

# Ethnobotanical Characteristics and Identification of Volatile Components of Endemic *Sideritis* spp. Taxa in the Alanya Region

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Between 2024 and 2026, a 25-question survey was conducted to assess the demographic and socio-economic characteristics of the local population in the Alanya region, as well as their purposes for consuming non-wood forest plant products, consumption timing, frequency, procurement methods, perceived benefits and side effects of the consumed products, and the factors influencing consumption habits. Three endemic species *Sideritis arguta* Boiss & Heldr, *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor were included in the evaluation. Ethnobotanical analysis revealed that these species are most consumed for general health, therapeutic, and recreational purposes. For the first time in Turkey, this study highlighted the importance of informing the public about the benefits of these three species and emphasized that harvesting should be carried out consciously after seed maturation to prevent the depletion of these taxa. Solid-phase micro-extraction (SPME) analysis indicated that the highest volatile compound concentrations in *Sideritis arguta* Boiss & Heldr were  $\alpha$ -pinene (25.7%), germacrene-D (8.4%), and *trans*-caryophyllene (6.4%). In *Sideritis argyrea* P.H. Davis, the main compounds were  $\alpha$ -pinene (11.8%), germacrene-D (9.2%), and  $\beta$ -myrcene (4.5%), whereas in *Sideritis albiflora* Hub. Mor, the primary compounds were  $\alpha$ -pinene (12.9%), *germacrene*-D (7.8%), and 1,8-cineole (5.6%). Analysis of volatile compound classes revealed a high proportion of sesquiterpene hydrocarbons across species.

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## INTRODUCTION

The flora of Türkiye comprises approximately 11,466 plant taxa, of which about 3,649 are endemic (Güner 2012). Approximately 500 plant species are used for medicinal purposes in Türkiye, and nearly 200 of these species are considered to have export potential (Faydaoglu and Sürücüoglu 2011). The diversity of medicinal and aromatic plant species naturally occurring in Türkiye is particularly remarkable (Sarıkaya and İlhan 2025). The World Health Organization (WHO) defined medicinal plants in 1980 as plant species that, through one or more of their organs, possess therapeutic or disease-preventive properties, or that can serve as precursors for chemical pharmaceutical synthesis (Yıldırım 2004). The history of medicinal plants is known to be as old as human history itself. Moreover, medicinal and aromatic plants are used for a wide range of purposes, including as teas, spices, seasonings, cosmetic ingredients, and sources of essential oils (Başer 2000; Başer 2007; Zhang and Wang 2008; Turkmenoglu 2025). Medicinal plants, which constitute an

integral component of terrestrial biodiversity, are adversely affected by ongoing changes in climate and land use; however, comprehensive studies addressing the risks posed by extinction to medicinal biodiversity remain highly insufficient (Theodoridis *et al.* 2024). In particular, the Lamiaceae family includes widely known medicinal and aromatic plants that produce essential oils (Chrysargyris *et al.* 2023).

Ethnobotany, in its broad sense, refers to the relationships between humans and plants within the evolutionary process. In a narrower sense, it can be summarized as the knowledge of how local communities utilize plants found in their surroundings to meet various needs, as well as the impacts of these practices on the plants (Yıldırım 2004). Türkiye, which has hosted numerous civilizations, represents a highly valuable research area for ethnobotanical studies due to its rich cultural and floristic diversity. Ethnobotanical studies are particularly important for transmitting the knowledge of interactions between local communities and plants to future generations. The emergence of the term “ethnobotany” primarily stems from humans’ efforts to combat diseases by observing the natural fauna and flora in their surroundings, thereby acquiring new knowledge and experiences that enabled them to utilize plants beyond their inherited knowledge and personal experience (Vural 2008; Baydar 2009; Kendir *et al.* 2010).

Türkiye represents a potential resource in the field of medicinal plants because of its rich flora and the knowledge associated with traditional folk medicine (Hudson *et al.* 2000). In particular, the region of Anatolia possesses a rich heritage in the medicinal use of plants, which has been revealed through ethnobotanical studies about the experiences and knowledge of people who, by trial and error, learned the therapeutic properties of local plants and transmitted this information to subsequent generations over many years (Ertem 1987; Alpınar 2010; Yücel 2010). Furthermore, today Antalya has become Turkey’s most important center for cut flower production and export, catering to both domestic and international markets. Meanwhile, in the Marmara Region, Yalova; in the Aegean Region, İzmir; and in the Mediterranean Region, Antalya and Isparta serve as the main hubs of cut flower cultivation (Türkmenoğlu 2016).

Medical folklore, which emerged from centuries of accumulated experience, began to lose its significance with the development of the synthetic pharmaceutical industry. However, in recent years, the emergence of adverse side effects associated with synthetic drugs has brought medicinal plants back into focus. Today, treatment with plants, known as “phytotherapy,” has become a recognized scientific discipline. Medicinal plants, often referred to as the “green wave” or “green medicine,” are now widely used worldwide, particularly in Europe and the Americas (Sarer 1991; Saya *et al.* 2001). Notably, it was determined that some physical and chemical changes occurred in the flower during the floral development period of the Halfeti black rose (Erbaş and Mutlucan 2025).

Anatolia’s long history of hosting numerous cultures has led to the development of a rich ethnobotanical cultural heritage, and the region has agricultural biodiversity. Many local plants have been used for centuries for various purposes, including food, human and animal medicine, natural dyes, and aesthetic applications. In this regard, such uses of plants in Anatolia are characterized by their originality (Polat 2010). The analysis may be useful for future research (Koşkan *et al.* 2025). In *Sideritis* spp., antimicrobial and antioxidant effects have been the most extensively studied pharmacological activities (Chrysargyris *et al.* 2023). The solid-phase microextraction (SPME) technique significantly reduces processing time and costs due to its solvent-free nature (Dönmez 2024). The increasing use of *Sideritis* spp in cosmetics, fragrances, and medicine has expanded the market size in Türkiye, leading to problems of overharvesting. Consequently, unregulated collection and

grazing activities have caused significant declines in the natural populations of these species (Turkmenoglu 2025). *Sideritis scardica* is traditionally consumed as mountain tea in the Balkans to strengthen the body and improve mood. Several reports indicate that it has beneficial effects on the digestive system and may support weight loss and the prevention of insulin resistance (Żyżelewicz *et al.* 2020).

This study assessed the demographic and socioeconomic characteristics of the local population in Alanya (Türkiye) and evaluated the consumption patterns of non-timber plant products, primarily medicinal plants, including their purposes, timing, frequency, procurement methods, perceived benefits and side effects, as well as the factors influencing consumption habits. It was determined that the high costs and potential side effects of synthetic drugs have led to a continuous increase in demand for medicinal plants. Endemic *Sideritis* spp taxa used in Alanya across various industries including food, medicine, pharmacy, and cosmetics were identified, and their volatile components were analyzed. The identified *Sideritis* spp taxa were found to be environmentally friendly natural antioxidants suitable for medicinal, cosmetic, and food applications when managed with sustainable approaches. Three notable species are *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H.Davis, and *Sideritis albiflora* Hub. Moreover, they represent species that have not been previously studied, highlighting the significance of this research as the first investigation of these taxa in Türkiye.

