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Furo- and pyranocoumarins from plant species *Angelica silvestris* and *Peucedanum austriacum*

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An investigation of the coumarin content of plant species *Angelica silvestris* (roots and fruits) and *Peucedanum austriacum* (Jacq.) Koch (roots), both belonging to the family *Apiaceae* is reported. *A. silvestris* contained only linear furocoumarins (four in the roots and five in the fruits), two of them (heraclenol and heraclenin) found for the first time in this species. The photoactive compound bergapten (also known as 5-methoxypsoralen) was also among the isolated coumarins. In *P. austriacum* only reduced (dihydro) coumarins were detected (four compounds): linear dihydrofurocoumarins, deltoin and sekorin, an angular dihydrofurocoumarin, zosimin and a linear dihydropyranocoumarin, agasyllin. None of them has been found before in this plant species.

The plant family *Apiaceae*, encompassing ca. 3000 species, occurs throughout the northern hemisphere in the temperate zones. In Serbia, this family is represented by 138 species (53 genera).¹ Hitherto, the chemical constituents of *Apiaceae* species have received considerable attention, which is due to various bioactivities of their extracts and essential oils. Thus, the medicinal properties (stomachicum, spasmolyticum and sedativum) of the roots (containing a high percentage of furocoumarins) and the insecticidal properties of the fruits (the major source of essential oil) of *A. silvestris* have been known for a long time.² Similarly, the extracts obtained from the roots and the essential oils from the fruits of some species of the genus *Peucedanum* (e.g., *P. officinale* and *P. oreoselinum*) have been used in traditional medicine for different cures.³

RESULTS AND DISCUSSION

The extracts of both plants analysed in this study were prepared according to the same procedure, i.e., the extraction of air-dried ground plant material with ethyl acetate. The subsequent silica gel column chromatography (petrol ether – ethyl acetate) of the extracts afforded coumarins, identified by means of spectral data (¹H-NMR, IR, MS and UV).

(i) Coumarins from *A. silvestris*. – Previous works concerning the chemical constituents of *A. silvestris* (roots and fruits) revealed quite a few linear furocoumarins,⁴⁻⁶ as well as a sesquiterpenic ketoalcohol, bisabolangelone.⁷

The plant material which we examined originated from two localities, roots from Homolje (Eastern Serbia) and fruits from Tara Mountain (Western Serbia) (see the Experimental). All coumarins (1–9) isolated from *A. silvestris* are listed in Fig. 1. The

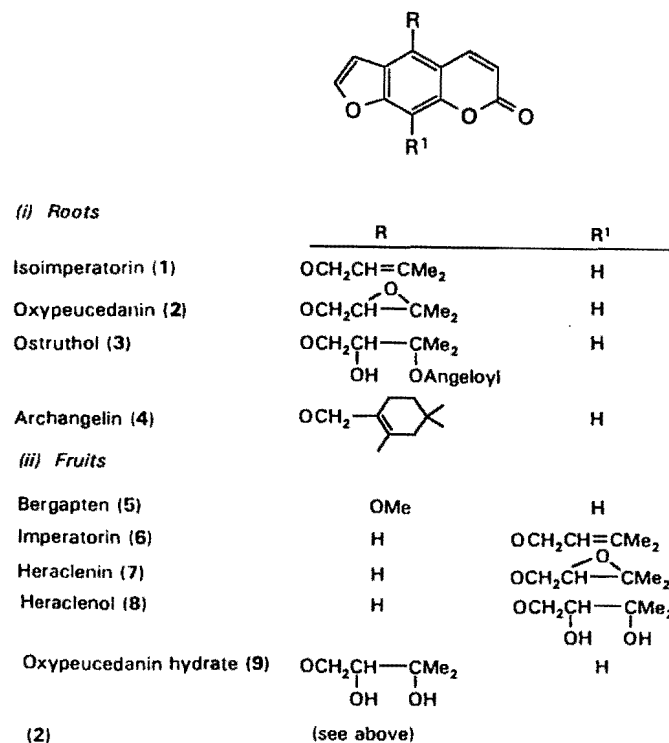


Fig. 1. Coumarins from *A. silvestris*

structures of these compounds were also verified by a comparison of their spectral data (mostly ¹H-NMR and IR) to those published.^{5,8-11} The roots contained only 5-substituted linear furocoumarins, also previously detected in the roots of *A. silvestris*,⁴⁻⁶ however the ripe fruits exhibited both 5- and 8-substituted linear furocoumarins, and two of them, heraclenol and heraclenin (7 and 8) were found for the first time in this species. The presence of bergapten (also known as 5-methoxypsoralen = 5-MOP) (5), detected previously¹² in the extracts of *A. silvestris* only by TLC, should also be noted. Bergapten, together with isomeric xanthotoxin (*i.e.*, 8-MOP), whose presence was also previously detected in the fruits of *A. silvestris*,⁵ belongs to the most potent so-called photoactive furocoumarins.¹²⁻¹⁴ Such compounds, after absorption of the near UV-light (300-380 nm), intercalate readily into DNA, forming mono- or di-adducts with pyrimidine bases, thus preventing DNA from replicating, which leads to mutagenic and

photocarcinogenic effects. Due to these properties, photoactive compounds are used in so-called photochemotherapy to cure some types of skin cancer, *e.g.*, cutaneous T-cell lymphoma, which is treated using xanthotoxin (8-MOP) in combination with UV-irradiation.¹⁴

