Volatile organic compounds of six French Dryopteris species: natural odorous and bioactive resources
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Aerial parts of six Dryopteris species collected in France were investigated for volatile organic compounds (VOC) for the first time. Fifty-three biosynthesized VOC from the shikimic, lipidic and terpenic pathways were identified using gas chromatography/mass spectrometry. Many bioactive polyketide compounds as filicinic derivatives (from 8.5 to 23.5%) and phloroglucinol derivatives (from 8.2 to 53.8%) with various pharmacological activities were detected in high amount from five analysed Dryopteris species, in particular D. oreades and D. borreri, i.e., propionyfilicinic acid (> 10% in D. affinis and D. ardechensis) and 2,6-dihydroxy-4-methoxy-3-methylbutyrophenone (aspidinol) (19.1% and 14.6% in D. oreades and D. borreri, respectively). Several terpenic derivatives with a low odor threshold were identified, i.e., carota-5,8-diene (from 2.5 to 18.4%: floral, woody or fresh bark note), (Z)-nerolidol (> 10% for D. borreri and D. cambrensis; floral or woody odor), α-selinene (> 7% for D. ardechensis; woody-spicy odor), and aristolene (12.8% in D. affinis; flower, sweet odor). The main isoprenoid derivatives were 4-hydroxy-5,6-epoxyionol, 3-oxoα-ionol and 4-oxo-7,8-dihydro-β-ionone (essentially in D. remota), whereas the main aromatic compound was 4-hydroxy-3-methoxyacetophenone (20.6% and 12.6% in D. cambrensis and D. borreri, respectively) and the main lipid derivative was 1-octen-3-ol with a mushroom-like odor (from 0.4 to 8.3%). Dryopteris species resources are of great interest as a reservoir of odorous and bioactive compounds.

Keywords: Fern, Volatile Organic Compounds, Carota-5,8-diene, (E)-Nerolidol, Phloroglucinols, Filicinic derivatives, 1-Octen-3-ol, Biological activities.

Dryopteridaceae is a subcosmopolitan family including approximately one thousand species and with only two native genera in Western Europe: Dryopteris Adans and Polydictium Roth [1a]. Dryopteris affinis group is constituted in Western Europe by D. affinis (R. Lowe) Fras.-Jenk., D. borreri (Newm.) Newm. ex Oberh. & Tavel, D. cambrensis (Fras.-Jenk.) Beitel & W.R. Buck, the uncommon D. pseudosuisuncta (Tavel ex Fras.-Jenk.) Fras.-Jenk. and a very recently reported species, i.e., the rare D. lacunosa S. Jess., Zemner, Ch. Stark & Bujnoch [1b,1c].

Dryopteris species have been mainly investigated for phloroglucinol derivatives due to their various pharmacological activities for humans and many ethnoveterinary uses, i.e., schistosomicidal, antimicrobial, antitumor, anti-inflammatory and antioxidant properties [2a-2m].

Few Dryopteris species are known having an odor. D. villarii (Bellardi) Schinz & Thell. and D. mindshelkensis Pavlov have a balsamic odor when crushed [3a]. D. aemula (Aiton) O. Kuntze and D. crispsfolia Rashbach, Reichstein & Vida smell like newly mown hay, whereas D. fragrans (L.) Schott has a spicy odor when dry [3b]. Very few data have been recently reported on the volatile organic compounds (VOC) of Dryopteris species and none from the D. affinis group. D. filix-mas (L.) Schott contains in particular (E)-nerolidol (38.7%) with floral, woody or fresh bark odor [4a], acylfilicinic acids and 1-octen-3-ol [4b]. D. dilatata (Hoffm.) A. Gray odor is characterized by (E)-2-hexenal and (Z)-3-hexenol, responsible for the “green odor” and 1-octen-3-ol [4c], whereas the odor of D. fragrans is based on terpenic derivatives such as 10-hydroxy-15-oxo-a-cadinol, albicyan acetate, a-cadinene and albicinal [4d].

