

NAPHTHOQUINONES CONTENT OF SOME SUNDEWS (*DROSERA* L)

JOZEF KOVÁČIK • MIROSLAV REPČÁK • Department of Botany • Institute of Biology and Ecology
 • Faculty of Science • P. J. Šafárik University • Mánesova 23 • 041 67 Košice • Slovak Republic
 • jozkovacik@yahoo.com

Keywords: chemistry: *Drosera*.

Introduction

Naphthoquinones are distributed within eight families of flowering plants and are known also in fungi, lichens, and in some spiders. These compounds are characteristic for Droseraceae; they were detected in genera *Dionaea*, *Aldrovanda* and *Drosophyllum* (Culham & Gornall, 1994). Plumbagin (5-hydroxy-2-methyl-1,4-naphthoquinone) and 7-methyljuglone (5-hydroxy-7-methyl-1,4-naphthoquinone) are two main naphthoquinones of the genus *Drosera* (Bonnet *et al.*, 1984). Plumbagin was also detected in the genus *Nepenthes* and in the genera *Triphyophyllum* and *Dioncophyllum* of Dioncophyllaceae. Within angiosperms, 7-methyljuglone is the predominant quinone in Ebenaceae and plumbagin in Plumbaginaceae and Iridaceae (Culham & Gornall, 1994). Aglycones droserone (3,5-dihydroxy-2-methyl-1,4-naphthoquinone) and hydroxydroserone (3,5,8-trihydroxy-2-methyl-1,4-naphthoquinone) are present in minor amounts (Šamaj *et al.*, 1999). Other known minor naphthoquinones are diomuscione and diomuscipulone, identified in *Dionaea muscipula* (Miyoshi *et al.*, 1984). In sundews these compounds probably act as allelopathic, molluscidal, antimicrobial, and antifeedant chemicals (Šamaj *et al.*, 1999).

The taxonomic significance of naphthoquinones within Droseraceae was studied by Culham & Gornall (1994). They found that their occurrences within various species were not useful taxonomic tools because closely related taxa (e.g., subspecies of *Drosera stolonifera*) did not have the same naphthoquinone. Mainly *D. rotundifolia* was studied for naphthoquinones content due to its pharmacological use (e.g., Galambosi *et al.*, 2000; Repčák *et al.*, 2000). The 7-methyljuglone content in *D. rotundifolia* and *D. anglica* in dependence on ontogenetic phases of the leaf were studied by Repčák *et al.* (2000). The highest content was found in young and adult green leaves, while it was lower in older leaves.

In this paper, the content of 7-methyljuglone and plumbagin was studied in several non-European *Drosera* species.

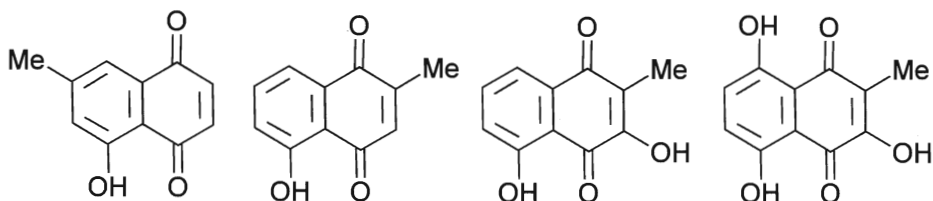


Figure 1: From left to right, 7-methyljuglone, plumbagin, droserone, hydroxydroserone.

Materials and Methods

Plants were cultivated in a greenhouse of the Botanical Garden of P. J. Šafárik University at Košice (Slovak Republic) in pots with peat and were watered with distilled water. For 7-methyljuglone and plumbagin estimation, we harvested fully developed leaves of comparable age from six different plants of each species. Fresh material was homogenized and extracted with

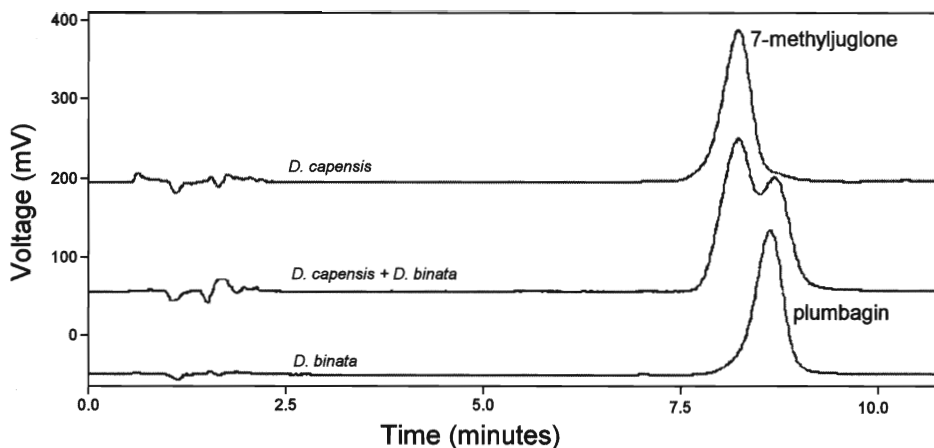


Figure 2: HPLC chromatograms of 7-methyljuglone and plumbagin in extracts from fresh leaves of *Drosera capensis*, *D. binata*, and their mixture.