## EXPERIMENTAL

### Materials

The study materials consisted of three *Sideritis* spp. specimens collected from the Alanya District, Antalya Province, Türkiye, between 2024 and 2026. The *Sideritis* spp. specimens were collected during their flowering period. The *Sideritis* spp. specimens were collected from areas located between 32° 18' 76"-36° 54' 75", 32° 18' 67"-36° 54' 33", and 39° 03' 79"-40° 55' 18" north latitudes, at an altitude of 1,320 m above sea level. Sampling plots measuring 20 × 20 m were established. In addition, care was taken to select specimens that had reached a certain level of maturity, were healthy, represented different growth habitats, and were as unaffected by human activity as possible. Examination of the soil characteristics in the Alanya District, which constitutes the study area, revealed that the dominant soil type is Red Mediterranean (Terra Rossa) soil. Between the Red Mediterranean Soils and Regosols that extend across the Taurus Belt, there are also Brown Forest Soils developing northwestward from Alanya. The study area includes the Western Taurus Mountains to the north of Alanya, with elevations exceeding 1,000 m. To the south, Alanya is bordered by the Mediterranean Sea, to the east by Gazipaşa (Antalya), and to the west by Manavgat (Antalya).

The region consists of the Dim and Alara Valleys, named after Koçdavut Pass, Kuşyuvası, Yelköprü, and the Dim and Alara rivers in Central Anatolia. The Alanya district is dominated by a Mediterranean climate and is morphologically composed of a coastal plain and mountainous terrain to the north. The coastal plain, which rises to 300 m along the seashore, is formed from pre-Miocene schists, while the mountains to the north reach elevations of up to 1,300 m, forming part of the Taurus range. In the northern region of Alanya, limestone and dolomite dominate, and flash floods have carved deep gorges, creating extensive surface areas. The terrain is arid and rocky, covered with pine forests and pastures, displaying the typical arrangement of karstic morphology. Pine trees,

particularly Turkish red pine (*Pinus brutia*), are the predominant forest species in the region. Alanya exhibits the characteristic features of a Mediterranean climate, with hot and dry summers and mild, rainy winters. During the winter season, prevailing winds blow from the southwest in the southern half of the Mediterranean Basin and from the northeast in the northern half. Along the Mediterranean coasts, winter is generally marked by alternating periods of rainfall, wind, and mild temperatures. During the summer months, Alanya is dominated by hot and dry conditions, which are characteristic of a Mediterranean climate. Analysis of the 20-year monthly and annual average temperatures in Alanya shows an average of 29.8 °C in August and 12.5 °C in January, resulting in an annual mean temperature of 21.1 °C (Yıldırım 2021).

## Methods

This study was conducted in two phases. In the first phase, taxa were collected from their identified distribution areas between 2024 and 2026, following a fieldwork schedule and throughout their flowering period. During the flowering period in June-July between 2024 and 2026, leaf and flower samples of the species were collected from their natural habitats. The collected samples were placed in paper bags and transported to the laboratory on the same day, without delay or exposure to sunlight. The samples were air-dried at room temperature (25 °C) until they reached a constant weight.

The volatile constituents of the flowering samples were analyzed using headspace solid-phase microextraction (HS-SPME) combined with gas chromatography-mass spectrometry (GC-MS). According to the SPME procedure, about 2 g of leaf-flower sample from each specimen were placed into 10 mL vials, sealed with a silicone cap, and incubated at 60 °C for 30 min. To adsorb the volatile compounds, an SPME device equipped with a 75 µm Carboxen/ Polydimethylsiloxane (CAR/PDMS) coated fiber was exposed to the headspace and directly injected into the capillary column of a Shimadzu 2010 Plus GC-MS system. The procedure was repeated three times, and the accuracy of the results was compared with averages calculated to obtain the final data. The instrument, operating in EI mode (70 eV), was coupled to a mass-selective detector of the same brand. Helium was used as the carrier gas at a flow rate of 1.61 mL/min. The volatile components were identified using the Wiley, NIST Tutor, and FFNSC libraries. In the second phase of the study, a survey was conducted between 2024 and 2026. The survey phase of the study was administered to a total of 100 participants in Alanya, Türkiye. The study employed a questionnaire developed by Korkmaz *et al.* (2011), consisting of 25 questions. The questions and response options included in the questionnaire were designed to obtain information on the following topics: (1) Demographic and socioeconomic characteristics of consumers, (2) Purposes of consuming non-timber plant products, primarily medicinal plants, (3) Timing of consumption, (4) Frequency of consumption, (5) Methods of procurement, (6) Perceived benefits and side effects of the consumed plant products, (7) Factors influencing the formation of consumption habits, and (8) Evaluations regarding points of sale. During the survey, participants were encouraged to complete the questionnaires independently to ensure that their responses were not influenced by external factors. The completed questionnaires were analyzed by converting the numerical values of the responses into percentages. During the ethnobotanical studies, field excursions with the local population were conducted, and identified plant specimens were shown to the community while asking questions.

## Statistical Analysis

Statistical analyses were performed using the Minitab 19 software package. Cluster analysis was conducted, considering only components without missing data, to identify the most similar or most dissimilar components. In addition, principal component analysis (PCA) was applied, again using only components without missing data, to determine the components with the highest contribution to the total variance.

## RESULTS AND DISCUSSION

In this study, a total of three endemic species belonging to the Lamiaceae family *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor were identified and evaluated. A database was established for these plant taxa, including their scientific names, families, the parts used as non-timber forest products, regional applications, identification of endemic species, and contributions from the local population (Table 1). Among the survey participants in Alanya, 56.5% were male and 43.5% were female. Most respondents were in the 46 to 65 age group. Most participants had completed high school or university education. The income levels of the respondents varied widely, with the majority falling into the middle- to high-income groups. Regarding occupational groups, 12.5% of participants were housewives, 32.5% were civil servants, 5% were workers, 10% were self-employed, 27.5% were farmers, and 12.5% were retired.

**Table 1.** The Obtained Taxa and their Characteristics

Scientific Name	Family	Local Name	Used Part	Traditional Use	Endemism	IUCN
<i>Sideritis arguta</i> Boiss & Heldr	Lamiaceae	Köyçayı	Leaves and shoots.	It is employed both in the management of the common cold and for recreational use.	Endemic	LR
<i>Sideritis argyrea</i> P.H. Davis	Lamiaceae	Boz eşek çayı	Leaves and shoots.	It is used for the treatment of the common cold.	Endemic	NE
<i>Sideritis albiflora</i> Hub. Mor.	Lamiaceae	Akçiçekçayı	Leaves and shoots.	It is used for immune support and for recreational purposes.	Endemic	NE

Hazard Classes: LR: Lower Risk, NE: Not Evaluated.