Fresh aerial parts of three main species from the D. affinis group, i.e., D. affinis, D. borreri, and D. cambrensis, and three related species, D. oreades Fomin, D. ardechensis Fraser-Jenkins and D. remota (A. Braun ex Döll) Druce were investigated for their volatile profiles using GC-MS. The VOC were identified as previously reported [4b, 4c,4e,4f,5a].

Fifty-three components biosynthesized from the shikimic, lipidic and terpenic pathways were identified from the concentrated diethyl ether extracts of the six Dryopteris species (Table 1).

D. affinis was dominated by a large number of terpenic derivatives (49.5%), i.e., carota-5,8-diene (14.7%; floral, woody or fresh bark note), aristolene (12.8%; flower, sweet odor) [5b], (E)-nerolidol (5.9%; with floral odor), aristol-a(10),8-diene (3.4%), α-selinene (3%); amber type odor or sweet-woody, slightly peppery odor [5c]), β-selinene (2.5%; mild, woody, warm, herbaceous peppery odor) and eremophilene (2.4%). It also contained polyketide derivatives (36.4%) as filinic compounds (19.7%; [5d]), i.e., propionyfilicinic acid (11%) and acetylfilicinic acid (6.7%), and phloroglucinol compounds (16.7%). The main lipid derivative was 1-octen-3-ol (6.9%; mushroom-like odor), well-known for many mushrooms [5e-5g] and, previously reported for ferns, including D. filix-mas and D. dilatata, horsetails and Angiosperms [4b,4c,5a,5h].
The volatile pattern of *D. borreri* was based on polyketide derivatives (45.5%), mainly phloroglucinols (28.8%), i.e., 2,6-dihydroxy-4-methoxybutyrophenone, also named aspidinol (14.6%), 2,6-dihydroxy-4-methoxyvalerophenone (7.2%) and 2,6-dihydroxy-3-methyl-4-methoxypropionophenone (6.7%), as well as filicinic compounds (16.8%), in particular propionylfilicinic acid (7.7%). The investigation indicated a lower amount of terpenic compounds (22.3%). The volatile pattern of *Dryopteris* indicated a lower amount of terpenic compounds (22.3%).
The broad spectrum of volatile components identified in *D. cambrensis* contributed to its complex smell, including isoprenoid, polyketide, aromatic and terpenic derivatives and also an odorous lipid derivative, 1-octen-3-ol. The terpenic profile (32.8%) was based on carota-5,8-diene (12.7%), (E)-nerolidol (12.2%) and eremophilenne (4.4%). The fern also contained a high level of aromatic components (24.8%), mainly 4-hydroxy-3-methoxyacetophenone (20.6%). Table 1 lists the polyketide derivatives (22.3%) divided into flicinic compounds (13.5%), i.e., acetylflicinic acid (4.9%), propionylflicinic acid (4.4%) and butyrylflicinic acid (3.1%), as well as phloroglucinols (8%), mainly 2,6-di-hydroxy-4-methoxyvalerophenone (7%) and aspidinol (1.8%). The main isoprenoids (15.7%) were β-ionone derivatives, i.e., 4-hydroxy-7,8-dihydro-β-ionone (3.1%) and 4-oxo-7,8-dihydro-β-ionone (2.5%), already found in *Dryopteris dilatata* and *Phegopteris connectilis* (Michx) Watt, and in *Gymnocarpium dryopteris* (L.) Newman, respectively [4c].

The volatile content of *D. oreades* was mainly dominated by polyketide derivatives (62.3%), essentially phloroglucinols (53.8%) as 2,6-di-hydroxy-4-methoxy-3-methylbutyrophenone (aspidinol; 19.1%), 2,6-di-hydroxy-4-methoxyvalerophenone (12.9%), 2,4,6-trimethoxypropiophenone (6%) and 2,5-di-hydroxy-4-methoxybutyrophenone (desaspidinol; 2.7%), as well as flicinic components (8.8%), in particular butyrylflicinic acid (4.3%). It should be noted that aspidinol or desaspidinol are well-known for their anthelmintic, anti-tumor and antibacterial properties at very low concentration [6a,6b,2e]. The main terpenes were carota-5,8-diene (18.4%) and (E)-nerolidol (4.3%), and the major lipid derivative was still 1-octen-3-ol (3%).

