# AGRICULTURAL SCIENCES

## BIOLOGICALLY ACTIVE COMPOUNDS IN *HYSSOPUS OFFICINALIS*: COMPARATIVE ANALYSIS OF THREE INTRODUCED VARIETIES UNDER THE CONDITIONS OF ARMENIA

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**Abstract**

This research examines the diversity of biologically active compounds in three introduced varieties of *Hyssopus officinalis* L. grown under the valley conditions of Armenia. Measurements of total phenolic content (TPC), total flavonoid content (TFC), and phenolic acid levels were carried out to assess their potential for nutritional and functional applications. The varieties exhibited significant variability in the accumulation of these compounds, suggesting the combined influence of genetic traits and local environmental factors. This study offers a novel perspective, as most prior investigations have concentrated on wild populations of *H. officinalis*, with little information available regarding cultivated, introduced varieties. The outcomes highlight the relevance of expanding plant genetic resources to strengthen agrobiodiversity and to support the development of climate-adapted, functional crops. By demonstrating the suitability of *H. officinalis* cultivars for cultivation under the arid conditions of the Ararat Valley, the findings contribute to efforts aimed at improving food security and advancing the use of plants with health-promoting properties. Future investigations should further address the optimization of agronomic practices and the impact of environmental stressors on bioactive compound production.

**Keywords:** hyssop, bioactive compounds, functional food.

**Introduction.** Enhancing agrobiodiversity through both the conservation of traditional crops and the introduction of new plant species and varieties is essential for maintaining food and nutrition security under the challenges of climate change. This strategy contributes not only to the preservation of genetic resources but also to the diversification of agricultural systems and human diets. Aromatic and medicinal plants are particularly valuable in this regard due to their multifunctional applications and health benefits. *Hyssopus officinalis* L., commonly known as hyssop, is a perennial herb of the Lamiaceae family, traditionally cultivated for its aromatic, medicinal, and culinary properties. In addition to its essential oil content, hyssop is a significant source of bioactive compounds, which contribute to its antioxidant and health-promoting properties [9]. These attributes position hyssop as a promising candidate for incorporation into functional food and nutraceutical products.

To support efforts aimed at diversifying local agricultural production, three *H. officinalis* varieties were assessed under the conditions of the Ararat Valley in Armenia. This study focuses on evaluating their total phenolic content, total flavonoid content, and phenolic acid profiles, highlighting their potential role in enhancing the nutritional value of food products and strengthening agrobiodiversity. Although the phytochemical composition of wild populations of *Hyssopus officinalis* has been relatively well studied, there is a lack of information regarding introduced cultivars. In particular, varieties cultivated under the valley conditions of Armenia have not yet been characterized for their content of biologically active compounds. This study provides the first comparative evaluation of three introduced varieties, offering new insights into their phytochemical profiles and adaptation potential under local environmental conditions.

**Materials and Methods.** Three cultivars of Hyssopus officinalis L. (Accord, Inej, and Lazur') were cultivated on the experimental plot of the Scientific Centre of Vegetable and Industrial Crops (SCVIC) located in the Ararat Valley of Armenia. Cultivation practices appropriate for medicinal and aromatic species were followed to ensure uniformity and optimal growth. The accessions of the Genebank of the SCVIC were used for the conducted research [3].

Leaves and flowering tops were collected during full bloom, dried at ambient temperature in the shade, ground into a fine powder, and stored in dark containers until analysis.

For all analyses, 0.5 g of powdered plant material was extracted with 25 mL of 70% ethanol by continuous shaking at room temperature for 24 hours. Extracts were filtered through Whatman No. 1 filter paper.

Total phenolic content (TPC) was measured by the Folin–Ciocalteu colorimetric assay [7]. 0.5 mL of plant extract was reacted with 2.5 mL of 10% Folin–Ciocalteu reagent and 2 mL of 7.5% sodium carbonate. After

30 minutes of incubation in the dark at room temperature, absorbance was recorded at 765 nm with a Cary 60 UV-Vis spectrophotometer. TPC results were expressed as milligrams of gallic acid equivalents (mg GAE) per gram of dry weight.

Total flavonoid content (TFC) was determined using the aluminum chloride method [8]. 0.5 mL of extract was mixed with 0.5 mL of 2% aluminum chloride. After 30 minutes, absorbance was read at 415 nm. TFC was calculated as milligrams of quercetin equivalents (mg QE) per gram of dry weight (DW).