An analysis of the purposes for which consumers use the plant species revealed that their primary use is for general health (Fig. 1). In addition, the plants are also used for therapeutic and recreational purposes. Among the respondents, 80% reported using the plants for general health, 15% for therapeutic purposes, 3% for recreational purposes, and 2% for cosmetic use. Regarding consumption frequency, 2% of participants used these products daily, 12% weekly, 6% monthly, while 74% reported no regular usage. When considering continuous or alternating use, most consumers reported using the plants intermittently or rotating between different species. Among the respondents, 29% reported using the same plants continuously, 63% alternated between different species occasionally, and 8% used different plants. Consumers obtained these products from various sources: 73% from the wild, 10% from markets, and 17% from herbalists or supermarkets. This pattern reflects the long-standing tradition of collecting and using naturally growing species in the vicinity of villages. Most consumers reported consuming the products by

boiling and brewing (62%). In addition, 22% added them to food, 8% used them as oil, 2% as ointments, 1% extracted and used their juice, and 3% of respondents left the question unanswered. Regarding perceived benefits, 81% of consumers stated that they experienced positive effects, 8% reported slight benefits, 2% reported no benefits, and 9% were unsure. When asked about prior knowledge, 2% of respondents indicated that they sought information before using the plants, 14% did so for certain species, 37% stated “I know myself,” and 47% reported using the plants without any prior information. The percentage distribution of consumers’ opinions regarding the prices of purchased products was as follows: 38% considered them expensive, 47% considered them reasonable, 3% considered them cheap, and 12% had no opinion. The majority of consumers (76%) reported recommending the plants they use to close friends, while 24% did not. Regarding preferences, 72% of respondents preferred using plants in their natural form, 22% preferred ready-made products, and 6% used both forms. Concerning dosage knowledge, 57% of consumers stated that they learned it through use, 38% obtained information for certain plants only, and 5% reported having no information. Only 2% of consumers reported experiencing side effects from the plants they used. This finding is consistent with their level of knowledge regarding proper usage. Specifically, 59% reported no side effects, while 39% had heard of potential side effects but had not personally experienced any. All respondents were knowledgeable about whether the plants they used were toxic. The most influential factor in the formation of usage habits was advice from close acquaintances, reflecting the traditional transfer of knowledge from previous generations. Doctor recommendations and personal curiosity were also identified as contributing factors. The highest influence was observed through close acquaintances, accounting for 57% of the responses. The most frequently reported responses from our survey are presented below (Fig. 1).

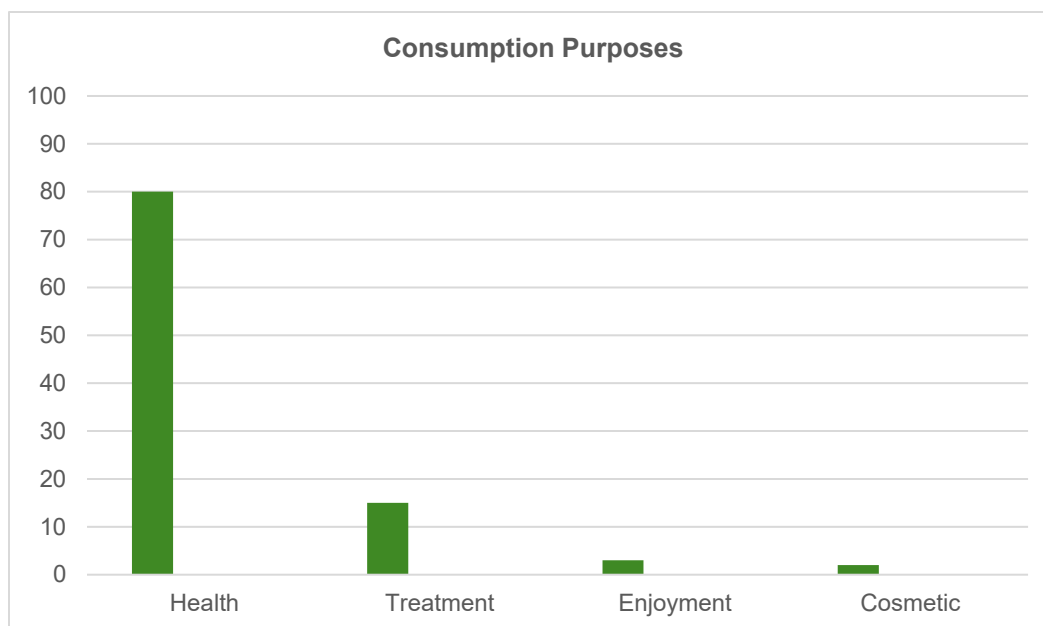


Fig. 1. Utilization purposes

The SPME analysis results showed that the highest concentrations of volatile compounds in *Sideritis arguta* Boiss. & Heldr. were  $\alpha$ -pinene (25.7%), germacrene-D (8.44%), and *trans*-caryophyllene (6.38%). In *Sideritis argyrea* P.H. Davis, the major

compounds were  $\alpha$ -pinene (11.8%), germacrene-D (9.16%), and  $\beta$ -myrcene (4.46%), while in *Sideritis albiflora* Hub. Mor, the predominant compounds were  $\alpha$ -pinene (12.9%), germacrene-D (7.79%), and 1,8-cineole (5.65%) (Table 2; Fig. 5).

