

UDC 582.943.17:[581.19:547.56]  
DOI <https://doi.org/10.32782/2522-9680-2026-1-225>

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**To cite this article:** Boika O. (2026). Short comparative literature review of the phenolic content of the leaves of some *Salvia* species. *Fitoterapiia. Chasopys – Phytotherapy. Journal*, 1, 225–233, doi: <https://doi.org/10.32782/2522-9680-2026-1-225>

**SHORT COMPARATIVE LITERATURE REVIEW OF THE PHENOLIC CONTENT OF THE LEAVES OF SOME SALVIA SPECIES**

**Actuality.** Sage is among the most significant medicinal plants due to its valuable biochemical composition. Phenolic compounds form a broad class of organic substances that include a benzene ring and have a wide range of pharmacological effects. However, the reserves of medicinal raw materials from all types of medicinal plants, including sage, are continually diminishing. This issue is particularly pronounced now due to the impact of military operations on Ukraine's environment and industrial capacity. Species within the same genus, but differing in their genotype, also exhibit slight variations in their biochemical composition. Comparing species that are systematically close to each other can help identify species suitable for use alongside commonly utilised ones and aid in maintaining pharmaceutical production at a level that meets our country's needs.

**The purpose of the study** is to conduct a comparative analysis of the content of phenolic compounds in sage officinalis and five wild sage species growing on the territory of Khortytsia Island, according to literary sources.

**Material and methods.** The study analysed the phenolic compound content in the leaves of six sage species: *Salvia aethiopsis*, *Salvia nutans*, *Salvia austriaca*, *Salvia verticillata*, *Salvia nemorosa*, and *Salvia officinalis*, based on literature sources. These species were chosen for comparison because they are part of the natural flora of Khortytsia Island and the wider Zaporizhzhia region, and are common, suggesting a significant potential supply of medicinal raw materials. The presence of *Salvia officinalis* in the natural flora of Khortytsia Island was not documented. Literature sources on these species were analysed, and the most recent sources were selected. Sources in which extraction and compound determination were carried out using the same methods were also chosen.

**Research findings.** The comparative study revealed that 18 phenolic compounds were detected across all examined species. Only one compound – luteolin-7-O-glucoside – was present in all studied species. Two compounds – caffeic and rosmarinic acids – were found in five of the six species. Four compounds were unique to a single species. Biochemically, *Salvia verticillata* was most like *Salvia officinalis*.

**Conclusion.** The most common phenolic compounds in the studied species were luteolin-7-O-glucoside, caffeic acid, and rosmarinic acid. Analysis found that *Salvia verticillata* is most similar to *Salvia officinalis*. So, this species needs more detailed analyses and, probably, may be used to prepare products that use *Salvia officinalis* as a source of phenolic compounds. The lowest levels of phenolic compounds were recorded in *Salvia austriaca*. *Salvia nutans* contained the most unique compounds in its composition, with two compounds found only in its leaves.

**Key words:** medicinal plants, *Salvia* sp., phenolic compounds, comparison, genotypes.

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**Бібліографічний опис статті:** Бойка О. (2026). Короткий порівняльний літературний огляд фенольного вмісту листя деяких видів шавлії. *Фітоterapia. Часопис*, 1, 225–233, doi: <https://doi.org/10.32782/2522-9680-2026-1-225>

**КОРОТКИЙ ПОРІВНЯЛЬНИЙ ЛІТЕРАТУРНИЙ ОГЛЯД ФЕНОЛЬНОГО ВМІСТУ ЛИСТЯ ДЕЯКИХ ВИДІВ ШАВЛІЇ**

**Актуальність.** Шавлія – це одна з найважливіших лікарських рослин, яка має дуже цінний біохімічний склад. Фенольні сполуки – це великий клас органічних сполук, до складу яких входить бензолне кільце. Вони мають широкий спектр фармакологічної дії. Проте запаси лікарської сировини всіх видів лікарських рослин, включаючи і шавлію, постійно зменшуються. І особливо це відчувається зараз через вплив військових дій на оточуюче середовище та промислові потужності України.

Види, що належать до одного роду, однак, відрізняються за своїм генотипом мають і децю різний склад біохімічних речовин. Порівняння систематично наближених один до одного видів дасть змогу виявити види, які можна використовувати поряд із широко застосованими, та допоможе підтримувати виробництво фармацевтичних препаратів на достатньому для потреб нашої країни рівнях.

**Мета дослідження** – за літературними джерелами провести порівняльний аналіз умісту фенольних сполук шавлії лікарської та п'яти дикорослих видів шавлії, що зростають на території острова Хортиці.

