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Original Scientific Paper

Chemical characterization of essential oil from seeds of wild and cultivated carrots from Serbia

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ABSTRACT: Seeds from wild carrot (*Daucus carota* L. ssp. *carota*) have been used for medicinal purposes since ancient times. Today the oil of its seeds has been proved to possess antinociceptive, antiinflammatory, hypoglycaemic, antidiabetic, antioxidative and anticancer activity. The cultivated carrot (*Daucus carota* L. ssp. *sativus* (Hoffm.) Arcang.) is mainly used as a root vegetable, while its seed oil is sometimes employed as a flavouring agent in food products and in the cosmetics industry. In the light of this very different usage, the aim of our investigation was to identify chemical compounds from essential oils of the seeds of these two subspecies of *D. carota* collected during 2014 in northern Serbia. It is established that wild carrot contains 1.67% of essential oil in the seeds, while cultivated carrot contains 0.55%. In the case of wild-grown carrot, gas chromatographic-mass spectrometric (GC-MS) analyses of seed essential oil show that sabinene (40.9%) and α-pinene (30.1%), followed by β-bisabolene (6.2%), β-pinene (5.7%) and *trans*-caryophyllene (5.3%) are the dominant compounds. The major constituents of essential oil from cultivated carrot seeds are carotol (22.0%), sabinene (19.6%) and α-pinene (13.2%). The mixture of aromadendrene, β-farnesene and sesquisabinene comprises 8.2%, the content of *trans*-caryophyllene is 5.7% while that of myrcene amounts to 4.7%. Analysis of seeds from both carrots reveals significantly different chemical characteristics of their essential oil, the existence of which influences their different usage.

Keywords: *Daucus carota* L. ssp. *sativus* (Hoffm.) Arcang., *Daucus carota* L. ssp. *carota*, GC/MS, sabinene, α-pinene, carotol

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INTRODUCTION

The carrot, *Daucus carota* L., originated in Central Asia and spread in early times to the Mediterranean region (Snowdon 1992). Wild carrot (*Daucus carota* L. ssp. *carota*) is the ancestor of cultivated carrot (*D. carota* L. ssp. *sativus* (Hoffm.) Arcang.) (Rong *et al.* 2010). The wild form has been used as a medicinal plant since ancient times (Tawil *et al.* 2015). However, the cultivated carrot is mainly used as a root vegetable, its seed oil being sometimes employed as a flavouring agent in food products and perfumes (Staniszewska *et al.* 2005).

Herbs have been used since ancient times as medicines for the treatment of a wide range of diseases. Today, modern methods enable scientists to approve medicinal plants for healing many disorders. Vasudevan *et al.* (2006) affirmed antinociceptive and antiinflammatory properties of wild carrot seed extracts, while Rao & Reedy (2013) demonstrated hypoglycaemic

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Table 1. Chemical compounds in essential oils from seeds of wild and cultivated carrot.

Compound name	**RI**	*Daucus carota* ssp. *carota*	*Daucus carota* ssp. *sativus*
α-thujene	923	0.2	0.3
α-pinene	933	30.1	13.2
Camphene	944	1.4	0.8
tuja-2,4(10-diene)	950	nd	0.1
Sabinene	970	40.9	19.6
β-pinene	974	5.7	2.4
Myrcene	991	3.3	4.7
α-terpinene	1015	0.1	0.1
p-cymene	1025	nd	0.1
Limonene	1028	1.9	1.7
β-ocymene	1045	0.1	nd
γ-terpinene	1056	0.2	0.4
Terpinolene	1100	0.1	0.6
NI	1100	0.5	nd
α-campholenal	1125	nd	0.2
NI	1137	nd	0.4
trans-2,3-*epoxy cis*-carane	1141	nd	0.9
Sabina ketone	1154	nd	0.1
Pinocarvone	1159	nd	0.2
Borneol	1162	trace	nd
NI	1164	nd	0.1
NI	1174	0.1	0.4
α-terpineol	1186	trace	nd
Myrtenal	1192	nd	0.3
Verbenone	1206	nd	0.1
Boron acetate	1282	0.4	0.6
α-terpinyl acetate	1346	nd	0.1
α-longipinene	1347	trace	nd
α-copaene	1373	0.2	Trace
Daucene	1376	nd	1.0
trans-myrtanol acetate	1382	nd	2.5
β-cubebene	1387	0.2	nd
7-*epi*-sesquithujene	1388	nd	0.2
β-elemene	1389	0.1	nd
Sesquithujene	1392	nd	0.1
cis-*α*-bergamotene	1414	nd	1.8