**Table 2.** Essential Oil Composition of *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor

Compounds	LRI <sup>a</sup>	Class	Formula	<i>Sideritis arguta</i> Boiss & Heldr	<i>Sideritis argyrea</i> P.H. Davis	<i>Sideritis albiflora</i> Hub. Mor.
Tricyclene	927	MH	C <sub>10</sub> H <sub>16</sub>	0.07	-	0.18
$\alpha$ -Thujene	928	MH	C <sub>10</sub> H <sub>16</sub>	2.12	3.14	2.58
$\alpha$ -Pinene	933	MH	C <sub>10</sub> H <sub>16</sub>	25.72	11.80	12.94
$\beta$ -Myrcene	1011	MH	C <sub>10</sub> H <sub>16</sub>	4.32	4.46	4.71
( <i>E,E</i> )-2,4-Heptadienal	1023	AA I	C <sub>7</sub> H <sub>10</sub> O	-	0.26	-
$\alpha$ -Phellandrene	1024	MH	C <sub>10</sub> H <sub>16</sub>	-	1.98	3.82
<i>p</i> -Cymene	1049	MH	C <sub>10</sub> H <sub>14</sub>	0.11	0.18	-
Limonene	1050	MH	C <sub>10</sub> H <sub>16</sub>	3.88	3.42	1.62
1,8-Cineole	1056	OM	C <sub>10</sub> H <sub>18</sub> O	0.29	3.56	5.65
$\beta$ -Ocimene Y	1077	MH	C <sub>10</sub> H <sub>16</sub>	2.37	2.52	3.64
$\gamma$ -Terpinene	1088	MH	C <sub>10</sub> H <sub>16</sub>	2.65	0.22	-
( <i>E,E</i> )-3,5-Octadien-2-one	1092	AA I	C <sub>8</sub> H <sub>12</sub> O	0.44	0.68	-
<i>cis</i> -Farnesol	1102	OS	C <sub>15</sub> H <sub>26</sub> O	0.80	-	3.24
$\alpha$ -Terpinolene	1120	MH	C <sub>10</sub> H <sub>14</sub>	1.72	1.84	1.92
Linalool	1121	OM	C <sub>10</sub> H <sub>18</sub> O	-	1.18	2.14
Nealloocimene	1249	MH	C <sub>10</sub> H <sub>16</sub>	0.43	-	-
Carveol	1267	OC	C <sub>10</sub> H <sub>16</sub> O	0.98	0.96	0.60
4-Terpineol	1301	OM	C <sub>10</sub> H <sub>18</sub> O	0.24	-	-
Hex-3( <i>Z</i> )-enyl acetate	1306	FA	C <sub>8</sub> H <sub>14</sub> O <sub>2</sub>	-	0.12	0.28
Methyl salicylate	1312	OC	C <sub>8</sub> H <sub>9</sub> NO	0.56	-	-
$\alpha$ -Terpineol	1316	AA I	C <sub>9</sub> H <sub>18</sub> O	2.05	4.39	3.54
Decanal	1327	MA	C <sub>10</sub> H <sub>20</sub>	-	1.69	1.14
Hexyl 2-methylbutyrate	1357	SH	C <sub>6</sub> H <sub>12</sub>	0.80	0.12	0.64
Tridecane	1423	OC	C <sub>13</sub> H <sub>28</sub>	0.82	0.01	-
Carvacrol	1425	OM	C <sub>10</sub> H <sub>14</sub> O	-	0.38	0.60
Hexenyl-tiglate	1445	OC	C <sub>11</sub> H <sub>18</sub> O <sub>2</sub>	0.80	-	-
Bicycloelemene	1454	OC	C <sub>15</sub> H <sub>24</sub>	2.48	1.52	1.94
$\alpha$ -Cubebene	1469	OC	C <sub>15</sub> H <sub>24</sub>	2.18	2.01	3.58
Ylangene	1491	SH	C <sub>15</sub> H <sub>24</sub>	0.28	0.58	0.56
Copaene	1497	SH	C <sub>15</sub> H <sub>24</sub>	-	1.02	2.46
$\beta$ -Elemene	1512	SH	C <sub>15</sub> H <sub>24</sub>	3.08	1.58	2.16
Tricyclo[6.3.0.0(2,4)]undec-8-ene,3,3,7,11-Tetramethyl	1517	SH	C <sub>15</sub> H <sub>24</sub>	0.62	-	-
Tetradecane	1524	H	C <sub>14</sub> H <sub>30</sub>	-	0.48	0.40
$\alpha$ -Gurjunene	1530	SH	C <sub>15</sub> H <sub>24</sub>	3.01	4.03	1.48

Compounds	LRI <sup>a</sup>	Class	Formula	<i>Sideritis arguta</i> Boiss & Heldr	<i>Sideritis argyrea</i> P.H. Davis	<i>Sideritis albiflora</i> Hub. Mor.
<i>Trans</i> -Caryophyllene	1544	SH	C <sub>15</sub> H <sub>24</sub>	6.38	3.76	4.79
$\beta$ -Cubebene	1552	SH	C <sub>15</sub> H <sub>24</sub>	2.06	2.58	3.18
$\beta$ -Gurjunene	1557	SH	C <sub>15</sub> H <sub>24</sub>	-	0.48	-
$\alpha$ -Cedrol	1557	OS	C <sub>15</sub> H <sub>26</sub> O	-	-	0.14
Aromadendrene	1561	SH	C <sub>15</sub> H <sub>24</sub>	2.95	2.16	1.02
$\gamma$ -Gurjunene	1568	SH	C <sub>15</sub> H <sub>24</sub>	-	0.90	0.70
Cadina-1(6),4-diene<10- $\beta$ -H	1572	SH	C <sub>15</sub> H <sub>24</sub>	2.34	2.01	1.96
$\alpha$ -Humulene	1578	SH	C <sub>15</sub> H <sub>24</sub>	0.28	1.42	1.69
( <i>E</i> )- $\beta$ -Farnesene	1578	SH	C <sub>15</sub> H <sub>24</sub>	0.32	7.12	3.01
Germacrene-D	1592	SH	C <sub>15</sub> H <sub>24</sub>	8.44	9.16	7.79
$\delta$ -Cadinene	1596	SH	C <sub>15</sub> H <sub>24</sub>	4.74	3.98	2.89
$\gamma$ -Muurolene	1598	SH	C <sub>15</sub> H <sub>24</sub>	1.08	2.59	1.51
$\alpha$ -Amorphene	1598	SH	C <sub>15</sub> H <sub>24</sub>	2.94	1.92	1.01
$\gamma$ -Cadinene	1598	SH	C <sub>15</sub> H <sub>24</sub>	1.46	1.59	2.70
$\alpha$ -Bergamotene	1614	SH	C <sub>15</sub> H <sub>24</sub>	0.60	-	0.92
Bicyclogermacrene	1620	SH	C <sub>15</sub> H <sub>24</sub>	1.65	1.09	1.94
$\alpha$ -Muurolene	1623	SH	C <sub>15</sub> H <sub>24</sub>	-	0.71	0.84
( <i>E,E</i> )- $\alpha$ -Farnesene	1628	SH	C <sub>15</sub> H <sub>24</sub>	0.38	0.50	-
Cadina-1,4-diene	1656	SH	C <sub>15</sub> H <sub>24</sub>	-	1.24	1.32
$\alpha$ -Cadinene	1661	SH	C <sub>15</sub> H <sub>24</sub>	1.56	2.66	0.18
$\alpha$ -Calacorene	1666	OC	C <sub>15</sub> H <sub>20</sub>	-	-	0.59
<b>Total</b>				100.00	100.00	100.00
<b>Number of compounds</b>				41	45	43
<b>MH:</b> Monoterpene hydrocarbon				43.39	29.56	31.41
<b>AAI:</b> Aromatic aldehyde				2.49	5.33	3.54
<b>AA:</b> Aromatic alcohol				-	-	-
<b>OS:</b> Oxygenated sesquiterpene				0.80	-	3.38
<b>AH:</b> Aromatic hydrocarbon				-	-	-
<b>OM:</b> Oxygenated monoterpene				0.53	5.12	8.39
<b>OC:</b> Other components				7.82	4.50	6.71
<b>MA:</b> Monoterpene aldehyde				-	1.69	1.14
<b>PP:</b> Phenylpropanoid				-	-	-
<b>SH:</b> Sesquiterpene hydrocarbon				44.97	53.20	44.75
<b>H:</b> Hydrocarbon				-	0.48	0.40
<b>FA:</b> Fatty acid				-	0.12	0.28

<sup>a</sup>: Linear Retention Indices, as determined on a Restek Rxi-5Sil MS column using a series of the standards of C7\_C30 saturated n-alkanes, -: not detected.