**Матеріал і методи.** У роботі було проаналізовано за літературними джерелами вміст фенольних сполук у листі шести видів шавлії, а саме: *Salvia aethiopsis*, *Salvia nutans*, *Salvia austriaca*, *Salvia verticillata*, *Salvia nemorosa* та *Salvia officinalis*. Ці види було вибрано для порівняння через те, що вони зустрічаються у природній флорі острова Хортиці та у Запорізькому регіоні у цілому і є доволі поширеними, тобто потенційний запас лікарської сировини досить великий. Присутність *Salvia officinalis* у природній флорі острова Хортиці не було зафіксовано. Проаналізовано літературні джерела з інформацією саме про ці види, вибирались найновіші зі знайдених джерел. Вибрано ті джерела, де екстракція та визначення сполук проводилися тими самими методами.

**Результати дослідження.** Результати порівняльного дослідження виявили, що загалом у всіх досліджуваних видах було виявлено присутність 18 фенольних сполук. Лише одна сполука – лютеолін-7-О-глікозид – була присутня у всіх досліджених видах. Дві сполуки – кавова та розмаринова кислоти – зустрічаються у п'яти з шести видів. Чотири сполуки були унікальними для якогось виду (зустрічалися лише у представників одного виду). За своїм біохімічним складом *Salvia verticillata* виявилася найбільш схожою із *Salvia officinalis*, концентрація частини сполук у ній навіть перевищує концентрацію у шавлії лікарській.

**Висновки.** Загалом уміст фенольних сполук у дикорослих видів шавлії, які зростають на о. Хортиця, схожий на вміст сполук у шавлії лікарської, проте їх кількість коливається як у бік зменшення, так і в бік збільшення. Найчастіше зустрічаються три сполуки: лютеолін-7-О-глікозид, кавова та розмаринова кислоти. Після проведення аналізу було виявлено, що шавлія кільчата (*Salvia verticillata*) найбільш подібна до шавлії лікарської та може бути використана для виготовлення препаратів, для приготування яких шавлія лікарська виступає джерелом фенольних сполук. Найменше фенольних сполук було зафіксовано у *Salvia austriaca*. Шавлія поникла (*Salvia nutans*) мала у своєму складі найбільше унікальних сполук (дві сполуки були лише у її листі).

**Ключові слова:** лікарські рослини, шавлія, фенольні сполуки, порівняння, генотипи.

**Introduction.** Medicinal plants are a vital part of the plant kingdom. According to the World Health Organisation (WHO), 80% of developing countries and 60% of the global population rely on medicinal herbs (Mahajan et al., 2020). Herbal remedies have been utilised for over 5000 years. About 60% of plants were reported to possess medicinal properties in the post-Neolithic era (Chen et al., 2015). The biological effectiveness of medicinal plants varies by organ. These plant species are also employed in the beauty sector as cosmetics, perfumes, and soaps, as well as in the food industry (Efferth & Greten, 2012). Only 5000 plant species out of 250,000–300,000 have been thoroughly studied for their therapeutic potential (Payne et al., 1991). The World Health Organisation (WHO) has listed 21,000 therapeutic plants from around the globe (WHO, 2015). According to the International Union for Conservation of Nature and the World Wildlife Fund, over 50,000 plant species are used for medicinal purposes worldwide (Chen et al., 2016; Kumar et al., 2018; Prakash et al., 2023).

*Salvia* is the largest genus in the *Lamiaceae* family, with approximately 700–900 species of shrubs, herbaceous perennials, and annuals. Many species are used as herbs, ornamental plants (usually for flower interest), and sometimes for their decorative and aromatic foliage (Kalnyuk et al., 2025). Some species of *Salvia* have been cultivated worldwide for use in folk medicines and for culinary purposes. The genus *Salvia* is known to be a rich source of flavonoids and phenolic acids, with

more than 160 polyphenols identified (Lu, Foo, 2002). However, nowadays, we can notice that the areas of the *S. officinalis* is disappeared and amount of the medical raw materials is decrease. The problem with decreasing of the raw materials is very actual. So, it is essential to find new alternative sources for the pharmacological industry. One of the possible ways to solve this problem is use new wild nature species related to the official medical species. That's why very important to investigate those species and to compare their content with medical plants.

**The aim of the study** is to compare the phenolic content of the leaves of five *Salvia* species: *Salvia aethiopsis*, *Salvia nutans*, *Salvia austriaca*, *Salvia verticillata*, *Salvia nemorosa* growing on Khortica Island with that of the main medicinal species, *Salvia officinalis* L., based on a literature review.

