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Catnip essential oil: There is more to it than making your cat go crazy

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Abstract
Catnip (*Nepeta cataria*) essential oil shows a wide range of biological activities, not only cat stimulation, but also relaxant, antispasmodic, insect repellent, and allelopathic activities. The essential oil is generally dominated by nepetalactone isomers, but the compositions have shown wide variation depending on phenological cycle and geographical location. Numerous other *Nepeta* species are known and many of those have been characterized in terms of essential oil compositions and biological activities. This review presents an overview of the volatile phytochemistry of catnip (*Nepeta cataria*), its biological activities, and a survey of recent reports on *Nepeta* essential oils.

Keywords: *Nepeta*, nepetalactone, essential oil, bioactivity

1. Introduction
Catnip (*Nepeta cataria*) is a member of the mint family (Lamiaceae). The plant is well known for its behavioral effect on domestic cats (*Felis catus*) [1]. Not only are domestic cats affected, but other members of the cat family (Felidae) are also affected. Lions (*Panthera leo*), leopards (*Panthera pardus*), jaguars (*Panthera onca*), snow leopards (*Panthera uncia*), ocelots (*Leopardus pardalis*), and margays (*Leopardus wiedii*), are particularly sensitive to catnip. Tigers (*Panthera tigris*), cougars (*Puma concolor*), servals (*Leptailurus serval*), and bobcats (*Lynx rufus*) are apparently little affected, however [2].
Catnip has been used as an herbal medicine for many years [3]. Catnip tea and infusions have been used to treat nervous problems. Catnip tea was used as an antispasmodic to treat infantile colic, as a carminative to treat flatulence, and to assist parturition and evacuate the placenta during birth. Catnip juice from the herb was taken to induce menstruation. Catnip poultice has been used to treat toothache, sore breasts of nursing mothers, hemorrhoids, and generally to reduce swelling. Catnip herb has been smoked to relieve respiratory ailments. Catnip had brief popularity in the 1960s as a hallucinogenic drug in place of marijuana or as a filler in marijuana.

2. Catnip Essential Oil
The volatile chemistry of *N. cataria* is well known and is dominated by the iridoid nepetalactones [4]. There are eight possible stereoisomers of nepetalactone (Figure 1), of which six have been found in nature [5], and three are the principal isomers found in *N. cataria*, 4aα,7α,7aα-nepetalactone, 4aα,7α,7aβ-nepetalactone, and 4aα,7β,7aα-nepetalactone. The predominant stereoisomers in *N. cataria* are 4aα,7α,7aα-nepetalactone (up to 90%) [4, 6] and 4aα,7α,7aβ-nepetalactone (up to 78%) [4, 7]. The cat attractant is the 4aα,7α,7aα-isomer [8]. This stereoisomer is also the sex pheromone of the cabbage aphid, *Brevicoryne brassicae* [9], the greenbug, *Schizaphis graminum*, the pea aphid, *Acyrthosiphon pisum*, the black bean aphid, *Aphis fabae*, the bird-cherry aphid, *Rhopalosiphum padi*, the peach-potato aphid, *Myzus persicae*, and the potato aphid, *Macrosiphum euphorbiae* [10].

3. Other *Nepeta* Essential Oils
In addition to *N. cataria*, there are numerous other species of *Nepeta*. The Missouri Botanical Garden currently lists 795 taxa in *Nepeta*, which includes many different subspecies, varieties, and cultivars [11]. The phytochemistry of many of these have been reported [4, 12]. A summary of nepetalactone concentrations in recent reports of *Nepeta* essential oil analyses is summarized in Table 1. It is obvious that the chemistry of *N. cataria* as well as different species of *Nepeta* is highly variable and likely depends on environmental factors.