benzene, evaporated to dryness, dissolved in methanol, and analysed by an isocratic HPLC system. Compounds identity were detected according to their T_R (retention time). UV-VIS spectrum was measured during the analysis to confirm the identity of naphthoquinones. Juglone (Fluka) was used as an internal standard. HPLC conditions: column Biospher SI C 18, 7 μm (Tessek, Prague, Czech Rep.) – 3.3×150 mm, flow rate 0.5 ml min^{-1} . The mobile phase was 50 % acetonitrile (Merck). The detection was performed at 421 nm.

Results and Discussion

We detected 7-methyljuglone in nine out of eleven analysed species and plumbagin in *D. binata* and *D. prolifera*. Very different minimal and maximal values in each species shown in Table 1 could reflect different leaf age and support the well-known fact that naphthoquinone content is negatively correlated with the age of tissue (Repčák & Galambosi, 1994). It is difficult to collect the leaves from the same position on the stem, e.g., in sundews forming leaf rosettes. In spite of this fact, on the basis of naphthoquinone content, we can divide the analysed species into three groups.

The first group, with the highest content of these compounds, is represented by *D. collinsiae*, *D. capensis*, and *D. binata*. More extensive quantitative data were published by Caniato *et al.* (1989). In aboveground parts in *D. binata*, they found a mean plumbagin content 0.23-0.31 % (per unit fresh weight). For this species, we found 0.31 % of plumbagin in fresh leaves. In aboveground parts in *D. capensis*, they found 0.10-0.11 % (FW) of 7-methyljuglone. For this species, we found a value of 0.36 % in fresh leaves. Note that in the sepals and the pistil of *D. capensis*, we detected 7-methyljuglone and, in the same parts of *D. binata* flower, we detected plumbagin.

The second group (*D. communis*, *D. venusta*, *D. admirabilis*, and *D. spathulata*) had a medium content of the analysed compounds but 3-5 times smaller when compared to the first group. No quantitative data referring the content of 7-methyljuglone in some species of this group have been found in the literature.

The third group with low content of the analysed compounds includes *D. burkeana*, *D. aedae*, and *D. hamiltonii*. They contain approximately 10-times less 7-methyljuglone in comparison with the first group. The position of *D. prolifera* is somewhere in between the first and second group. The variance of values is narrow what can be satisfactorily explained by the shape of leaf rosette when it is easy to determine the leaves of the same age on different plants.

As reported in the literature (Culham & Gornall, 1994), naphthoquinones are present in all four genera of the *Droseraceae*. The plumbagin content in *Aldrovanda vesiculosa* collected from

7-methyljuglone	X±SD	min.	max.
<i>Drosera collinsiae</i>	46.0±12.6 a	24.7	61.6
<i>Drosera capensis</i>	40.8±7.39 ab	33.0	50.5
<i>Drosera communis</i>	9.14±5.05 cd	2.63	14.9
<i>Drosera venusta</i>	8.54±3.25 cd	7.16	11.6
<i>Drosera admirabilis</i>	8.19±2.99 cd	4.63	13.0
<i>Drosera spathulata</i>	7.88±5.42 cd	3.18	16.1
<i>Drosera burkeana</i>	4.93±3.32 d	1.26	8.86
<i>Drosera adalae</i>	4.03±2.14 d	1.80	6.69
<i>Drosera hamiltonii</i>	3.83±2.34 d	1.26	7.34
Plumbagin			
<i>Drosera binata</i>	30.3± 8.70 b	22.3	46.2
<i>Drosera prolifera</i>	18.7±1.66 c	16.9	21.5

Table 1: Naphthoquinones content in *Drosera* species (mg g^{-1} of dry weight). Values in the vertical column followed by the same letter do not differ significantly at $P < 0.05$ by Tukey's pairwise comparison; n=6; X, mean value; SD, standard deviation; min./max., minimal/maximal detected value.

different sites or originating from different continents is similar to the content of naphthoquinones in the first group with the highest content of these compounds (for comparison see another paper in this issue of Carnivorous Plant Newsletter; Adamec, *et al.* 2006).

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