**Materials and methods.** A comparison was conducted of five *Salvia* species growing on the island of Khortica – *Salvia aethiopsis*, *Salvia nutans*, *Salvia austriaca*, *Salvia verticillata*, *Salvia nemorosa* (Okhrimenko et al., 2016) – with *Salvia officinalis* L., based on literature sources. The sources used for the analyses span from 2012 to 2025 and were selected according to the focus of their studies. All of them investigate the species central to this review, utilising leaves as the initial material to prepare a 70% ethanolic extract and employing HPLC methodology to detect phenolic compounds.

*Salvia aethiopsis* (fig. 1a), commonly known as Mediterranean sage, is a biennial or short-lived perennial herb with very woolly leaves.

*Salvia nemorosa* (fig. 1b), also known as woodland sage, Balkan clary, blue sage, or wild sage, is a perennial plant. The leaves vary in shape, making them heterophyllous.

*Salvia verticillata* (fig. 2a), the lilac sage or whorled clary, is a perennial herb. It has a leafy base of mid-green leaves covered with hairs, with leaf-covered stems that bear inflorescences up to 0.91 m tall.

*Salvia austriaca* (fig. 2b), or Austrian sage, is a perennial species. The leaves are predominantly basal, ovate, elliptical, or oblong. Usually, there is one or two pairs of stem leaves, which are small, elliptical, obtuse, sessile, often deeply incised and nearly lobed.

*Salvia nutans* (fig. 2c), commonly known as nodding sage, is a perennial species. The basal leaves are ovate-cordate and have a twice-serrated margin. They are glabrous on the upper surface and short, densely pubescent on the underside. There is one pair of cauline leaves.

*Salvia officinalis* (fig. 2d), known as common sage or simply sage, is a perennial, evergreen subshrub with woody stems. The leaves are oblong. They are grey-green, rugose on the upper surface, and almost white underneath due to numerous short, soft hairs.

**Results and discussion.** According to the literature, the phenolic content of the leaves of six different *Salvia* species was analysed. All these species are perennial plants. However, they all have different genotypes because they are different species, and these differences

also may affect the biochemical composition of their leaves.

Eighteen phenolic compounds were identified in the studies investigated. They include: apigenin, apigenin-7-O-glucoside, apigenin derivatives, luteolin, luteolin-7-O-glucoside, luteolin derivatives, catechin, chlorogenic acid, caffeic acid, rosmarinic acid, salvianolic acid, rutin, hydroxycinnamic acid, flavone, hispidulin, cirsimaritin, vicenin-2, and 6-hydroxyluteolin-5-glucoside.

It is interesting to observe that only one compound – luteolin-7-O-glucoside – was present in all six species. Four compounds were unique and were identified in only one species (fig. 3). Apigenin derivatives were found only in *S. aethiopsis*. Rutin – a potential antioxidant – was detected only in the common medicinal species – *S. officinalis*.

As shown in the bar chart above, two acids – caffeic and rosmarinic – were present in five of the six species. Only *Salvia nutans* lacks these acids. Instead, it contains its own two unique compounds – vicenin-2 and 6-hydroxyluteolin-5-glucoside.

It was observed that *S. verticillata* is most similar to *S. officinalis* in phenolic content; they share the presence of 9 compounds: apigenin, apigenin-7-glucoside, luteolin, luteolin-7-glucoside, catechin, chlorogenic acid, caffeic acid, rosmarinic acid, and salvianolic acid. Myha et al. (2020) revealed that the sum of phenolic compounds



a

[https://en.wikipedia.org/wiki/Salvia\\_aethiopsis](https://en.wikipedia.org/wiki/Salvia_aethiopsis)



b

[https://en.wikipedia.org/wiki/Salvia\\_nemorosa](https://en.wikipedia.org/wiki/Salvia_nemorosa)  
<https://www.inaturalist.org/photos/304085905>

**Fig. 1. *Salvia aethiopsis* (a) and *S. nemorosa* (b)**



a

[https://en.wikipedia.org/wiki/Salvia\\_verticillata](https://en.wikipedia.org/wiki/Salvia_verticillata)



b

[https://en.wikipedia.org/wiki/Salvia\\_austriaca](https://en.wikipedia.org/wiki/Salvia_austriaca)  
<https://www.inaturalist.org/photos/133349080>



c

[https://en.wikipedia.org/wiki/Salvia\\_nutans](https://en.wikipedia.org/wiki/Salvia_nutans)



d

[https://en.wikipedia.org/wiki/Salvia\\_officinalis](https://en.wikipedia.org/wiki/Salvia_officinalis)  
<https://www.inaturalist.org/photos/511369646>

