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Chemical Composition of the Essential Oil Isolated from Wild Catnip Nepeta cataria L. cv. citriodora from the Drôme Region of France

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RESEARCH REPORT

Chemical Composition of the Essential Oil Isolated from Wild Catnip *Nepeta cataria* L. cv. *citriodora* from the Drôme Region of France

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Abstract

Nepeta cataria L. cv. *citriodora* growing wild in the Drôme region of France was brought into cultivation. Oils produced from cultivated plants harvested throughout the growing season were analyzed by GC and GC/MS. Although 42 components were identified, the oil composition did not depend on the time of harvesting or storage of the plant material prior to distillation. The oil was found to comprise mainly of citronellol (11.44-16.73%), nerol (19.95-30.70%), geraniol (25.13-31.00%) and geranial (4.93-11.05%). The highest oil yield was found to be at the time of full flowering.

Key Word Index

Nepeta cataria L. cv. *citriodora*, Labiatae, essential oil composition, citronellol, citronellyl acetate, geranial, nerol, geraniol.

Introduction

The genus *Nepeta* is represented by either annual or perennial herbs or shrubs most often found in temperate Eurasia and North Africa. Though not native to North America, three species have been found (1): *Nepeta cataria* L., including the garden escape cv. *citriodora*, *N. grandiflora* Bieb. and *N. racemosa* Lam. (Syn. *N. mussinii* Spreng. ex Henckel). Six other species (2) are in collections, in a Southern Ontario experimental garden [*Nepeta distans* Royle, *N. nepetella* L., *N. nuda* L. ssp. *nuda* (syn. *N. pannonica* L.) and *N. podostachys* Benth.], and in an experimental garden in North Carolina (*N. nervosa* Royle ex Benth. and *N. teydea* Webb. et Benth.).

N. cataria, usually called catnip, is native to Europe and Asia but is well-acclimatized in North America where it occurs in abundance near the Great Lakes. Its essential oil (2-7) is characterized by the presence of terpenes and isomers of nepetalactone, the most abundant of which can account for 99% of the total (2-7). An oil from *N. cataria* cv. *citriodora* (sometimes incorrectly named *Nepeta citriodora*)

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Table I. Chemical composition of essential oil

No.	Year of harvest / Batch / Name	1989 *1*	1989 *2*	1989 *3*	1989 *4*	1989 *5*	1989 *6*	1989 *7*
3	α-Pinene	0.65	0.30	0.09	0.42	0.32	0.12	0.19
4	α-Thujene	-	-	t	t	t	t	t
5	α-Pinene	1.54	2.88	0.72	2.38	0.79	0.50	0.99
6	Sabinene	-	-	0.19	-	0.23	t	0.23
7	Myrcene	t	0.11	t	0.08	-	t	t
8	Limonene	0.49	0.22	t	0.16	t	t	t
9	1,8-Cineole	-	-	t	t	t	t	t
11	γ-Terpinene	0.19	0.18	t	0.18	t	t	0.10
12	(E)-β-Ocimene	0.34	0.94	t	0.82	-	t	t
13	p-Cymene	0.20	t	t	0.08	-	t	t
14	Terpinolene	0.15	0.11	t	0.09	0.05	t	t
15	6-Methyl-5-hepten-2-one	0.14	0.10	t	0.08	0.08	0.07	0.19
16	trans-Rose oxide	t	0.12	0.14	0.08	0.08	0.32	0.17
17	cis-Rose oxide	-	t	t	t	t	t	t
18	Photocitral B	-	-	0.15	0.05	0.28	0.19	0.36
19	Photocitral A	-	-	t	-	t	t	t
20	Perillene	-	-	-	t	-	-	t
21	Artemisia ketone	-	-	0.10	0.06	0.09	0.08	0.10
22	Nerol oxide	t	0.11	t	0.09	0.10	t	0.11
23	cis,cis-Photocitral	0.23	0.12	0.25	0.11	0.14	0.19	0.28
24	Citronellal	-	-	1.28	-	0.90	0.69	1.03
25	trans,trans-Photocitral	0.34	0.28	0.56	0.28	0.98	0.58	0.77
26	Linalool	1.42	0.55	1.74	0.50	0.33	0.29	0.21
27	Linalyl acetate	0.20	0.12	10.75	0.15	0.37	0.24	0.13
28	β-Caryophyllene	3.24	4.89	3.39	4.81	3.27	2.74	2.62
29	Geranyl formate	-	-	-	-	t	t	t
30	Citronellyl formate	t	-	0.14	0.23	t	0.10	0.10
31	α-Humulene	0.28	0.41	0.26	0.37	0.29	0.25	0.24
32	Neral	3.07	3.31	7.79	3.17	5.81	6.10	6.68
33	Isoborneol	-	-	-	-	0.06	0.10	0.12
34	Neryl acetate	1.18	0.28	0.13	0.29	0.06	0.12	0.10
35	Piperitone	-	-	0.30	-	0.08	0.13	0.14
36	Methyl chavicol	0.44	0.44	0.47	0.42	0.57	0.60	0.71
37	Geranial	5.12	5.12	11.05	4.99	8.15	8.93	9.37
38	p-Menth-3-en-9-ol	0.56	0.64	0.29	0.63	0.62	0.60	0.83
39	Citronellol	15.10	16.73	12.02	16.47	14.36	13.66	14.62
40	Nerol	28.19	30.53	19.95	30.21	30.34	29.36	30.13
41	Geraniol	27.64	25.96	23.50	25.97	27.48	28.05	25.13
42	2-Phenylethyl hexanoate	-	-	-	-	t	0.05	-
43	iso-Caryophyllene oxide	-	-	0.19	-	0.21	0.26	0.43
44	Caryophyllene oxide	-	t	0.74	0.08	0.86	1.35	1.65
45	Humulene oxide*	-	-	0.09	-	0.09	0.11	0.15