Phenolic acids were quantified using Arnow's spectrophotometric method [5]. 1 mL of the extract was sequentially mixed with 1 mL of 0.5 M HCl, 1 mL of Arnow's reagent, and 1 mL of 1 M NaOH. Absorbance was measured at 490 nm. Results were expressed as milligrams of caffeic acid equivalents (mg CAE) per gram of dry weight.

All measurements were carried out in triplicate. Data are presented as mean ± standard deviation (SD).

**Results.** The total phenolic content (TPC) of *Hyssopus officinalis* varieties demonstrated noticeable variation (Figure 1). Among the three varieties, Accord exhibited the highest TPC value - 51.4 mg GAE/g DW, followed by Lazur' (49.7 mg GAE/g DW) and Inej (48.1 mg GAE/g DW). Phenolic compounds are recognized for their strong antioxidant properties, which contribute to the plant's potential for health-promoting functional food applications. The higher TPC observed in Accord suggests a greater capacity for neutralizing free radicals and preventing oxidative stress-related disorders.

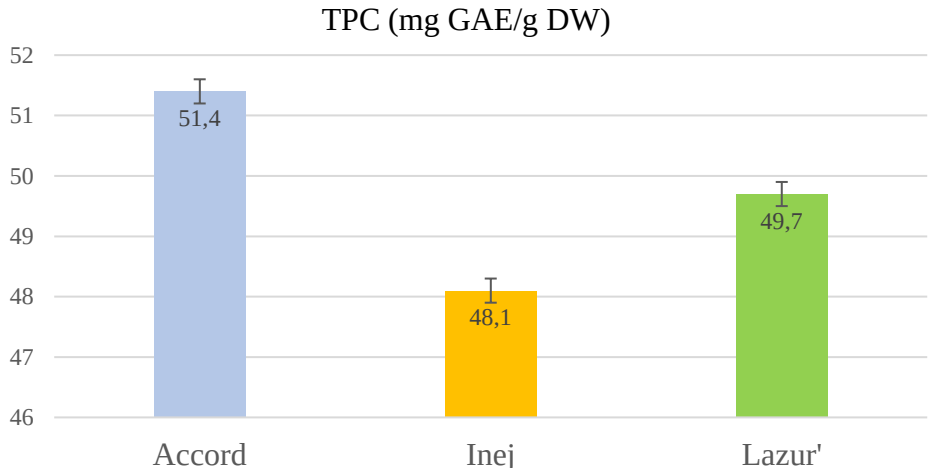



*Figure 1. Total phenolic content in Hyssopus officinalis varieties*

The total flavonoid content (TFC) results revealed a similar pattern. Accord presented the highest TFC (29.8 mg QE/g DW), while Inej and Lazur' displayed slightly lower values - 27.5 and 28.1 mg QE/g DW, respectively (Figure 2). Flavonoids are key contributors to antioxidant, anti-inflammatory, and antimicrobial activities. The relatively high flavonoid content across all varieties, especially in Accord, indicates a valuable potential for the development of nutraceuticals and functional foods based on *H. officinalis.*

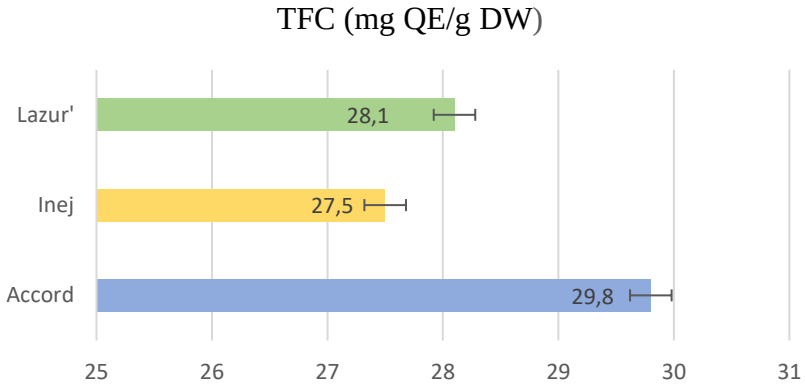



*Figure 2. Total flavonoid content in Hyssopus officinalis varieties*

In terms of phenolic acids, the varieties also showed moderate differences. Accord again had the highest content (34.2 mg CAE/g DW), followed with minor difference by Inej (33.0 mg CAE/g DW) and Lazur' (31.5 mg CAE/g DW) (Figure 3). Phenolic acids, such as caffeic and rosmarinic acids commonly found in *H. officinalis*, are associated with antioxidant, antimicrobial, and anti-inflammatory effects. The relatively elevated phenolic acid levels suggest that all three varieties can serve as promising sources of bioactive compounds, although the Accord and Inej varieties demonstrated the most favourable profile.

