COMPOSITION AND ANTIMICROBIAL ACTIVITY OF THE ESSENTIAL OILS OF *Achillea nobilis* L. SUBSP. *sipylea* AND SUBSP. *neilreichii*

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The genus *Achillea* (Asteraceae) is represented by 42 species, 20 being endemic in Turkey [1, 2]. *Achillea nobilis* L. subsp. *sipylea* (O. Schwarz) Bassler, an endemic plant of the flora of Turkey, and *A. nobilis* L. ssp. *neilreichii* (Kerner) Formanek are perennial plants with medicinal value. These plants are known as "ayvadana", and dried flower heads of plants are sold in local markets and used as a diuretic and emmenagogue , in wound healing, for abdominal pain, and against diarrhea and flatulence in Turkey [3, 4].

A. nobilis represents different subspecies in the flora of Turkey and because of non-specified subspecies names, exact plant materials are not known in some studies. The present study was carried out for the first time to determine the chemical composition of the essential oils of *A. nobilis* subsp. *sipylea* and *A. nobilis* subsp. *neilreichii* collected from Turkey, and their antimicrobial activities were tested against eight Gram positive and Gram negative bacteria strains and *Candida albicans*.

The percentage compositions of the oils are listed in Table 1. These results demonstrate variations in the qualitative and quantative composition in the oil obtained from different subspecies and from different localities. In the essential oil of *A. nobilis* grown in Yugoslavia the prevailing components were α-thujone (25.7%), artemisia ketone (14.8%), borneol (9.9%), and camphor (8.2%) [5], compounds that in our oil are present in lower concentration, while artemisia ketone is absent. Although fragranol, 1,8-cineole, piperitone, chrysanthenone, α-bisabolol, and linalool have been found in several *Achillea* species [6–8], this genus has a huge genetic potential for different oil types, and ecological factors could play an important role in expressing a particular oil type [9].

The identification of oil components were carried out by comparison of the relative retention times with those of authentic samples or by comparison of their relative retention index (RRI) to a series of *n*-alkanes [10]. Computer matching against commercial (Wiley 275 1.) and in-house library built up by genuine compounds, as well as MS literature data [6, 7, 11], was also used for the identification.

Antimicrobial activity results are shown in Table 2. The essential oils of *A. nobilis* subspecies showed a broad spectrum of antimicrobial activity. Slight antifungal activity of the essential oil of *A. nobilis* has previously been reported [12]. In our study, oils remarkably inhibited the growth of all tested microorganisms except *Pseudomonas aeruginosa*. The antimicrobial activities of the oils could be related to the presence of a high amount of 1,8-cineole or minor components such as borneol and linalool. These results may partially support the use of these medicinal plants as traditional remedies for wound treatment.

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TABLE 1. Chemical Composition of the Essential Oils of Flower Heads of *Achillea nobilis* subsp. *sipylea* (**1**) and *A. nobilis* subsp. *neilreichii* (**2b**, **2c**), %*

Compound	RRI[a]	**1**	**2**[b]	**2**[c]	Compound	RRI[a]	**1**	**2**[b]	**2**[c]
α-Thujene	928	Tr.	Tr.	Tr.	Pinocarvone	1161	1.1	-	-
α-Pinene	936	3.1	2.5	1.4	Borneol	1164	2.0	-	-
Camphene	953	Tr.	Tr.	Tr.	Terpinen-4-ol	1177	0.6	2.2	1.1
Sabinene	976	Tr.	Tr.	Tr.	α-Terpineol	1187	0.9	1.3	1.2
β-Pinene	977	0.7	0.6	1.7	Fragranol	1216	19.3	-	-
Myrcene	1003	-	-	1.0	Tetrahydro-linalool acetate	1234	-	9.6	-
α-Terpinene	1016	Tr.	3.6	0.8	Piperitone	1254	-	2.9	16.3
p-Cymene	1020	-	6.7	0.8	Sabinyl acetate	1265	-	-	8.5
Limonene	1031	-	-	1.3	Bornyl acetate	1287	2.0	5.2	7.0
1,8-Cineole	1034	2.3	17.0	12.6	Eugenol	1346	0.5	0.4	0.3
γ-Terpinene	1056	-	0.7	-	Geranyl acetate	1378	1.8	-	1.4
cis-Sabinene hydrate	1072	0.6	-	-	β-Bisabolene	1509	-	1.2	-
Terpinolene	1091	0.6	-	-	γ-Cadinene	1513	2.7	-	1.0
α-Thujone	1097	6.1	3.9	-	Viridiflorol	1612	-	1.1	2.8
Linalool	1100	16.4	5.1	14.1	β-Eudesmol	1651	-	9.1	-
Chrysanthenone	1118	17.1	13.5	4.7	Dihydro-eudesmol	1657	13.2	-	1.1
Camphor	1140	0.9	1.0	1.9	β-Bisabolol	1669	-	3.4	-
Camphene hydrate	1145	0.7	-	-	α-Bisabolol	1678	-	-	12.8

*Percent calculated from flame ionization detector (FID) data; [a]RRI, relative retention indices calculated against *n*-alkanes on the HP-1 column; [b]*A. Nobilis* subsp. *neireichii* (from Eskisehir); [c]*A. Nobilis* subsp. *neilreichii* (from Burdur); Tr.: trace (<0.1%).

TABLE 2. Antibacterial Activity of *Achillea nobilis* subsp. *sipylea* and *A. nobilis* subsp. *neilreichii* Essential Oils [15, 16]

Microorganisms	Essential oils[a]			Standards[a]	
	1	**2**[b]	**2**[c]	SA	A
Escherichia coli ATTCC 29998	14	9	10	12	12
Pseudomonas aeruginosa ATCC 27853	-	-	-	10	10
Staphylococcus epidermidis ATCC 12228	10	8	10	18	13
Staphylococcus aureus ATCC 6538/P	14	11	15	19	17
Salmonella typhimurium CCM 5445	12	9	10	18	16
Enterobacter cloacae ATCC 13047	9	8	10	19	15
Enterococcus faecalis ATCC 29212	10	9	10	8	8
Proteus vulgaris ATCC 6897	14	13	16	17	14
Candida albicans ATCC 10239	41	17	18	NT	NT

[a]Zone of inhibitions, including the diameter of the filter paper disc (6 mm); mean value of six independent experiments, tested at a concentration of 30 µL/disc.
1, *A. nobilis* subsp. *sipylea*; *A. nobilis* subsp. *neilreichii* (from Eskisehir **2**[b]); (from Burdur **2**[c]); SA, Sulbactam/Ampicillin, tested at a concentration of 10/10 µg/disc (Oxoid); A, Amoxicillin, tested at a concentration of 20 mg/disc (Oxoid).
-: No inhibition; NT: Not tested.

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