*Correct isomer not given

of *Nepeta cataria* cv. *citriodora* oil

1989 *8*	1989 *9*	1989 *10*	1989 *11*	1989 *12*	1989 *13*	1989 *14*	1989 *15*	1989-I *16*	1989-I *17*
0.37	0.50	0.53	0.26	0.24	0.31	-	-	0.15	0.31
t	-	-	0.07	-	1.17	2.05	t	t	
2.43	3.16	3.04	1.83	1.92	2.32	0.34	0.48	0.89	1.56
0.67	0.92	0.79	0.51	0.46	0.51	-	0.05	0.19	0.37
t	0.07	-	-	0.02	-	0.07	0.08	t	-
0.12	0.06	-	0.05	0.09	0.08	0.11	0.07	t	-
0.19	0.06	-	t	0.04	0.11	-	-	t	-
0.28	0.30	-	0.09	-	-	-	-	t	-
-	-	-	-	-	-	-	-	t	-
-	-	-	-	-	-	-	-	0.05	-
-	-	-	-	-	-	-	-	t	-
-	-	-	0.16	-	-	-	-	0.26	0.76
-	0.02	-	0.29	0.06	-	-	0.05	0.09	-
-	0.09	-	0.05	0.09	-	-	t	0.04	-
-	0.06	-	-	0.04	-	-	t	0.34	0.15
-	0.03	-	0.06	0.14	0.19	-	0.16	t	t
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	0.10	t
-	0.04	-	0.05	0.05	-	-	-	0.04	t
-	-	-	-	-	-	-	-	0.14	0.44
0.12	0.30	0.28	0.36	0.18	0.21	0.20	0.20	0.39	1.09
1.18	1.56	1.17	1.19	0.68	0.82	0.61	0.67	0.94	0.76
0.32	0.75	0.84	0.74	0.34	0.62	0.38	0.57	0.35	t
-	0.16		0.16	0.85	0.35	0.45	-	1.05	-
-	0.08	-	0.47	1.28	0.40	-	0.19	3.09	2.22
3.64	4.73	3.79	6.53	4.56	4.73	5.46	5.30	0.06	-
-	-	-	-	0.08	-	0.13	0.03	0.07	t
0.24	0.38	0.38	1.10	0.04	0.31	0.52	0.42	0.23	0.13
7.14	6.53	6.78	5.70	0.37	4.80	3.44	4.57	5.73	7.11
-	-	-	-	4.97	-	-	-	0.07	-
-	-	-	0.21	0.04	-	-	0.18	0.16	-
-	-	-	-	0.07	-	-	-	0.11	-
0.22	0.26	0.39	0.29	0.54	0.49	0.46	0.41	0.58	0.50
9.65	8.96	9.32	7.70	6.70	6.37	4.93	6.26	7.49	9.88
0.22	0.32	0.35	0.36	0.42	0.55	0.39	0.48	0.68	0.50
13.12	11.76	11.44	11.57	12.98	12.78	12.52	12.25	13.93	13.42
28.70	26.05	27.87	26.62	26.65	30.57	28.20	30.70	30.03	29.28
29.84	28.56	31.00	28.08	27.17	30.42	30.80	30.26	26.58	30.09
-	-	-	-	-	-	-	-	t	-
-	0.07	-	0.14	0.65	0.22	0.08	0.17	0.23	t
0.19	0.37	0.46	0.60	3.25	1.41	0.42	1.33	0.94	0.23
-	-	-	0.05	0.18	-	-	-	0.08	t