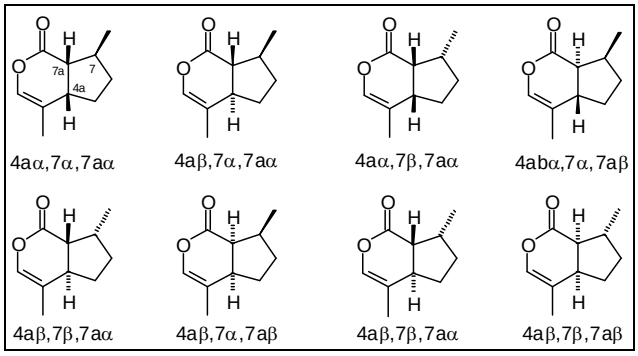

Fig 1: Possible stereoisomers of nepetalactone.

4. Biological Activities of *Nepeta* Essential Oils

4.1 Antimicrobial Activity

A *N. cataria* essential oil sample that was composed of 4aα,7α,7aβ-nepetalactone (70.4%), 4aα,7α,7aα-nepetalactone (6.0%), and 4aα,7β,7aα-nepetalactone (2.5%), was screened for antimicrobial activity against a panel of 24 bacteria and 16 fungi [13]. The oil showed excellent activity against the bacteria *Klebsiella pneumoniae*, *Bacillus macerans*, and *Staphylococcus aureus*, and the fungi *Aspergillus flavus*, *A. veriecolor*, *Fusarium solani*, *F. tabacinum*, *Rhizopus* sp., *Rhizoctonia solani*, and *Trichophyton mentagrophytes*. The essential oil of *N. crispa*, rich in 4aα,7α,7aβ-nepetalactone, showed good antimicrobial activity against *Bacillus subtilis* and *Candida albicans* [14].

Table 1: Nepetalactone stereoisomers in essential oils from different species of *Nepeta*.

Nepeta species	Country of Origin	Ref.	Nepetalactone Stereoisomer					
			4aα,7α,7aα	**4aα,7α,7aβ**	**4aα,7β,7aα**	**4aα,7β,7aβ**	**4aβ,7α,7aβ**	**4aβ,7α,7aα**
N. cataria	France	[15]	73.3	0.4	1.1			
N. cataria	Turkey	[13]	6.0	70.4	2.5			
N. cataria	Iran	[16]	31.2	55.0				
N. argolica	Greece	[17]	3.5-10.5	64.5-91.3				
N. clarkei	UK	[18]	0.8					
N. crassifolia	Iran	[19]	92.6	tr			0.6	tr
N. crispa	Iran	[14]	0.1	20.3			1.9	
N. deflersiana	Yemen	[20]	3.0	19.2		4.6		
N. deflersiana	Yemen	[20]	77.7	0.7		0.2		
N. eremophila	Iran	[21]	2.6				73.3	
N. grandiflora	UK	[18]	1.0					
N. meyeri	Iran	[22]	3.4	53.2				
N. nuda	Turkey	[23]	37.6	37.6			2.1	
N. nuda	Tajikistan	[24]	4.7	1.8	21.0	0.9		
N. parnassica	Greece	[4]	1.5	22.0		7.9		
N. parnassica	Greece	[4]	17.3	8.9		2.0		
N. persica	Iran	[25]	26.5	0.5				
N. racemosa	Iran	[26]	24.4	25.6			33.6	
N. sintenisii	Iran	[27]		1.6			23.4	

4.2 Insect Repellent / Insecticidal Activity

Of the stereoisomers present in *N. cataria*, 4aα,7α,7aβ-nepetalactone showed better insect repellent activity toward the German cockroach (*Blattella germanica*) than did the 4aα,7α,7aα-isomer, the essential oil itself, or *N*,*N*-diethyl-*m*-toluamide (DEET) [28]. House flies (*Musca domestica*), however, were more responsive to 4aα,7α,7aα-nepetalactone [29]. In addition, mosquitoes (*Culex pipiens*) showed high repellency to surfaces treated with catnip essential oil. 4aα,7α,7aβ-Nepetalactone showed insecticidal activity against *Pogonomyrmex* sp. ants [4]. Catnip oil was found to be superior to DEET as an insect repellent against the stable fly, *Stomoxys calcitrans* [30]. Schultz and co-workers found that catnip oil (55% 4aα,7α,7aα-nepetalactone, 32% 4aα,7α,7aβ-nepetalactone) showed superior six-hour repellent activity against cockroaches (*Periplaneta americana*) and better short-term repellent activity against house flies (*Musca domestica*) than DEET [31].