The results of the volatile compound analyses were initially subjected to cluster analysis. The dendrogram shown in Fig. 2 indicates that the compounds can be grouped into four main clusters. The first cluster includes compound 1 ( $\alpha$ -thujene), compound 6 ((*E*)- $\beta$ -farnesene), compound 12 ( $\gamma$ -muurolene), compound 17 ( $\alpha$ -terpineol), compound 9 (Ylangene), compound 5 ( $\beta$ -myrcene), compound 21 ( $\beta$ -cubebene), compound 3 (1,8-cineole), compound 23 ( $\alpha$ -terpinolene), and compound 16 ( $\alpha$ -humulene). The second cluster consists of compound 4 (limonene), compound 15 (carveol), compound 11 ( $\delta$ -

cadinene), compound 19 ( $\alpha$ -amorphene), compound 14 ( $\alpha$ -gurjunene), and compound 18 (germacrene-D). The third cluster comprises compound 7 ( $\alpha$ -pinene), compound 27 (Cadin-1(6),4-diene<10- $\beta$ -H), compound 26 (Hexyl2-methylbutyrate), compound 20 (bicycloelemene)), compound 8 ( $\beta$ -elemene), compound 10 (*Trans*-caryophyllene), and compound 13 ( $\beta$ -ocimene Y). The fourth cluster includes compound 24 ( $\delta$ -cadinene), compound 28 ( $\alpha$ -cubebene), and compound 22 (bicycloelemene) (Fig. 2; Fig. 3; Fig. 4).

