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Botanical and Morphological Characterization of Elderberry (Sambucus ebulus L.) Distributed in the Adjara–Guria Ecosystems and Comparative Analysis of the Phytochemical and Pharmacological Potential of Its Leaves

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ABSTRACT

The aim of the study was to investigate the botanical and morphological characteristics, phytochemical profile, and multi-element composition of the leaves of dwarf elder (*Sambucus ebulus* L.) distributed in the Adjara–Guria ecosystems, and to comparatively assess their functional and pharmacological potential. The research materials consisted of elder leaves collected from the villages of Charnali, Tkhilnari, and Dzimiti.

The study included the determination of extractive substances, tannins, catechins, total acidity, vitamin C, pectic substances, and total ash content. In addition, the contents of macroelements, microelements, and toxic elements were analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES).

According to the research results, samples collected from Tkhilnari were distinguished by high contents of extractive substances and soluble pectin, while the Charnali samples showed elevated levels of catechins and total pectin. The Dzimiti samples were characterized by high concentrations of tannins, mineral substances, iron, calcium, and magnesium. The concentrations of toxic elements were low in all samples and did not exceed permissible limits, indicating

the ecological safety of the plant material.

The findings demonstrated that the ecological, soil, and climatic conditions of different locations significantly influence the chemical composition and biological activity of *Sambucus ebulus* L. leaves. Elder leaves represent an important source of biologically active compounds and a promising raw material for the production of functional foods, phytopharmaceuticals, and therapeutic-preventive products. Among the studied samples, those collected from Dzimiti exhibited the highest functional and pharmacological value due to their richness in both mineral constituents and pharmacologically active compounds.

KEYWORDS: Sambucus ebulus L., phytochemical analysis, morphology, pharmacological potential, quality

RELEVANCE OF THE STUDY

Black elder (*Sambucus ebulus* L.) is an important medicinal and edible plant rich in biologically active compounds, vitamins, antioxidants, flavonoids, and pectins, which determine its wide application in both the pharmaceutical and food industries. In traditional medicine, all parts of the plant are used, including fruits, flowers, leaves, and roots. Approximately 40 species of elder are known worldwide, of which two are distributed in Georgia – *Sambucus ebulus* (dwarf elder) and black elder [1, 2]. Elder is used in the production of functional foods, dietary supplements, and natural colorants. In the context of changing climatic and ecological conditions, elder is of particular interest as an adaptable and widely distributed plant species. Therefore, its study, phytochemical analysis, and evaluation of pharmacological potential are of both scientific and practical importance.

Research Objective

The aim of the study was to determine the qualitative characteristics of *Sambucus ebulus* L. leaves collected from selected locations in Adjara and Guria, and to comparatively evaluate their pharmacological potential based on experimental data.

Research Objects

The study objects were *Sambucus ebulus* L. leaves collected from **Charnali** and **Tkhilnari villages** (Khelvachauri Municipality) and **Dzimiti village** (Ozurgeti Municipality), Georgia.

Methods Used in the Study

The following methods were applied: descriptive analysis [3, 4], gravimetric methods, titrimetric methods [5, 6, 7, 8], and inductively coupled plasma atomic emission spectrometry (ICP-AES) [9].

Material and Technical Base

The research was conducted using the facilities and laboratory infrastructure of the **Institute of Agrarian and Membrane Technologies of Batumi Shota Rustaveli State University (BSU)**.

I. MAIN PART
I.1. Botanical and Morphological Description of Sambucus ebulus L.

Sambucus ebulus L. – scientific classification: Kingdom: Plantae; Phylum/Division: Magnoliophyta (flowering plants); Class: Magnoliopsida (dicotyledons); Order: Dipsacales; Family: Adoxaceae; Genus: *Sambucus*; Species: *Sambucus ebulus* L. It is a perennial herbaceous plant with a height of 0.5–2 m. The stem is herbaceous and erect. Leaves are odd-pinnate, consisting of 7–11 leaflets, which are lanceolate or elongated-ovate in shape. The inflorescence is an umbel, with flowers that are white or pinkish-white in color. The flowering period extends from June to August. The fruit type is a berry, black or dark purple in color, arranged in clusters. Ripening occurs from late summer to early autumn. The species is found in forest edges and roadside slopes, preferring moist soils. It is distributed in Europe and Western Asia, and in Georgia it is mainly widespread in the western regions [1].

I.2. Medicinal Properties and Economic Importance of Sambucus ebulus L.

Sambucus ebulus L. is rich in phenolic compounds and flavonoids and also contains triterpenes, organic acids, and cyanogenic glycosides, which determine its antioxidant, anti-inflammatory, and various biological activities [2]. The medicinal properties of elder include anti-inflammatory action, antimicrobial activity, antioxidant effects, antipyretic and diaphoretic properties, and diuretic action. It is also used in the treatment of joint and skin diseases. In addition to its medicinal value, *Sambucus ebulus* L. has ecological and economic importance. It contributes to soil stabilization on slopes and helps reduce erosion. It is also used as a bioindicator species for assessing soil moisture conditions.