Catnip oil (~80% "nepetalactone") was found to exhibit topical repellency to three species of mosquitoes (*Aedes aegypti*, *Anopheles albimanus*, and *Anopheles quadrimaculatus*), but less effective than DEET [32]. In another study, catnip oil (36% 4aα,7α,7aα-nepetalactone, 45% 4aα,7α,7aβ-nepetalactone) showed mosquito-repellent activity against *Aedes albopictus*, *Aedes aegypti*, and *Culex pipiens pallens*, with better six-hour protection than DEET [33]. Catnip oil (composition not reported) showed mosquito repellent activity against both *Aedes aegypti* and *Anopheles harrisoni* [34]. The essential oil of *N. parnassica*, rich in 4aα,7α,7aβ-nepetalactone, showed notable mosquito repellent activity against *Culex pipiens molestus* [4]. Two different catnip oils (one with 92% 4aα,7α,7aα-nepetalactone and the other with17.0% 4aα,7α,7aα-nepetalactone and 69.8% 4aα,7α,7aβ-nepetalactone) both showed better mosquito-repellent activity against *Anopheles gambiae* and *Culex quinquefasciatus* than DEET [35]. Interestingly, the catnip oils showed better mosquito-repellent activity than either of the purified stereoisomers alone, indicating synergistic activity between the isomers and possibly other components in the essential oils. Catnip oil has also shown repellent activity against the brown ear tick, *Rhipicephalus appendiculatus*, and the red poultry mite, *Dermanyssus gallinae* [35].

4.3 Other Bioactivities

Catnip oil has shown spasmolytic and myorelaxant activities, which may explain its traditional use in colic, diarrhea, cough, and asthma [36]. The main component of the essential oil of *N. caesarea* from Turkey was 4aα,7α,7aα-nepetalactone (92-95%) [37]. This essential oil showed significant analgesic activity, in addition to marked sedation, which was also blocked by naloxone, indicating involvement of opioid receptors. Moreover, the oil was only active on mechanical, not thermal, analgesic response which suggests selectivity for specific opioid receptor subtypes, excluding μ-opioid

receptors. *N. cataria* essential oil has shown allelopathic (phytotoxic) effects, inhibition of seed germination as well as seedling growth on several plant species (*Hordeum spontaneum*, *Taraxacum officinale*, *Avena fatua*, *Lipidium sativum*, *Nepeta cataria*, and *Ocimum basilicum*) [16]. Thus, *N. cataria* essential oil can be considered as an allelochemical agent in formulation of natural herbicides in weed control.

5. Conclusions

Catnip (*Nepeta cataria*) essential oil shows a wide range of biological activities, not only cat stimulation, but also relaxant, antispasmodic, insect repellent, and allelopathic activities. The essential oil is generally dominated by nepetalactone isomers, but the compositions have shown wide variation depending on seasonal, environmental, and geographical factors. There are numerous *Nepeta* species known and although many of those have been characterized in terms of essential oil compositions and bioactivities, there are many more to be investigated and additional biological activities to be screened.