**Fig. 2. *Salvia verticillata* (a), *S. austriaca* (b), *S. nutans* (c) and *S. officinalis* (d)**

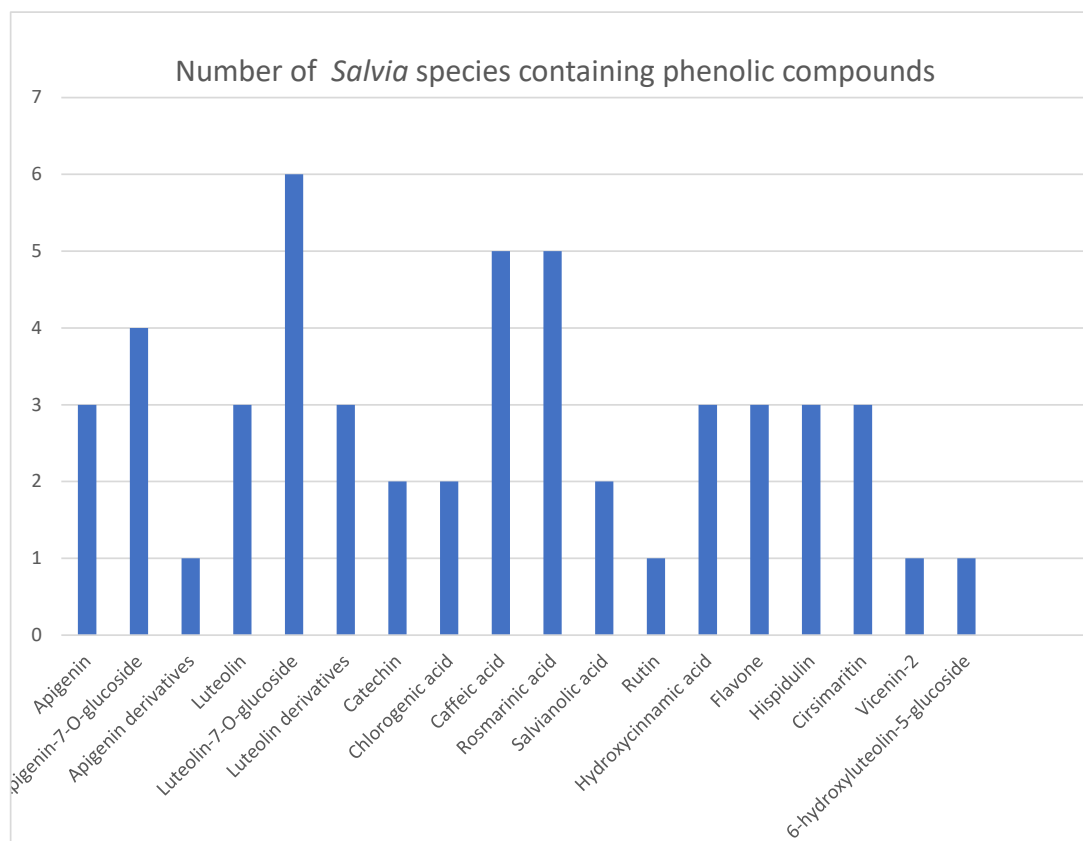


Fig. 3. Number of *Salvia* species containing phenolic compounds

in terms of gallic acid was even higher in *S. verticillata* ( $3,17 \pm 0,02$ ) than in *S. officinalis* ( $2,31 \pm 0,05$ ). Therefore, this species may potentially be used similarly to *S. officinalis* to produce medicinal products. However, this issue needs to be studied in more detail.

Overall, the polyphenolic contents of these species are shown in table 1.

As shown in table 1, *Salvia austriaca* contains a minimal number of polyphenolic compounds (only 4). The amounts of these substances in *Salvia nemorosa* and *Salvia nutans* are the same (8), while *Salvia verticillata* has a slightly higher amount of polyphenolic compounds (9). *Salvia officinalis* – the primary medicinal species – has ten polyphenolic compounds, and finally, *Salvia aethiopsis* contains 11 compounds.

*Salvia nutans* contains two distinctive compounds (vicenin-2 and 6-hydroxyluteolin-5-glucoside) that are not found in other species. Therefore, this species may be regarded as the most different from others.