II. SAMBUCUS EBULUS L. PHYTOCHEMICAL ANALYSIS
II.1. Main Qualitative Characteristics of Elder Leaves

The highest content of extractive substances in elder leaves was recorded in the Tkhilnari location (30.0%), while the lowest value was observed in Charnali (20.4%) (Table 1). The content of tannins was highest in Dzimiti (6.9%) and lowest again in Charnali (4.5%). The content of catechins was highest in Charnali (2.6%) and lowest in Tkhilnari (2.1%). The total acidity index was identical across all three locations (4.2%). The content of vitamin C was highest in Charnali and Tkhilnari (59%), and comparatively lower in Dzimiti (53%). Overall, elder leaves from Charnali and Tkhilnari are richer in ascorbic acid (vitamin C) compared to those from Dzimiti.

Table 1. Qualitative Characteristics (%)

Location	Extractive substances	Tannins	Catechins	Total acidity	Vitamin C
Charnali	20.4	4.5	2.6	4.2	59
Tkhilnari	30.0	5.8	2.1	4.2	59
Dzimiti	29.0	6.9	2.3	4.2	53

II.2. Pectic Substances and Total Ash Content in Elder Leaves

The highest content of total ash was recorded in Dzimiti (1.8%), while the lowest value was observed in Tkhilnari (0.6%). The highest content of soluble pectin was found in Tkhilnari (10.89%), whereas the lowest was recorded in Dzimiti (9.8%). The amount of insoluble pectin was maximal in Charnali (5.99%) and minimal in Dzimiti (2.7%). Leaves from Charnali and Tkhilnari are therefore richer in pectic substances, which increases their functional and pharmacological significance (Table 2). Overall, Charnali is characterized by a higher content of total and insoluble pectin, **Tkhilnari** by the highest soluble pectin content, while Dzimiti shows the highest level of mineral substances (total ash).

Table 2. Ash and Pectin Content in Elder Leaves (%)

Location	Ash (%)	Soluble pectin	Insoluble pectin	Total pectin
Charnali	0.8	10.4	5.99	16.39
Tkhilnari	0.6	10.89	5.2	16.09
Dzimiti	1.8	9.8	2.7	12.5

III. MULTI-ELEMENT ANALYSIS OF ELDER LEAVES

The highest content of potassium was recorded in elder leaves collected from Charnali Village, while the lowest value was observed in Tkhilnari Village (Table 3). The content of calcium was maximal in Dzimiti, and minimal in Charnali. The highest concentration of magnesium was also found in Dzimiti (5694 mg/kg). The highest value of sodium was observed in Tkhilnari (698 mg/kg), while the lowest was recorded in Dzimiti (582 mg/kg). The content of phosphorus was highest in Tkhilnari, and lowest in Charnali.

Table 3. Macroelement Content (mg/kg)

Location	K	Ca	Mg	Na	P
Charnali	10987	1800	3237	600	1930
Tkhilnari	1210	2740	5610	698	2890
Dzimiti	9280	3850	5694	582	2640

The highest concentration of **iron** was recorded in leaves collected from **Dzimiti (345.6 mg/kg),** which significantly exceeds the values observed in **Charnali (109.8 mg/kg)** and **Tkhilnari (130.0 mg/kg)** (Table 4). The content of **silicon** was also maximal in Dzimiti, while the lowest value was found in Charnali. The highest **boron** content was observed in Charnali, and the lowest in Tkhilnari. The **aluminum** concentration was highest in Tkhilnari and lowest in Dzimiti, which may be associated with soil acidity and local geochemical conditions. The concentration of **cobalt** was low in all samples. The maximum **copper** content was recorded in Tkhilnari, while the minimum was found in Dzimiti. The **manganese** content was highest in Tkhilnari and relatively lower in Dzimiti. The highest concentration of **nickel** was observed in Dzimiti (0.912 mg/kg), while the highest **zinc** content was found in Charnali (16.4 mg/kg).

Table 4. Microelement Content (mg/kg)

Location	Fe	Si	B	Al	Co	Cu	Mn	Ni	Zn
Charnali	109.8	89.3 H	27.0	429	0.0730 L	6.19	60.30	0.408	16.4
Tkhilnari	130.0	163 H	23.8	538	0.0637 L	7.89	90.63	0.715	15.8
Dzimiti	345.6	504 H	25.2	368	0.285 L	4.92	57.21	0.912	12.6

The content of toxic elements in elder leaves is relatively low and does not reach critical levels. However, samples from **Dzimiti** are characterized by comparatively lower concentrations of toxic elements than those from the other locations, which indicates their ecological advantage.

Table 5. Toxic Element Content (mg/kg)

Location	As	Ba	Cd	Cr	Mo	Pb	Se
Charnali	0.266 L	70.5	0.0016 L	0.216	0.913	0.353 L	0.0218 L
Tkhilnari	0.259 L	65.4	0.0236 L	0.377	1.32	0.401 L	-
Dzimiti	0.138 L	31.2	-	0.16	1.1	0.259 L	0.0691 L

CONCLUSION

Elder leaves distributed within the Adjara–Guria ecosystems represent an important source of biologically active compounds and are characterized by diverse functional and pharmacological properties. Samples collected from different locations differ in both organic and mineral composition, which determines their specific biological activity and practical significance. When evaluating the diversity of biologically active substances, antioxidant potential, mineral composition, and ecological safety, the highest functional and pharmacological value can be attributed to the samples from Dzimiti Village.

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