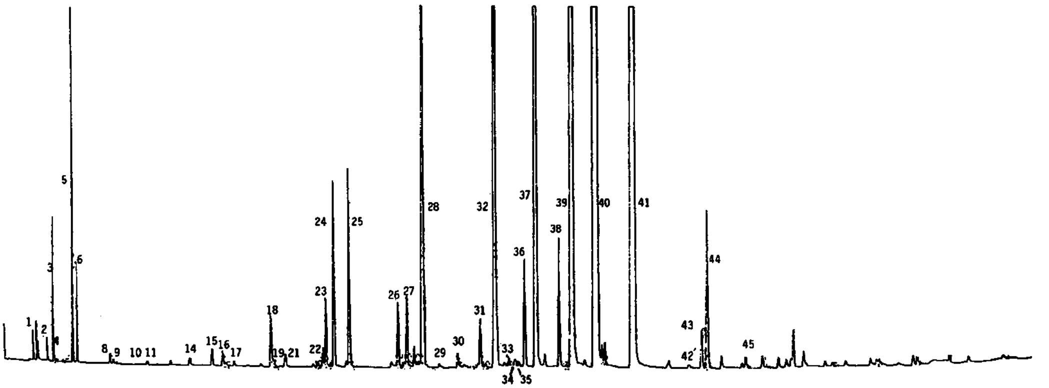

Figure 1. Chromatogram of *Nepeta cataria* L. cv. *citriodora* oil

Table II. Physical and chemical constants of essential oils of *Nepeta cataria* cv. *citriodora*

Year	Batch	n_D^{20}	$[\alpha]_D^{20}$	d_{20}^{20}
1989	3	1.4842	–2.54	0.906
1989	4	1.4820	–2.43	0.896
1989	6	1.4840	–1.71	0.895
1989	7	1.4831	–2.19	0.891
1991	12	1.4793	–3.70	0.904
1991	13	1.4863	–2.63	0.892
1991	15	1.4839	–2.25	0.892

Table III. Oil yields obtained from *Nepeta cataria* cv. *citriodora* harvested at different stages of maturity.

Batch	Harvest date	Distillation Date	Mass distilled (kg)	Total oil obtained (mL)	Yield of oil (mL/kg)	Vegetative stage		
						Buds	Flowers	Faded flowers
1	Jul 19, '89	Jul 19	29.0	25.0	0.86	50	50	
2*	Jul 19, '89	Jul 19	23.0	18.0	0.78	50	50	
3**	Jul 24, '89	Jul 24	5.2	3.6	0.70			
4	Jul 28, '89	Jul 29	4.4	5.0	1.13	30	50	20
5	Aug 2, '89	Aug 4	5.9	7.0	1.18	20	30	50
6***	Aug 2, '89	Aug 4	4.9	7.0	1.40	20	30	50
7	Aug 16, '89	Aug 18	16.9	24.0	1.40		end of flowering	
8	Jun 28, '91	Jun 26	5.2	2.2	0.42			
11	Jul 14, '91	Jul 14	7.0	7.9	1.10			
12***	Jul 14, '91	Jul 31	5.2	7.0	1.20			
13***	Jul 14, '91	Aug 21	6.4	11.0	1.70			
14***	Jul 14, '91	Aug 28	6.6	7.2	1.10			

*Very green plants; **Yellow plants; ***Dry distilled batches which was analyzed by Regnier (3), was found to comprise mainly of citronellol, geraniol, neral and geranial with nepetalactones making up at most about 10% of the mixture.