In summary, we can state that the phenolic compounds of species in the genus *Salvia* are very similar and are probably due to shared genes. But this suggestion needs further investigation by geneticists. However, given the environmental conditions in the regions

where these species grow, they exhibit distinct characteristics.

**Conclusions.** For the first time, the phenolic content of the leaves of five *Salvia* species native to the island of Khortica – *Salvia aethiopsis*, *Salvia nutans*, *Salvia austriaca*, *Salvia verticillata*, *Salvia nemorosa* – was compared with *Salvia officinalis*.

It was found that *Salvia verticillata* shows significant similarity in phenolic content to *S. officinalis*, which is why it can be used similarly for medicinal purposes. Four species have their own unique compounds. Only one compound – luteolin-7-O-glucoside – was found in all six species, and two compounds (caffeic and rosmarinic acids) were identified in five of the six species. Therefore, we can suggest that these acids are more common across *Salvia* species overall. The amount of the polyphenolic compounds in native for the Khortica Island species in comparison with the *S. officinalis* is different. In some cases, it is even bigger than in *S. officinalis* (for example, luteolin-7-O-glucoside or caffeic and rosmarinic acids). *Salvia austriaca* has the fewest phenolic compounds among these species, and *Salvia aethiopsis* has the most significant number.

Polyphenolic compounds of some *Salvia* species

№	Species	Polyphenolic compounds	Number of polyphenolic compounds	References
1	<i>Salvia aethiopsis</i>	apigenin, apigenin-7-O-glucoside, apigenin derivatives, luteolin-7-O-glucoside, luteolin derivatives, caffeic acid, rosmarinic acid, hydroxycinnamic acid, flavone, hispidulin, cirsimaritin	11	Afzal et al., 2025 Anagnostou et al., 2025 Bălășoiu et al., 2023 Bilginoğlu et al., 2025 Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Luca et al., 2023 Myha et al., 2021 Myha et al., 2020 Myha et al., 2019
2	<i>Salvia nemorosa</i>	luteolin-7-O-glucoside, luteolin derivatives, caffeic acid, rosmarinic acid, hydroxycinnamic acid, flavone, hispidulin, cirsimaritin	8	Afzal et al., 2025 Anagnostou et al., 2025 Bălășoiu et al., 2023 Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Luca et al., 2023 Moshari-Nasirkandi et al., 2024 Myha et al., 2021 Myha et al., 2020 Myha et al., 2019
3	<i>Salvia verticillata</i>	apigenin, apigenin-7-O-glucoside, luteolin, luteolin-7-O-glucoside, catechin, chlorogenic acid, caffeic acid, rosmarinic acid, salvianolic acid	9	Afzal et al., 2025 Anagnostou et al., 2025 Bălășoiu et al., 2023 Emre et al., 2021 Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Luca et al., 2023 Mervić et al., 2022 Myha et al., 2021 Myha et al., 2020 Myha et al., 2019 Stanković et al., 2020 Stavropoulou et al., 2024
4	<i>Salvia austriaca</i>	luteolin-7-O-glucoside, caffeic acid, rosmarinic acid, hydroxycinnamic acid	4	Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Myha et al., 2021 Myha et al., 2020 Myha et al., 2019
5	<i>Salvia nutans</i>	apigenin-7-O-glucoside, luteolin, luteolin-7-O-glucoside, luteolin derivatives, flavone, hispidulin, cirsimaritin, vicenin-2, 6-hydroxyluteolin-5-glucoside.	8	Afzal et al., 2025 Anagnostou et al., 2025 Hanganu et al., 2019 Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Luca et al., 2023 Myha et al., 2021 Myha et al., 2020 Myha et al., 2019
6	<i>Salvia officinalis</i>	apigenin, apigenin-7-O-glucoside, luteolin, luteolin-7-O-glucoside, catechin, chlorogenic acid, caffeic acid, rosmarinic acid, salvianolic acid, rutin	10	Afzal et al., 2025 Akrimi et al., 2025 Anagnostou et al., 2025 Koshovyi, O. M., 2012a Koshovyi, O. M., 2012b Maleš et al., 2022 Mascoloti Sprea et al., 2022 Myha et al., 2021 Myha et al., 2020 Myha et al., 2019 Silva et al., 2023 Tsitsigianni et al., 2023

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Дата першого надходження статті до видання: 12.10.2025

Дата прийняття статті до друку після рецензування: 14.02.2026

Дата публікації (оприлюднення) статті: 30.04.2026

Автор заявляє про відсутність конфлікту інтересів та участь інших авторів у написанні статті.

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