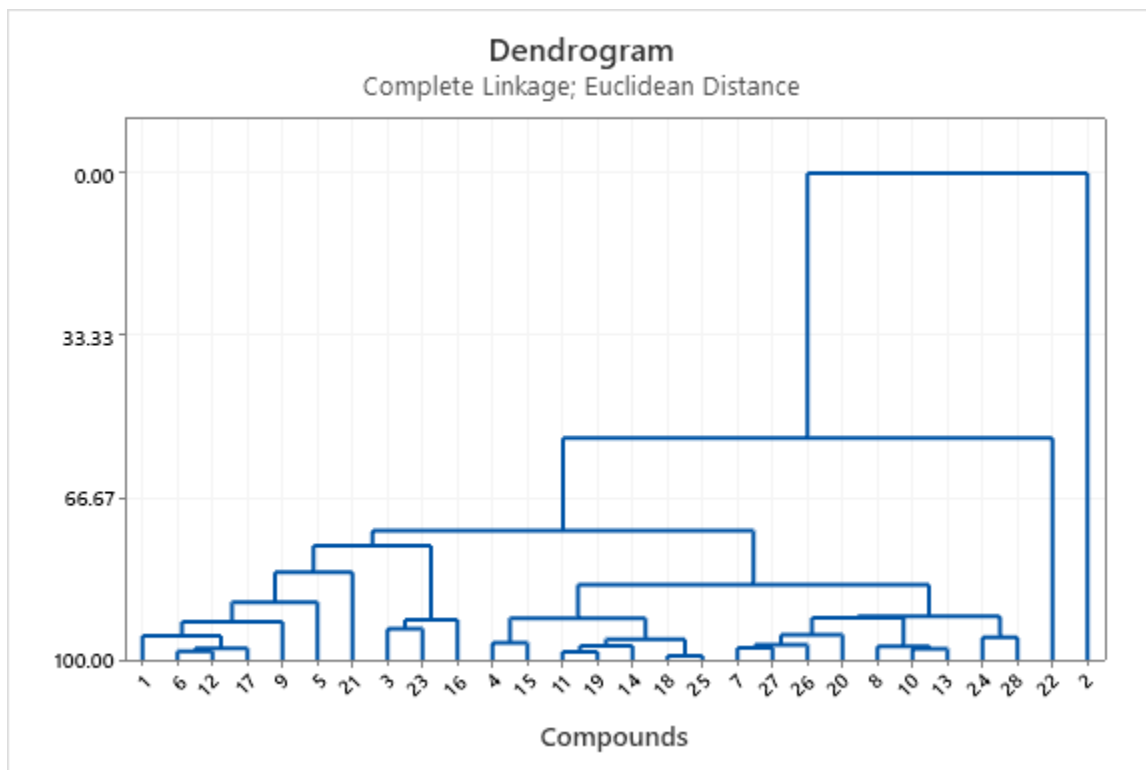


Fig. 2. Cluster analysis

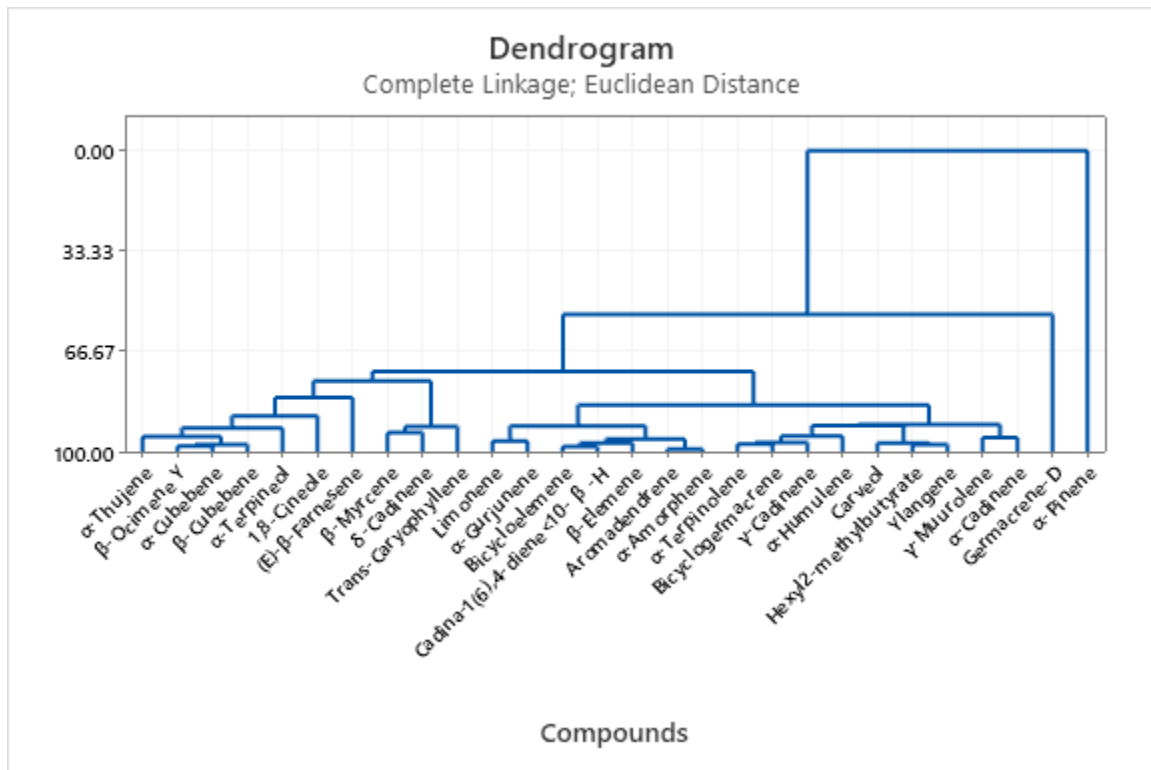


Fig. 3. Cluster analysis

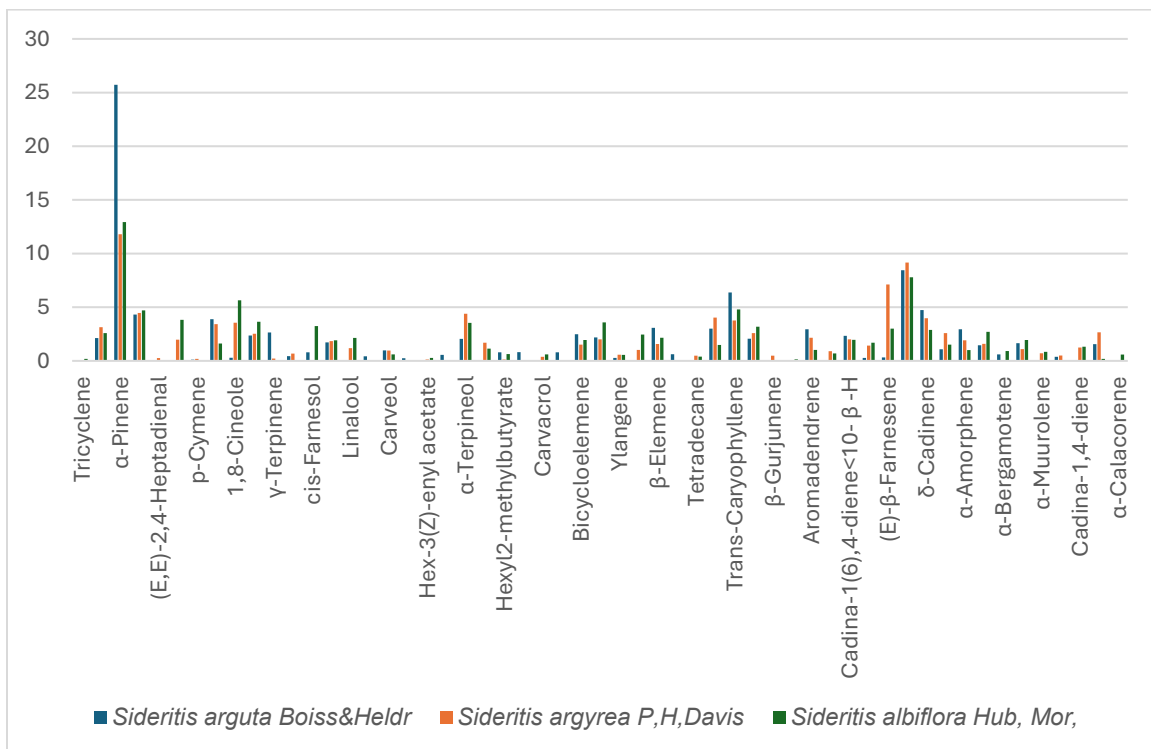


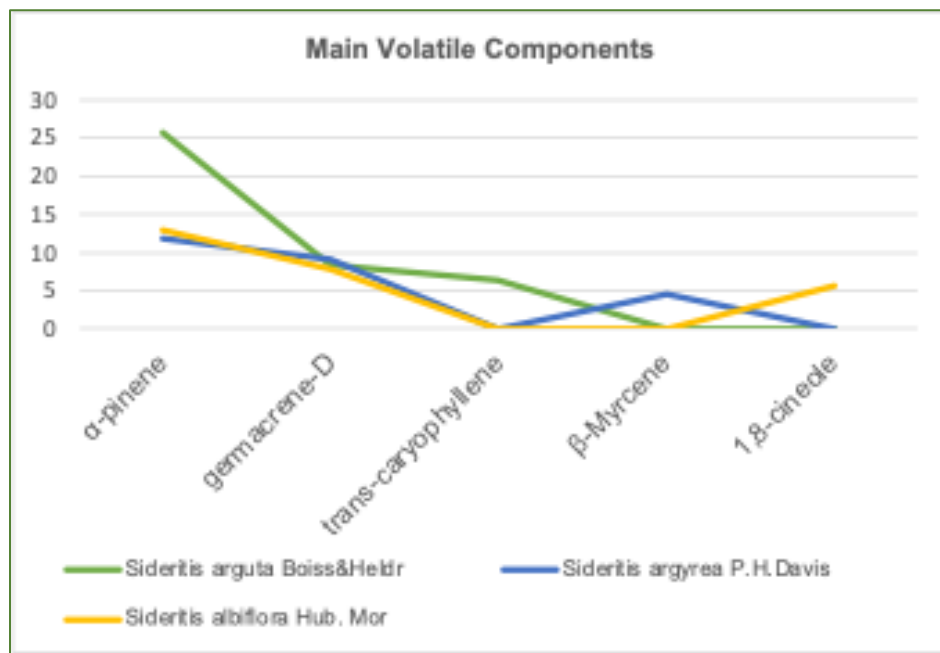
Fig. 4. Cluster analysis

According to the results of the cluster analysis, as shown in Table 3, component 18 (germacrene-D) and component 25 ( $\alpha$ -gurjunene) were grouped in the same cluster,