6. References

1. Tucker AO, Tucker SS. Catnip and the catnip response. Economic Botany, 1988; 42:214-221.
2. Hill JO, Pavlik EJ, Smith GL, Burghardt GM, Coulson PB. Species-characteristic responses to catnip by undomesticated felids. Journal of Chemical Ecology. 1976; 2:239-253.
3. Grognet J. Catnip: Its uses and effects, past and present. Canadian Veterinary Journal. 1990; 31:455-456.
4. Gkinis G, Tzakou O, Iliopoulou D, Roussis V. Chemical composition and biological activity of *Nepeta parnassica* oils and isolated nepetalactones. Zeitschrift für Naturforschung. 2003; 58c:681-686.
5. Dictionary of Natural Products on DVD, v 25.1, CRC Press, Boca Raton, FL, 2016.
6. Baser KHC, Kirimer N, Kurkcuoglu M, Demirci B. Essential oils of *Nepeta* species growing in Turkey. Chemistry of Natural Compounds. 2000; 36:356-359.
7. Mohammadi S, Saharkhiz MJ. Changes is essential oil content and composition of catnip (*Nepeta cataria* L.) during different developmental stages. Journal of Essential Oil Bearing Plants. 2011; 14:396-400.
8. Hatch RC. Effect of drugs on catnip (*Nepeta cataria*)-indiced pleasure behavior in cats. American Journal of Veterinary Research. 1972; 33:143-155.
9. Gabryś BJ, Gadomski HJ, Klukowski Z, Pickett JA, Sobota GT, Wadhams LJ *et al*. Sex pheromone of cabbage aphid *Brevicoryne brassicae*: Identification and field trapping of male aphids and parasitoids. Journal of Chemical Ecology. 1997; 23:1881-1890.
10. Liblikas I, Santangelo EM, Sandell J, Baeckström P, Svensson M, Jacobsson U *et al*. Simplified isolation procedure and interconversion of the diastereomers of nepetalactone and nepetalactol. Journal of Natural Products. 2005; 68:886-890.
11. Tropicos.org. Missouri Botanical Garden, http://www.tropicos.org/, accessed January 4, 2017.
12. Formisano C, Rigano D, Senatore F. Chemical constituents and biological activities of *Nepeta* species. Chemistry & Biodiversity. 2011; 8:1783-1818.
13. Adiguzel A, Ozer H, Sokmen M, Gulluce M, Sokmen A, Kilic H. *et al*. Antimicrobial and antioxidant activity of the essential oil and methanol extract of *Nepeta cataria*. Polish Journal of Microbiology. 2009; 58:69-76.
14. Sonboli A, Salehi P, Yousefzadi M. Antimicrobial activity and chemical composition of the essential oil of *Nepeta crispa* Willd. from Iran. Zeitschrift für Naturforschung. 2004; 59c:653-656.
15. Heuskin S, Godin B, Leroy P, Capella Q, Wathelet JP, Verheggen F *et al*. Fast gas chromatography characterisation of purified semiochemicals from essential oils of *Matricaria chamomilla* L. (Asteraceae) and *Nepeta cataria* L. (Lamiaceae). Journal of Chromatography A. 2009; 1216:2768-2775.
16. Saharkhiz MJ, Zadnour P, Kakouei F. Essential oil analysis and phytotoxic activity of catnip (*Nepeta cataria* L.). American Journal of Essential Oils and Natural Products. 2016; 4(1):40-45.
17. Tzakou O, Harvala c, Galati EM, Sanogo R. Essential oil composition of *Nepeta argolica* Bory et Chaub. subsp. *argolica*. Flavour and Fragrance Journal. 2000; 15:115-118.
18. Birkett MA, Bruce TJA, Pickett JA. Repellent activity of *Nepeta grandiflora* and *Nepeta clarkei* (Lamiaceae) against the cereal aphid, *Sitobion avenae* (Homoptera: Aphididae). Phytochemistry Letters. 2010; 3:139-142.
19. Dabiri M, Sefidkon F. Chemical composition of *Nepeta crassifolia* Boiss. & Buhse oil from Iran. Flavour and Fragrance Journal. 2003; 18:225-227.
20. Al Maqtari MA, Alhamzy EH, Saeed MA, Ali NAA, Setzer WN. Chemical composition and antioxidant activity of the essential oils from different aromatic plants grown in Yemen. Journal of Global Biosciences. 2014; 3:390-398.
21. Sefidkon F, Jamzad Z, Mirza M. Chemical composition of the essential oil of five Iranian *Nepeta* species (*N. crispa*, *N. mahanensis*, *N. ispahanica*, *N. eremophila* and *N. rivularis*). Flavour and Fragrance Journal. 2006; 21:764-767.
22. Sefidkon F, Shaabani A. Essential oil composition of *Nepeta meyeri* Benth. from Iran. Flavour and Fragrance Journal. 2004; 19:236-238.
23. Kökdil G, Kurucu S, Topçu G. Composition of the essential oil of *Nepeta nuda* L. ssp. *albiflora* (Boiss.) Gams. Flavour and Fragrance Journal. 1996; 11:167-169.
24. Mamadalieva NZ, Sharopov FS, Satyal P, Azimova SS, Wink M. Chemical composition of the essential oils of some Central Asian *Nepeta* species (Lamiaceae) by GLC-MS. Natural Product Communications. 2016; 11:1891-1893.
25. Javidnia K, Miri R, Safavi F, Azarpira A, Shafiee A. Composition of the essential oil of *Nepeta persica* Boiss from Iran. Flavour and Fragrance Journal. 2002; 17:20-22.
26. Dabiri M, Sefidkon F. Chemical composition of the essential oil of *Nepeta racemosa* Lam. from Iran. Flavour and Fragrance Journal. 2003; 18:157-158.
27. Sajjadi SE. Analysis of the essential oil of *Nepeta sintenisii* Bormn. from Iran. DARU Journal of Pharmaceutical Sciences. 2005; 13:61-64.
28. Peterson CJ, Nemetz LT, Jones LM, Coats JR. Behavioral activity of catnip (Lamiaceae) essential oil components to the German cockroach (Blattodea: Blattellidae). Journal of Economic Entomology. 2002; 95:377-380.
29. Schultz G, Peterson C, Coats J. Natural insect repellents: Activity against mosquitoes and cockroaches. In: Rimando AM, Duke SO. (Eds), Natural Products for Pest Management, American Chemical Society, Washington,

