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Doğu Anadolu Bölgesinden Toplanan *Achillea wilhelmsii* K. Koch Türünün Uçucu Bileşiklerinin GC-MS Analizi

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ÖZ

Bu çalışma, Türkiye'nin Bingöl yöresinde doğal olarak yetişen *Achillea wilhelmsii* K. Koch bitkisinin çiçekli üst kısımlarından elde edilen uçucu yağ bileşenlerini incelemeyi amaçlamaktadır. GC-MS analizleri sonucunda toplam 31 farklı bileşik tespit edilmiş; bunlar arasında özellikle kamfor (%48,2), 3-siklohekzen-1-ol (%14,2), borneol (%10,3) ve 1,8-sineol (%6,6) öne çıkmıştır. Elde edilen bu veriler, daha önce İran ve Türkiye'de yapılan benzer çalışmalarla genel anlamda örtüşmektedir. Ancak 3-siklohekzen-1-ol'ün bu denli yüksek oranda bulunması, Bingöl bölgesine özgü olabilecek yeni bir kemotipin varlığını düşündürmektedir. Bu bulgu, çevresel koşullar ve uygulanan yöntemlerin uçucu yağ bileşimi üzerindeki etkisini net biçimde ortaya koymakta; ayrıca bölgesel botanik araştırmaların önemini bir kez daha gözler önüne sermektedir.

GC-MS Analysis of the Volatile Compounds in *Achillea wilhelmsii* K. Koch Collected from Eastern Anatolia

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ABSTRACT

This study aims to analyze the essential oil composition of *Achillea wilhelmsii* K. Koch, collected from the Bingöl region of Turkey, using the GC-MS method. A total of 31 different compounds were identified, with camphor (48.2%), 3-cyclohexen-1-ol (14.2%), borneol (10.3%), and 1,8-cineole (6.6%) being the most abundant. These results are largely consistent with previous findings from Iran and Turkey; however, the notably high proportion of 3-cyclohexen-1-ol suggests a potentially unique chemotype specific to the Bingöl region. The study highlights the impact of environmental and methodological factors on essential oil profiles and underscores the importance of region-specific research.

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1. Introduction

The genus *Achillea* (Asteraceae), comprising between 110 to 140 species globally, predominantly originates from Southeast Europe and Southwest Asia, extending further across Eurasia into North America. In Turkey, this genus is represented by 48 species, classified under 54 distinct taxa, with 24 recognized as endemic to the region (Arabacı, 2012; Baser, 2016). This plant commonly thrives on dry slopes, plains, and steppe ecosystems, especially across Central Anatolia. It typically enters its flowering phase during July and August (Davis, 1972).

Members of the *Achillea* genus are widely acknowledged for their medicinal value worldwide. Their significance spans from traditional herbal practices to evidence-based modern phytotherapy. The essential oils, primarily concentrated in the flowers, constitute the key pharmacologically active constituents. However, the biosynthesis and concentration of these essential oils are modulated by a range of biotic and abiotic factors. As such, both interspecific and intraspecific chemical variations are influenced by morphogenetic development stages and the chosen method of extraction. Despite their longstanding role in folk medicine, *Achillea* species have broader applications—most notably, their blossoms and flowering tops are frequently used in the preparation of herbal teas with nutritional and therapeutic benefits (Kindlovits and Németh, 2012).

Species of *Achillea*, commonly known as "yarrow," have long been used in traditional folk medicine due to their numerous medicinal properties. Today, their therapeutic applications including wound healing, spasmolytic, anti-inflammatory, and cholinergic effects are increasingly supported by scientific research findings. In Turkey, various species of the genus are traditionally used to treat wounds, ulcers, the common cold, diarrhea, abdominal pain, and to relieve gastrointestinal gas (Turkmenoglu et al., 2015).

Achillea wilhelmsii C. Koch contains a variety of compounds, including flavonoids, alkaloids, borneol, and cineole. Traditionally, this plant has been used as a remedy for relieving stomach pain, fatigue, neurological disorder symptoms, and epilepsy. Moreover, the aerial parts of *A. wilhelmsii* possess antioxidant properties. Additionally, flavonoids have been reported to exhibit phosphodiesterase type 5 inhibitory (PDE5I) activity (Saravani et al., 2017).