(ii) Coumarins from *P. austriacum*. – Hitherto, only reduced (dihydro) angular pyranocoumarins (three compounds), so-called khellactones, together with two linear dihydro(furo- and pyrano-)chromones have been reported as the constituents of the aerial parts of *P. austriacum* (originating from Stolovi Mountain, W. Serbia).¹⁵

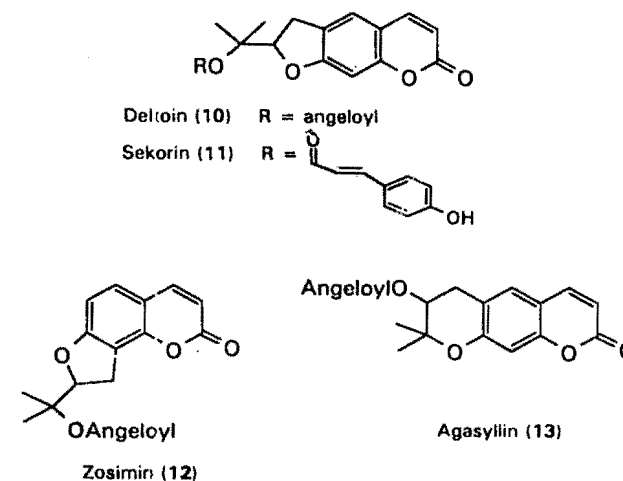


Fig. 2. Coumarins from the roots of *P. austriacum*

The plant material that we examined was collected on Tara Mountain (W. Serbia). The standard procedure (quoted above, extraction with EtOAc, followed by silica gel column chromatography) yielded three dihydrofurocoumarins, deltoin,¹⁶ sekorin,^{16,17} and zosimin¹⁶ (10–12, respectively, Fig. 2) and a dihydropyranocoumarin, agasyllin¹⁷ (13, Fig. 2). Compounds 10–13, exhibiting identical ¹H-NMR data to those published,^{16,17} were detected for the first time in *P. austriacum*.

EXPERIMENTAL

Plant material

The roots of *Angelica silvestris* were collected at Ribari/Žagubica in September 1987; the ripe fruits of *A. silvestris* were collected at Krnja Jela/Tara Mountain in August 1987; the roots of *Peucedanum austriacum* (Jacq.) Koch were collected at Brusnica/Tara Mountain in September 1987. Vaucher specimens of all species were deposited in The Institute of Botany, Faculty of Pharmacy, University of Belgrade.

Isolation

The air-dried ground plant material was extracted three times at room temperature with EtOAc (*ca.* 0.5 l/50 g of plant material). The crude extracts were subjected to silica gel column chromatography, starting

the elution with light petroleum and gradually increasing the polarity of the solvent by the addition of EtOAc. The following compounds, identified by means of $^1\text{H-NMR}$, IR, UV/Vis and MS (listed in order of elution in each case) were isolated:

(i) *A. silvestris* (200 g of roots) yielded: archangelin (4, 57 mg), isoimperatorin (1, 118 mg), oxypeucedanin (2, 42 mg) and ostruthol (3, 350 mg).

(ii) *A. silvestris* (150 g of ripe fruits) yielded: imperatorin (6, 309 mg), bergapten (5, 271 mg), oxypeucedanin (2, 571 mg), heraclenin (7, 450 mg), oxypeucedanin hydrate (9, 53 mg) and heraclenol (8, 57 mg).

(iii) *P. austriacum* (58.5 g of roots) yielded: zosimin (12, 15 mg) agasyllin (13, 98 mg), deltoin (10, 169 mg) and sekorin (11, 24 mg).

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ИЗВОД

ФУРО- И ПИРАНОКУМАРИНИ ИЗ БИЉНИХ ВРСТА *Angelica silvestris* И *Peucedanum austriacum*

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Приказано је испитивање садржаја кумарина у две биљне врсте (*Angelica silvestris* и *Peucedanum austriacum*) из фамилије *Apiaceae*. Код *A. silvestris* испитивани су корен и плодови, а код *P. austriacum* корен. У узорцима из *A. silvestris* идентификовани су само линеарни фуурокумарини (четири у корену и пет у плодовима), од којих су два (херакленол и херакленин) нађена по први пут у овој биљци. Међу кумаринима из плодова нађен је и бергаптен (познат и као 5-метокси-сорален) за кога се зна да показује различите биолошке активности када апсорбује зрачење из ултраљубичастог дела спектра (тзв. фотоактивност). У корену биљке *P. austriacum* детектована су четири редукована (дихидро) кумарина: делтоин и секорин (линеарни дихидрофуурокумарини), зозимин (ангуларни дихидрофуурокумарин) и агазилин (линеарни дихидропиранокумарин).

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