DC, 2006, 168-181.
30. Zhu JJ, Berkebile DR, Dunlap CA, Zhang A, Boxler D, Tangtrakulwanich K *et al*. Nepetalactones from essential oil of *Nepeta cataria* represent a stable fly feeding and oviposition repellent. Medical and Veterinary Entomology. 2012; 26:131-138.
31. Schulz G, Simbro E, Belden J, Zhu J, Coats J. Catnip, *Nepeta cataria* (Lamiales: Lamiaceae) – A closer look: Seasonal occurrence of nepetalactone isomers and comparative repellency of three terpenoids to insects. Environmental Entomology. 2004; 33:1562-1569.
32. Bernier UR, Furman KD, Kline DL, Allan SA, Barnard DR. Comparison of contact and spatial repellency of catnip oil and *N*,*N*-diethyl-3-methylbenzamide (Deet) against mosquitoes. Journal of Medical Entomology. 2005; 42:306-311.
33. Zhu J, Zeng X, YanMa, Liu T, Qian K, Han Y *et al*. Adult repellency and larvicidal activity of five plant essential oils against mosquitoes. Journal of the American Mosquito Control Association. 2006; 22:515-522.
34. Polsomboon S, Grieco JP, Achee NL, Chauhan KR, Tanasinchayakul S, Pothikasikorn J. *et al*. Behavioral responses of catnip (*Nepeta cataria*) by two species of mosquitoes, *Aedes aegypti* and *Anopheles harrisoni*, in Thailand. Journal of the American Mosquito Control Association. 2008; 24:513-519.
35. Birkett MA, Hassanali A, Hoglund S, Pettersson J, Pickett JA. Repellent activity of catmint, *Nepeta cataria*, and iridoid nepetalactone isomers against Afro-tropical mosquitoes, ixodid ticks and red poultry mites. Phytochemistry. 2011; 72:109-114.
36. Gilani AH, Shah AJ, Zubair A, Khalid S, Kiani J, Ahmed A *et al*. Chemical composition and mechanisms underlying the spasmolytic and bronchodilatory properties of the essential oil of *Nepeta cataria* L. Journal of Ethnopharmacology. 2009; 121:405-411.
37. Aydin S, Beis R, Oztürk Y, Baser KH. Nepetalactone: A new opioid analgesic from *Nepeta caesarea* Boiss. Journal of Pharmacy and Pharmacology. 1998; 50:813-817.