In 1980, Zamureenko (13) found the same components in oil from the former Soviet Union, but no nepetalactone was determined. In 1981, Dmitriev et al. determined the variations in oil accumulation and chemical composition during the growth cycle and storage of the harvested catnip plants that they referred to as *N. cataria* var. *citriodora* Balb. (14).

N. cataria cv. *citriodora* grows wild in the Drôme region of France. The results of initial work on wild plants have induced local herb growers to cultivate this species and develop pilot-scale industrial production of the oil. We report here the first analytical results obtained in 1989 and 1991 of the oil composition carried out on cultivated plants transplanted from the wild.

Experimental

Plant material: *N. cataria* cv. *citriodora* was harvested in July 1989 and 1991 in the Drôme region when the plants were in full flower. Except for batches 12, 13, 14 and 15, which were produced from dried plant material harvested on 14 July 1991 and distilled 31 July, 21 and 28 August and 3 September, all other oils were isolated from fresly harvested plant material. Oil isolation was performed by steam distillation (2-litre/h) on a stainless steel experimental pilot apparatus fitted with two 10-litre vessels custom built at the laboratories of the Chamber of Agriculture at Nyons, France. Pilot tests were carried out on cultivated plant material distilled in a 2000-litre industrial still at the farm.

Analysis: Physical and chemical characteristics of the oils such as refractive index, density and optical rotation, were determined by standard methods.

Analysis by GC was carried out on a DELSI 121C chromatograph fitted with a 25 m x 0.25 mm CP Wax 52CB capillary column with temperature programming from 50°C (5 min) to 220°C at 2°C/min. Injector and detector temperatures were set at 240°C and 255°C and the split ratio was 1/60.

GC/MS coupling was achieved using a SIGMA 300 chromatograph coupled to an HP 5970 mass spectrometer fitted with a 50 m x 0.3 mm CP Wax column which was temperature programmed from 60°-240°C at 2°C/min. Ionization voltage was 70 eV.

Components were identified by comparison of mass spectra with those reported in the literature (19), calculation of retention indices and also comparing them with our own as well as published data, and by the co-injection with standard compounds.

Results and Discussion

Forty-five components were identified in the oil (Table I, Figure 1). The oil of catnip studied, which was similar to that described elsewhere (3,14,15-17), was composed mostly of citronellal, neral, geranial, citronellol, nerol and geraniol (85 to 95%). In addition, small amounts of other oxygenated monoterpenes were also identified. Monoterpenes were also present, while β-caryophyllene and α-humulene together with their oxides were the only sesquiterpenes found. This may be explained by the variation of chemical composition during the hydrodistillation (18). It was surprising to us that no nepetalactone were found in the oils produced. As a result, we believe that this is a distinguishing feature of this cultivar of *N. cataria*.

As can be seen from Table I the chemical composition of the oil of *N. cataria* cv. *citriodora* varies little during its life cycle (batches 1 to 7). It is apparently not affected by drying the plant material before distillation, or by storage before distillation (batches 13 to 15). Also, large scale distillation (batches 16 and 17) yielded an oil similar to that obtained from lab-prepared oils. Given the consistent chemical composition, it is our belief that production could be optimized by choosing the time of harvest that afforded the highest yield (mid-August). Yields were much lower if plants were harvested earlier in the season (July) (batches 8, 11 and 12) (Table II). The physical and chemical characteristics (refractive index, density and optical rotation) of the batches analyzed were remarkably stable and did not vary with time of production (Table III).

The specific chemical composition of this oil gives it a potentially useful olfactive profile. Its consistent physical and chemical characteristics are not appreciably influenced by production conditions, which remain to be optimized. These features make it a potential complement or replacement for melissa *(Melissa officinalis)* and "verveine citronnée" *(Verbena citriodora)* oils, *Aloysia triphylla* (L'Herit.) Britton (syn. *A. citriodora* Palau) oils used in perfumery and flavorings.

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