The main bioactive components that contribute to the pharmacological actions of the plant are essential oils. The present study aims to characterize the essential oil profile of *Achillea wilhelmsii* and to evaluate the findings in comparison with existing literature data.

2.Material and Method

2.1. Sample of Plant

A. Demirpolat identified *Achillea wilhelmsii* (AD1007) K. Koch. using Flora of Turkey after the plant sample was dried using the herbarium process (Davis, 1972). *Achillea wilhelmsii* was obtained from Bingöl, Genç in July.

2.2. Essential Oil Extraction

Using a 2 L round-bottom flask and a modified Clevenger equipment, the essential oil was extracted by hydrodistillation. One liter of water and 100 grams of fresh plant material (aerial portions) were utilized in the extraction process. The Plant Products and Biotechnology Res. Lab. was where the chemical analysis was carried out. The extraction process took three hours to complete. The dry mass was used as the foundation for calculating the oil yields.

2.3. Analysis of Gas Chromatography (GC)

The HP 6890 GC with FID detector and an HP-5 MS capillary column (30 m x 0.25 mm I.d., film thickness 0.25 μm) were used to analyze the essential oil. As stated below, the column and analytical conditions were identical to those in the GC-MS. GC-FID peak regions were used to calculate the essential oils % composition without the use of correction factors.

2.4. Analysis of Gas Chromatography/Mass Spectrometry (GC-MS)

Hewlett Packard Gas Chromatography HP 6890 interfaced with Hewlett Packard 5973 mass spectrometer equipment with an HP 5-MS capillary column (30 m x 0.25mm id, film thickness 0.25 μm) was used to undertake GC-MS studies of the oils. The oven was set to operate between 70 and 240^0 at a rate of 5 degrees Celsius per minute. The electron ionization was set at 70 eV and the ion source was tuned at $24C^o$. The carrier gas, helium, was employed at a flow rate of 1 mL/min. 35 to 425 amu was the scanning range. The GC-MS was filled with 1.0 μL of diluted oil in n-hexane. Their mass spectra were compared to those from the NIST 98 Libraries (on ChemStation HP) and Wiley 7th Version in order to further identify them. Without the use of correction factors, the relative amounts of each component were determined using the GC peak area (HP5MS column). Table 1 lists the components of the essential oils that have been identified. Retention indices (RI) were determined by injecting a homologous series of *n*-alkanes (C8–C30) under identical GC–MS operating conditions. RI values were calculated according to the Van den Dool and Kratz method and compared with literature data and mass spectral libraries (NIST and Wiley) for compound identification.

Table 1. Essential oil components of *Achillea wilhelmsii*

No	Compound Name	Retention Index	Percentage (%)
1.	Tricyclene	1013	0,5
2.	α-Pinene	1021	1,5
3.	Camphene	1035	**7,9**
4.	Sabinene	1051	0,4
5.	β-Pinene	1055	1,1
6.	α-Terpinene	1085	0,3
7.	Benzene-1-methyl	1091	1,4
8.	Limonene	1094	0,5
9.	1,8-Cineole (Eucalyptol)	1098	**6,6**
10.	γ-Terpinene	1116	0,4
11.	trans-Sabinene Hydrate	1126	0,3
12.	α-Terpinolene	1136	0,2
13.	Camphor	1184	**48,2**
14.	Borneol	1201	**10,3**
15.	3-Cyclohexen-1-ol	1205	**14,2**
16.	Ethanone	1226	0,1
17.	Carveol	1230	0,2
18.	cis-Carveol	1240	0,4
19.	Endobornyl Acetate	1281	0,1
20.	Thymol	1286	0,2
21.	Eugenol	1339	0,1
22.	cis-Jasmone	1371	0,1
23.	trans-Caryophyllene	1392	0,2
24.	Aromadendrene	1420	0,2
25.	Naphthalene	1429	0,2
26.	β-Ionone	1432	0,1
27.	Germacrene D	1434	0,7
28.	Bicyclogermacrene	1444	0,5
29.	Spathulenol	1494	0,4
30.	Caryophyllene Oxide	1497	0,6
31.	α-Cadinol	1531	0,4
		% TOTAL	**98.3**

Results and Discussion

Using the GC–MS method, the essential oil composition of the flowering aerial portions of *Achillea wilhelmsii* K. Koch was examined in this study, oil yield %0.4 and 31 distinct components were identified based on a single analytical measurement. The predominant constituents were camphor (48.2%), 3-cyclohexen-1-ol (14.2%), borneol (10.3%), and 1,8-cineole (6.6%), respectively (Table 1). These findings are largely consistent with previous results obtained from *A. wilhelmsii* samples collected in Iran and Turkey (Motavalizadehkakhky et al., 2013; Salehi et al., 2025). The essential oil was predominantly composed of oxygenated monoterpenes (66.3%), followed by monoterpene hydrocarbons (12.8%), whereas sesquiterpenes were present only in minor proportions. This compositional pattern clearly indicates a camphor-rich oxygenated monoterpene chemotype (Table 2).