The major VOCs from *D. ardechensis* were terpenic derivatives (48.5%), i.e., carota-5,8-diene (9.3%), (E)-nerolidol (7.9%), α-selinene (7.8%), aristola-1(10),8-diene (6.6%) and linalool (2.7%; orange flower odor [6c]). It should be noted that eremophilenne, valencene, α- and β-selinene and 7-epi-α-selinene have the same biosynthetic pathway; several of them have antifungal or insecticidal properties [6d-6g]. The polyketide pathway (31.6%) produced three flicinic compounds (23.5%), namely propionylflicinic acid (10.1%), valeroylflicinic acid (5.2%) and butyrylflicinic acid (4.4%), and only one phloroglucinol compound, i.e., 2,6-di-hydroxy-4-methoxyvalerophenone (8.2%). Several isoprenoid derivatives, such as 4-hydroxy-β-ionone (1.4%), 3-oxo-α-ionone (1.2%) and β-ionone (1.1%) with a violet flower odor [6c] were also identified. Six lipid derivatives (3.2%), such as 3-octanol, decanal and 1-octen-3-ol completed the VOC content of *D. ardechensis*.

*D. remota* showed the highest amount of isoprenoid derivatives (72%), including eleven identified compounds. The VOC profile was widely dominated by 4-hydroxy-5,6-epoxionol (19.1%), 4-oxo-7,8-dihydro-β-ionone (8.1%) and 3-oxo-α-ionol (5.8%; spicy odor). It also contained several odorous C₈ to C₁₀ derivatives (20.7%), such as 1-octen-3-ol (8.3%), 3-hexenoic acid (3.1%; honey odor somewhat waxy fruity and herbal [6h]), nonanal (2.6%; orange and green scent [5j]), 3-octanol (2.5%; mushroom-like odor and butyryl) used in the food, flavor, cosmetic, pharmaceutical, tobacco and perfume industries [6i], and 2-hexenoic acid (2.1%), with a powerful fruity odor. Benzyl alcohol (2.9%; walnut flavor [6j]) and benzaldehyde (1.8%; bitter almond odor [4f]) emphasized the great interest of *D. remota* for aroma and flavor companies. Regarding the eight *Dryopteris* species investigated for VOC (fresh aerial part) in Table 1 and previously by the authors [4b,4c,5a], *D. remota* and *D. dilatata* do not contain any flicinic derivatives, phloroglucinols or (E)-nerolidol.

This paper emphasizes that ferns are novel resources for natural compounds. Table 1 demonstrates that *Dryopteris* species can generate a broad spectrum of VOC for both odorous and bioactive ingredients. Within the former, terpenic compounds with floral, fruity or spicy notes, i.e., linalool, (E)-nerolidol, and ionone derivatives are the main fragrant components required for aroma applications. Within the last, phloroglucinol and flicinic derivatives are of various biological interests for the pharmaceutical as well as the cosmetic and hygiene products industries. Because only aerial parts have been used, intensive culture of ferns may be developed to extract biomolecules from the natural resources without any plant destruction. Natural compounds can also be used for hemisynthesis of di- to polymeric bioactive derivatives. *Dryopteris* species resources are indeed of great interest as candidates for bioactive aroma ingredients and for the discovery of new drugs with various therapeutic applications due to their potential antioxidant, antibacterial and antitumor promoting properties [7a-7d].

**Plant material:** Fresh aerial parts of ferns were collected as follows: *Dryopteris affinis*: 14/07/2009, Gimel les Cascades (Corrèze), *D. borreri* and *D. cambrensis* 30/05/2010, Saint Etienne Vallée Française, (Ardèche), *D. oreades* 13/07/2011, Murat-le-Quaire, (Puy de Dôme), *D. ardechensis* and *D. remota*: 31/08/2010, Botanical Garden of Strasbourg. Voucher specimens are deposited at the Laboratory of Botany (Faculty of Pharmacy, Limoges, France).

**Plant part and GC-MS analyses:** Fresh aerial parts of 6 *Dryopteris* species were treated and investigated for volatile organic compounds as previously reported [4b,4c,5a].

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**References**


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