | 10.56 | Bornyl acetate | 6.06 |
| 18 | 1360 | 11.41 | α-Terpinyl acetate | 3.08 |
| 19 | 1434 | 12.46 | β-Caryophyllene | 6.20 |
| 20 | 1466 | 12.91 | α-Caryophyllene | 5.71 |
| 21 | 1490 | 13.24 | Germacrene D | 0.36 |
| 22 | 1519 | 13.65 | τ-Cadinene | 0.91 |
| 23 | 1527 | 13.76 | Calamenene / Cadina-1,3,5-triene | 0.22 |
| 24 | 1586 | 14.59 | Caryophyllene oxide | 3.43 |
| 25 | 1599 | 14.77 | α-Bisabolene epoxide | 0.20 |
| 26 | 1612 | 14.95 | Cubenol | 0.64 |
| 27 | 1637 | 15.30 | τ-Cadinol | 3.77 |
| | | | | |
| 28 | 1648 | 15.45 | α-Eudesmol | 1.24 |
| | | | *Other compounds* | *4.99* |

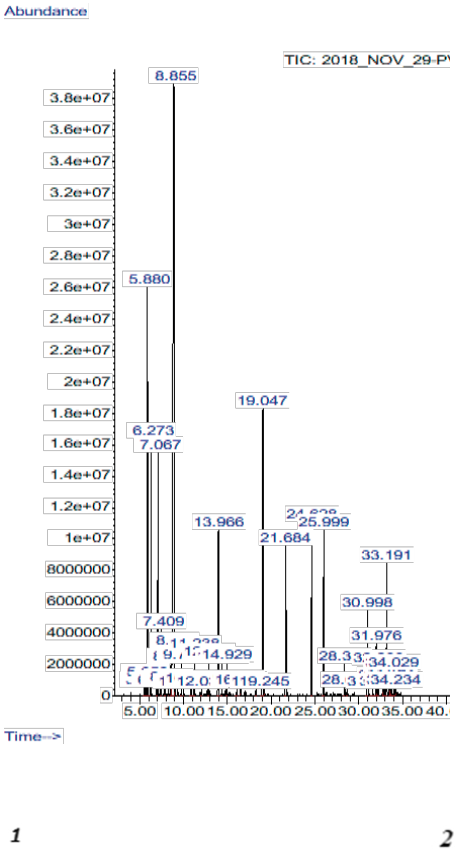



Figure 10. Chemical composition of the volatile oil of *Perovskia atripicifolia* Benth. by GC-MS
1- chemical compounds; 2 - chromatogram

## CONCLUSIONS

The pedoclimatic conditions of the Republic of Moldova are favorable for the growth and development of aromatic, medicinal and spice plants. All the highlighted species fully complete the ontogenetic cycle, are characterized by resistance to drought and frosts from -15°C of - 25°C.

The study of the peculiarities of volatile oil accumulation in plants shows that they depend on the age, phenological stage and plant organ. The maximum content was found in the species *Koellia virginiana* in the late flowering stage (1.41-1.52% of the absolute dry matter), followed by *Agastache urticifolia* (0.80-0.85%) in the full flowering stage. The researched species contain volatile oil and can serve as sources of local raw materials for the production and diversification of the range of plant-derived natural cosmetic and pharmaceutical products.

The laboratory research on the volatile oil obtained from *K. virginiana* and *Agastache urticifolia* plants confirms its antimicrobial properties are due to the high content of the main component – pulegone, which can be used as an antimicrobial and antifungal substance in the production of preparations for the treatment of mycoses and other diseases caused by some gram-positive and gram-negative bacteria.

The species *Elsholtzia stauntonii* Benth. *Koellia virginiana* (L.) MacM., *Agastache urticifolia* (Benth.) Kuntze, *Monarda fistulosa* L., *Perovskia atriplicifolia* Benth, which belong to the family *Lamiaceae,* are plants introduced and researched in the "Alexandru Ciubotaru" National Botanical Garden (Institute), with aromatic, medicinal and melliferous potential.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