Table 2. Percentage Distribution of Chemical Classes Identified in the Essential Oil of *Achillea wilhelmsii*

Chemical Class	Number of Compounds	Percentage (%)
Monoterpene hydrocarbons	9	12.8
Oxygenated monoterpenes	8	66.3
Sesquiterpene hydrocarbons	4	1.6
Oxygenated sesquiterpenes	3	1.4
Other compounds*	7	16.2
Total identified	**31**	**98.3**

Rustaiyan et al. (1999) reported camphor (38.1%), borneol (14.5%), and 1,8-cineole (9.8%) as dominant constituents in *A. wilhelmsii* essential oil collected from northern Iran. Similarly, in a study by Sefidkon et al. (2002), camphor (42.3%) and 1,8-cineole (7.4%) were identified as primary components, supporting the current findings regarding chemotype dominance. Motavalizadehkakhky et al. (2013) analyzed oils from Iranian populations and observed lower levels of camphor (25.7%) but higher proportions of thujone and artemisia ketone, suggesting possible intraspecific chemical polymorphism.

Camphor, in particular, is one of the most common monoterpene ketones found in this species and is known for its local anesthetic, anti-inflammatory, and antimicrobial properties (Ertaş et al., 2014). Other major compounds such as borneol and 1,8-cineole have also been reported to exhibit expectorant and antiseptic effects in respiratory tract infections. The presence of flavonoid derivatives pharmacologically supports the traditional use of the plant in the treatment of stomach pain and neurological disorders (Ayoobi et al., 2017).

Several studies have highlighted how environmental influences might affect the composition of essential oils. Baser (2016) and Kindlovits and Németh (2012) have reported that geographic origin, harvesting time, and the distillation process significantly influence essential oil composition. In this context, the high camphor content observed in the sample collected from the Bingöl region highlights the chemotypic diversity of this species. The essential oil composition obtained in the present study shows similarities with previously reported *Achillea wilhelmsii* populations collected from different regions of Turkey, where camphor and 1,8-cineole were identified as dominant constituents (Baser, 2016; Tosun and Kürkçüoğlu, 2018). The essential oil composition of *Achillea wilhelmsii* obtained in the present study demonstrated notable similarities as well as quantitative differences when compared with previously reported Turkish populations. Earlier investigations conducted on *A. wilhelmsii* collected from different regions of Turkey revealed camphor, 1,8-cineole, borneol, and oxygenated monoterpenes as dominant constituents of the essential oil. Similar compositional patterns have been reported particularly for Central Anatolian populations, where camphor was identified as the major component, followed by 1,8-cineole and related monoterpenoids (Baser, 2016; Tosun and Kürkçüoğlu, 2018).

Furthermore, differences in extraction procedures, harvesting period, and analytical parameters may also contribute to quantitative discrepancies among studies. The observed compositional variation therefore supports the existence of regional chemotypes within Turkish *A. wilhelmsii* populations. These findings highlight the importance of local population-based analyses for evaluating the phytochemical diversity and potential pharmacological applications of this species.

One particularly striking result from this study is the high concentration of 3-cyclohexen-1-ol (14.2%), which stands out because such elevated levels of this compound have not been consistently reported in earlier research. This unusual abundance may reflect the presence of a distinct local chemotype, possibly unique to the Bingöl region of Turkey.

Conclusion

In general, the dominance of borneol and camphor remains in line with findings from previous studies, reinforcing their role as key constituents in *Achillea wilhelmsii*. However, the noticeable differences in the amounts of other components clearly demonstrate how environmental factors and methodological choices can influence the essential oil profile of the plant. These findings underscore the importance of regional studies in capturing the chemical diversity within a species.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

The authors declare that they have contributed equally to the article

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