exhibiting a similarity of 99.21%. Similarly, components 11 ( $\delta$ -cadinene) and 19 ( $\alpha$ -amorphene) were classified in the same cluster with a similarity of 98.32% (Table 3). In the subsequent stage, component 6 (*E*)- $\beta$ -farnesene) and component 12 ( $\gamma$ -muurolene) exhibited a similarity of 98.20%. Component 10 (*trans*-caryophyllene) and component 13 ( $\beta$ -ocimene Y) exhibited a similarity of 97.70%. Component 6 (*E*)- $\beta$ -farnesene) and component 17 ( $\alpha$ -terpineol) exhibited a similarity of 97.67%. Component 7 ( $\alpha$ -pinene) and component 27 (cadin-1(6),4-diene<10- $\beta$ -H) exhibited a similarity of 97.52%. Component 8 ( $\beta$ -elemene) and component 10 (*trans*-caryophyllene) exhibited a similarity of 97.17%. Component 11 ( $\delta$ -cadinene) and component 14 ( $\alpha$ -gurjunene) exhibited a similarity of 97.11%. Component 7 ( $\alpha$ -pinene) and component 26 (Hexyl2-methylbutyrate) exhibited a similarity of 96.94%. Component 4 (limonene) and component 15 (carveol) exhibited a similarity of 96.47%. Component 11 ( $\delta$ -cadinene) and component 18 (germacrene-D) exhibited a similarity of 95.77%. Component 24 ( $\delta$ -cadinene) and component 28 ( $\alpha$ -cubebene) exhibited a similarity of 95.34%. Component 1 ( $\alpha$ -thujene) and component 6 (*E*)- $\beta$ -farnesene) exhibited a similarity of 95.03%. Component 7 ( $\alpha$ -pinene) and component 20 (bicycloelemene Y) exhibited a similarity of 94.86%. Component 3 (1,8-cineole) and component 23 ( $\alpha$ -terpinolene) exhibited a similarity of 93.66%. Component 1 ( $\alpha$ -thujene) and component 9 (Ylangene) exhibited a similarity of 92.16%. Component 3 (1,8-cineole) and component 16 ( $\alpha$ -humulene) exhibited a similarity of 91.72%. Component 4 (limonene e) and component 11 ( $\delta$ -cadinene Y) exhibited a similarity of 91.43%. Component 7 ( $\alpha$ -pinene) and component 8 ( $\beta$ -elemene) exhibited a similarity of 91.31%. Component 7 ( $\alpha$ -pinene) and component 24 ( $\delta$ -cadinene) exhibited a similarity of 90.99%. Component 1 (*Trans*-caryophyllene) and component 5 ( $\beta$ -myrcene) exhibited a similarity of 88.17%. Component 4 (limonene) and component 7 ( $\alpha$ -pinene) exhibited a similarity of 84.53%. Component 1 ( $\alpha$ -thujene) and component 21 ( $\beta$ -cubebene) exhibited a similarity of 82.03%. Component 1 ( $\alpha$ -thujene) and component 3 (1,8-cineole) exhibited a similarity of 76.49%. Component 1 ( $\alpha$ -thujene) and component 4 (limonene) exhibited a similarity of 73.46%. Component 1 ( $\alpha$ -thujene) and component 22 (bicycloelemene) exhibited a similarity of 54.41%.

**Table 3.** Cluster Analysis Results

Step	Clusters	Similarity (%)	Distance	First added	Second added	New cluster name	Number of observations in cluster
1	27	99.21	0.2404	18	25	18	2
2	26	98.32	0.5100	11	19	11	2
3	25	98.20	0.5475	6	12	6	2
4	24	97.70	0.6989	10	13	10	2
5	23	97.67	0.7066	6	17	6	3
6	22	97.52	0.7535	7	27	7	2
7	21	97.17	0.8600	8	10	8	3
8	20	97.11	0.8789	11	14	11	3
9	19	96.94	0.9294	7	26	7	3
10	18	96.47	1.0717	4	15	4	2
11	17	95.77	1.2857	11	18	11	5
12	16	95.34	1.4157	24	28	24	2
13	15	95.03	1.5101	1	6	1	4
14	14	94.86	1.5625	7	20	7	4
15	13	93.66	1.9285	3	23	3	2
16	12	92.16	2.3839	1	9	1	5
17	11	91.72	2.5195	3	16	3	3
18	10	91.43	2.6063	4	11	4	7
19	9	91.31	2.6443	7	8	7	7
20	8	90.99	2.7396	7	24	7	9
21	7	88.17	3.5986	1	5	1	6
22	6	84.53	4.7063	4	7	4	16
23	5	82.03	5.4678	1	21	1	7
24	4	76.49	7.1541	1	3	1	10
25	3	73.46	8.0756	1	4	1	26
26	2	54.41	13.8735	1	22	1	27
27	1	0.00	30.4359	1	2	1	28



**Fig. 5.** Major components of the essential oils of *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor. species

When the climatic data were evaluated according to the years in which the plant materials were collected, it was observed that in the Alanya district of Antalya Province, the average annual temperature in 2023 ranged between 9 °C and 32 °C, rarely falling below 5 °C and exceeding 36 °C during the summer months. The total annual precipitation for this year was recorded as 641.5 mm. Furthermore, the mean sea surface temperature, measured at approximately 19.7 °C, indicates that 2023 was relatively warmer compared to the other study years. In 2024, the mean annual temperature was recorded as 19.3 °C. Although the total precipitation was measured at approximately 638 mm, it was lower than that of the previous year. In 2025, the average temperature ranged between 20 °C and 35 °C and was above the multi-year average when compared to other years. Due to the elevated temperatures during this year, a decrease in precipitation relative to the average was observed. In particular, summer temperatures were frequently recorded above 30 °C.

This study aimed to elucidate the demographic and socioeconomic characteristics of the local population in Alanya, Türkiye, and to assess their use of *S. arguta* Boiss. & Heldr., *S. argyrea* P.H. Davis, and *S. albiflora* Hub. Mor. Specifically, the study examined the purposes, timing, and frequency of consumption, modes of acquisition, perceived benefits and side effects of the consumed plant products, as well as the factors influencing the formation of consumption habits. In the study, a questionnaire consisting of 25 questions was used to determine the characteristics of the consumers. Three non-wood forest plant products belonging to the Lamiaceae family were evaluated. A database was established for these plant taxa, including their scientific names, families, parts used as non-wood forest products, local applications, and contributions to the local population.

In their study, Kocabaş *et al.* (2016) aimed to identify certain ethnobotanical aspects of plants sold in local markets between 2014 and 2015. Within the scope of the study, visits were made to neighborhood markets in the city center to determine the purposes for which the plants were used and the ways in which they were utilized. As

a result of the study, certain ethnobotanical characteristics of 62 plant taxa sold in neighborhood markets were identified. In terms of species number, the largest families were found to be Lamiaceae with 9 taxa, Rosaceae with 6 taxa, Asteraceae and Liliaceae with 3 taxa each, while the remaining families each included 2 taxa.

Satıl *et al.* (2008) aimed to determine the ethnobotanical characteristics of plants identified during floristic surveys conducted between 2005 and 2007 in the Madra Mountains and surrounding areas (Balıkesir/İzmir, Türkiye). Traditional knowledge was compiled regarding the plants utilized by the local population for food, medicine, fodder, handicrafts, and other purposes. Over a two-year study period, interviews were conducted with 45 individuals in the research area. A total of 115 plant taxa and associated local knowledge were documented. Among the collected plants, 52 were used for food, 46 for medicinal purposes, 19 for fodder, 14 in handicrafts, and 10 as ornamental plants. Additionally, 12 plant species were identified as being collected and sold for commercial purposes in the region.

Fakir *et al.* (2016) conducted research over approximately four years (2011-2014) in several districts of Antalya Province. Additional information was collected through interviews with local consumers, vendors, shepherds, village heads, and midwives. As a result, a simplified list was compiled including 87 plant taxa belonging to 72 genera and 36 families, providing their scientific and local names, as well as information on plants used for pain relief. The dominant families were identified as Lamiaceae, Asteraceae, and Apiaceae, while *Salvia* sp., *Hypericum* sp., and *Achillea* sp. were determined to be the most common genera. These medicinal plants were traditionally used to manage or alleviate pain, particularly stomachaches, sore throats, toothaches, and abdominal pain. The findings of this ethnobotanical research emphasized the importance of the field in revealing local ethnobotanical knowledge. Elçi and Erik (2006), through ethnobotanical research conducted in the Güdül district (Ankara) and surrounding areas, identified 23 plants used as folk medicines and 11 plants used as food. These plants were documented with their scientific and local names, uses, utilized parts, and modes of application. Additionally, the local names of plants used for other purposes or without known ethnobotanical uses were recorded alongside their scientific names. The findings were compared with existing literature, highlighting information that was recorded for the first time.