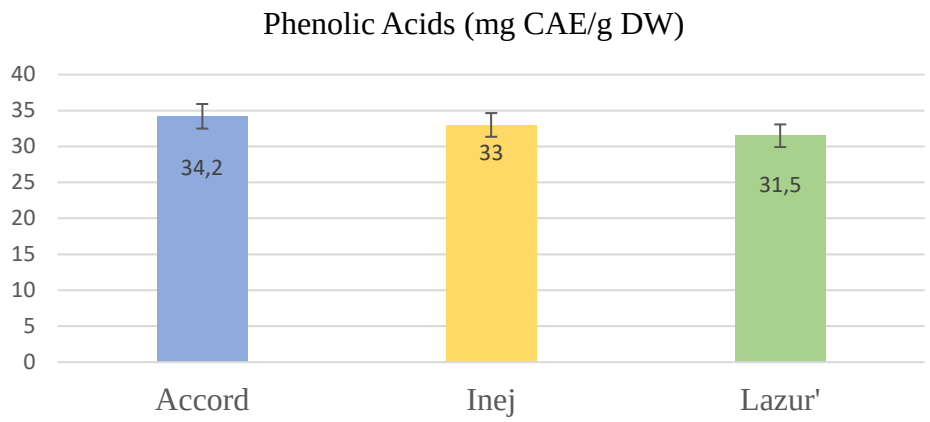



*Figure 2. Total phenolic acids content in Hyssopus officinalis varieties*

**Discussion.** The comparative analysis of three *Hyssopus officinalis* introduced varieties cultivated in the Ararat Valley revealed moderate variation in total phenolic content (TPC), total flavonoid content (TFC), and phenolic acid levels. Among the studied cultivars, 'Accord' consistently exhibited the highest content of all three compound groups, followed by 'Lazur'' and 'Inej'. These results are consistent with data reported in the literature for *H. officinalis*, where TPC values typically range between 45–60 mg GAE/g DW, and TFC and phenolic acid levels are reported in the range of 25–40 mg/g DW depending on variety and growing conditions [2].

The differences observed among the cultivars can be attributed to both genotypic variation and the environmental conditions of the Ararat Valley. This region is marked by high solar radiation, low precipitation, and extended dry periods during the growing season, conditions that are known to influence the biosynthesis of secondary metabolites. Previous studies have shown that phenolic and flavonoid production may be stimulated under moderate drought and strong UV exposure, acting as protective compounds that help mitigate oxidative stress [4, 1]. At the same time, excessive heat or prolonged stress can impair biosynthetic activity, potentially leading to reduced accumulation of these compounds [6].

In this context, the relatively high levels of phenolic compounds observed in the 'Accord' cultivar suggest good adaptability to the local environmental stressors and a potentially more robust biochemical response. The slightly lower values recorded for 'Inej' may indicate a less favorable reaction to climatic conditions, though still within a range suitable for functional and medicinal uses.

Given the increasing interest in aromatic and medicinal plants for use in health-promoting food products, the biochemical profile of *H. officinalis* under Ararat Valley conditions highlights its potential for further development. The observed levels of bioactive compounds support its suitability not only as a traditional herbal remedy but also as a valuable contributor to functional food innovation.

**Conclusion.** This research emphasizes the potential of *Hyssopus officinalis* varieties as rich sources of biologically active compounds, suitable for functional food development. The cultivars demonstrated notable differences in total phenolic content (TPC), total flavonoid content (TFC), and phenolic acid levels. The specific environmental conditions of the Ararat Valley — characterized by high temperatures and limited rainfall — appear to influence the biosynthesis of these compounds, with moderate drought stress and strong solar radiation likely enhancing their accumulation in certain varieties. The findings highlight the critical role of both genetic diversity and environmental factors in determining the phytochemical composition of plants. Among the studied varieties, Accord stood out with particularly promising levels of bioactive substances, suggesting its potential for further cultivation and breeding efforts in the region. These results support ongoing initiatives to broaden agrobiodiversity through the introduction of new plant species and varieties, fostering agricultural systems that are both resilient to climate change and beneficial to human health. Future research should aim to refine cultivation techniques, monitor seasonal variations in bioactive compound production, and deepen the understanding of how environmental stresses affect plant metabolism over time.

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