Koçyiğit (2005) aimed to determine the uses of plants in Yalova Province and identified 99 taxa utilized by the local population. Among these, 53 taxa were used for medicinal purposes, 40 for food, 5 as spices, 3 as toys, 4 for tool making, 2 for hay baling, 2 for dyeing, 1 as an ornamental plant, 1 for soap production, 2 for spell casting, 1 for mortar preparation, and 2 for hair care. Yapıcı *et al.* (2009) investigated the ethnobotanical characteristics and local names of certain plants identified in the Kurtalan district (Siirt). The study material consisted of various seed-bearing plants growing in the research area. The study documented local names, medicinal and food uses, and other ethnobotanical properties of 34 taxa.

Fakir *et al.* (2003) collected 242 plant specimens from the Nature Conservation Area during field studies conducted between 1999 and 2003. Identification of the specimens revealed 78 taxa belonging to 75 genera and 50 families, of which 4 were endemic. Additionally, the entire Nature Conservation Area was surveyed to identify the thickest and tallest trees and shrubs. Erkan *et al.* (2015) investigated the cytotoxic effects and lipid peroxidation inhibition capacities of *Sideritis arguta*, a wild plant species known

in Turkey as mountain tea, on cancer cells. The study found that carnosic acid and carnosol present in the plant extracts exhibited strong antioxidant and anticancer properties.

The SPME analysis results demonstrated that in *Sideritis arguta* Boiss. & Heldr., the highest concentrations of volatile compounds were  $\alpha$ -pinene (25.7%), germacrene-D (8.44%), and trans-caryophyllene (6.38%). In *Sideritis argyrea* P.H. Davis, the major constituents were  $\alpha$ -pinene (11.8%), germacrene-D (9.16%), and  $\beta$ -myrcene (4.46%), whereas in *Sideritis albiflora* Hub. Mor, the dominant compounds were  $\alpha$ -pinene (12.9%), germacrene-D (7.79%), and 1,8-cineole (5.65%). In terms of local usage, the consistently highest proportion of  $\alpha$ -pinene across all three *Sideritis* spp., followed by germacrene-D, suggests that these species are primarily used for the treatment of the common cold and, secondarily, for immune system support, as evidenced by the findings of this study.

## CONCLUSIONS

1. In this study, three endemic species were identified in the Alanya region: *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor. Significant differences were observed in their aromatic properties, and these variations can be attributed to differences in soil and climatic conditions. SPME analyses revealed 41 volatile compounds in *Sideritis arguta* Boiss. & Heldr., 45 in *Sideritis argyrea* P.H. Davis, and 43 in *Sideritis albiflora* Hub. Mor. Examination of volatile compound classes showed that sesquiterpene hydrocarbons were present in high amounts in all three species, indicating their potential as valuable resources for medicinal, pharmaceutical, and cosmetic industries.
2. During field studies conducted between 2024 and 2026, a database was established for the endemic plant taxa *Sideritis arguta* Boiss. & Heldr., *Sideritis argyrea* P.H. Davis, and *Sideritis albiflora* Hub. Mor. These results were obtained through the present study. The database included scientific and local names, endemism status, parts used as non-wood forest products, applications, and contributions to the local population. A questionnaire survey was also conducted, and it is recommended that these species be cultivated separately within the framework of sustainable agricultural practices to enhance their cultural and economic value. Consumers who have a usage habit regarding these plant species were found to predominantly prefer traditional modes of consumption. In the Alanya region, the most common purposes for consuming *Sideritis* spp. were for general health maintenance, therapeutic use, and recreational enjoyment.
3. The peak consumption periods of *Sideritis* spp. are during winter and autumn. During these periods, conservation of their natural habitats is vital and the implementation of protection measures are crucial. To prevent the extinction of these species and to enhance their cultural and economic value, it is recommended that they be cultivated through seed and cutting propagation. The close relationship between the purposes and timing of consumption is particularly important, as consumers tend to utilize the plants intensively in winter and autumn when upper and lower respiratory tract infections are most prevalent, aiming to benefit from the plants' protective, antipyretic, and immune-boosting properties. In this context, traditional consumption habit of *Sideritis* spp. persists in the Alanya region. This habit reflects the preferred species, usage areas, and

modes of consumption, further supporting the recommendation to propagate these plants via seeds and cuttings to prevent extinction and ensure sustainable cultivation.

4. A large proportion of consumers state that they believe they benefit from the products they use; however, there is a significant lack of knowledge regarding appropriate dosage. Only approximately one-third of consumers are aware of the correct amounts to be taken. In addition, the level of knowledge regarding potential side effects and the identification of toxic plants is limited. From an ethnobotanical perspective, although the use of non-wood forest products by the local population is widespread, some misuse has been observed due to insufficient knowledge. Therefore, efforts to promote the proper use of *Sideritis* spp. should be increased. Detailed studies on the antimicrobial, antiseptic, and antibacterial properties of *Sideritis* spp. species are recommended. Such research is important for ensuring that these plants are collected and used more responsibly, and it will also highlight their potential as pharmaceutical raw materials as well as their possible use as natural preservatives in food and cosmetic products.
5. In this context, this study is the first to reveal that the use of *Sideritis* spp. is widespread among the local population when examined from an ethnobotanical perspective. In recent years, due to factors such as the side effects of synthetic drugs and environmental pollution, public interest in natural substances and plants has increased significantly in many countries worldwide. Factors such as the ineffectiveness of some medicinal drugs or concerns about their side effects have led local people to turn to plants for health purposes. Therefore, it is crucial to develop policies that promote the sustainable utilization of these species in the region. The local population should be better informed about the benefits of these species and they should be harvested consciously after the seed-setting period. Collecting the plants after seed maturation was found to prevent the extinction of the species. Consequently, this study is the first to demonstrate that the Alanya region (Türkiye) is particularly rich in endemic *Sideritis* spp., highlighting the importance of promoting sustainable and informed collection and use of these plants.
6. The study concluded that educating the local population and consumers of non-wood forest products is essential to raising awareness of these valuable natural resources. To date, no comprehensive research has systematically examined plant use in this region. Therefore, documenting the traditional knowledge and practices of the local population is critically important, and this study helps to fill that gap. Overall, the findings indicate that plants have played and continue to play a significant role in the daily lives of local communities; however, increased consumer awareness and education remain necessary. Given the economic importance of these plants, further research is required to support their conservation, cultivation, and sustainable use. Such efforts are particularly vital for promoting conscious harvesting practices and encouraging successful propagation through seeds or cuttings.

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