Compound name	**RI**	*Daucus carota* ssp. *carota*	*Daucus carota* ssp. *sativus*
trans-caryophyllene	1416	5.3	5.7
trans-*α*-bergamotene	1435	0.2	2.6
amorpha-4,11-diene	1442	nd	0.9
NI	1445	nd	0.2
epi-*β*-santalene	1446	nd	Trace
α-humulene	1452	0.4	0.3
Aromarene, *trans*-*β*-farnesene, sesquisinene	1455	0.1	8.2
γ-muruolene	1470	nd	0.3
trans-muurola 4(14),5-diene	1480	0.7	0.3
NI	1484	0.1	0.8
NI	1494	0.5	0.1
iso-daucene	1498	nd	0.2
β-bisabolene	1509	6.2	2.4
δ-cadinene	1522	0.1	nd
β-sesquiphellandrene	1523	nd	0.7
NI	1536	0.1	nd
NI	1541	0.2	0.1
NI	1551	nd	0.1
NI	1559	nd	0.1
NI	1582	0.1	1.5
Carotol	1601	nd	22.0
NI	1608	nd	0.1
Daucol	1637	nd	0.3
cis-*α*-santalol	1670	nd	0.1
NI	1687	0.2	nd
NI	1694	0.3	nd
Number of compounds		**34**	**51**
Total (%)		**100**	**100**
NI compounds (%)		**2.3**	**4.9**
Essential oil content (%)		**1.67**	**0.55**

RI - retention indices on HP-5 MS capillary column; **NI** - not identified compounds; **trace** - compound present in an amount less than 0.1%; **nd** - compound not detected

and antidiabetic activity. Wild carrot seeds also show antioxidative and anticancer effects (Shebaby *et al.* 2013).

On the other hand, essential oil from cultivated carrot seeds possesses strong antimicrobial activity against fungi such as *Candida albicans* and *Alternaria alternate*, as well as bacteria (*Staphylococcus aureus*) (Jasicka-Misiak *et al.* 2004; Imamu *et al.* 2007). Production of medicated soap using oil extracted from carrot seeds to treat fungal infestations such as that caused by *Trichophyton rubrum* was found to be promising (Abdulrasheed *et al.* 2015).

In the light of this very different usage, the aim of our investigation was to identify chemical compounds in essential oils from the seeds of these two subspecies of *D. carota* from Serbia.

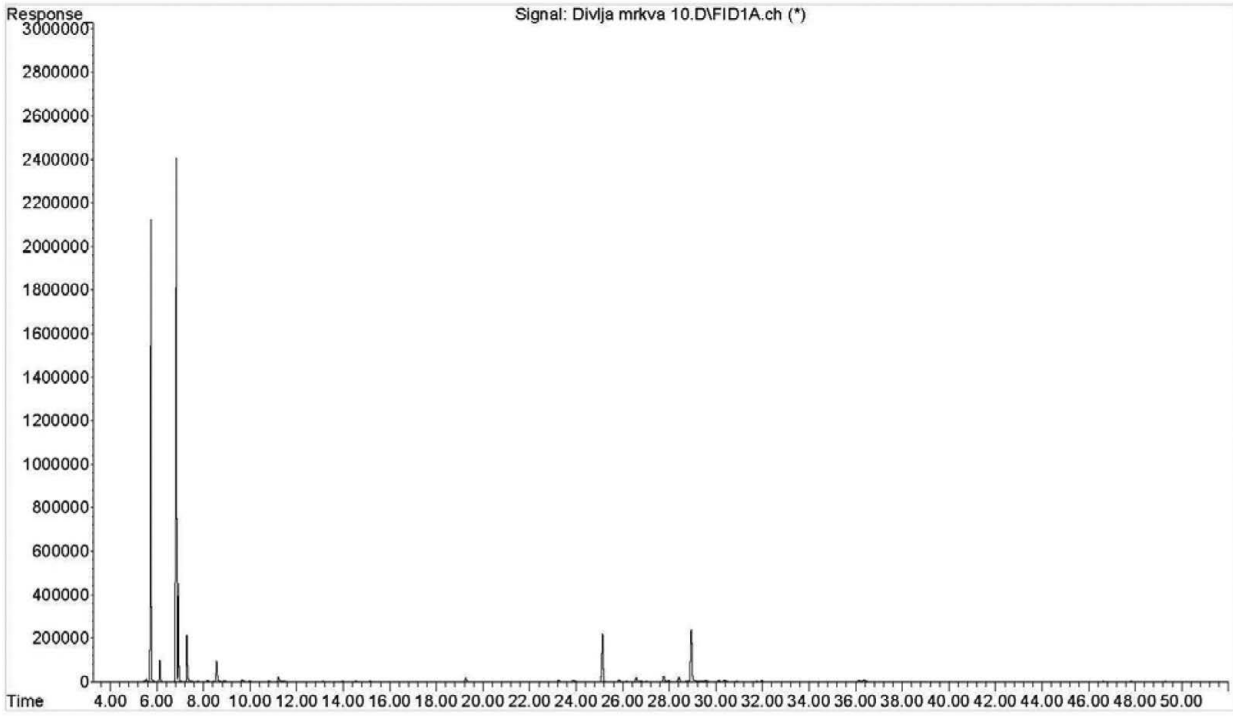

Figure 1. Chromatographic profiles of *Daucus carota* ssp. *carota* essential oil.

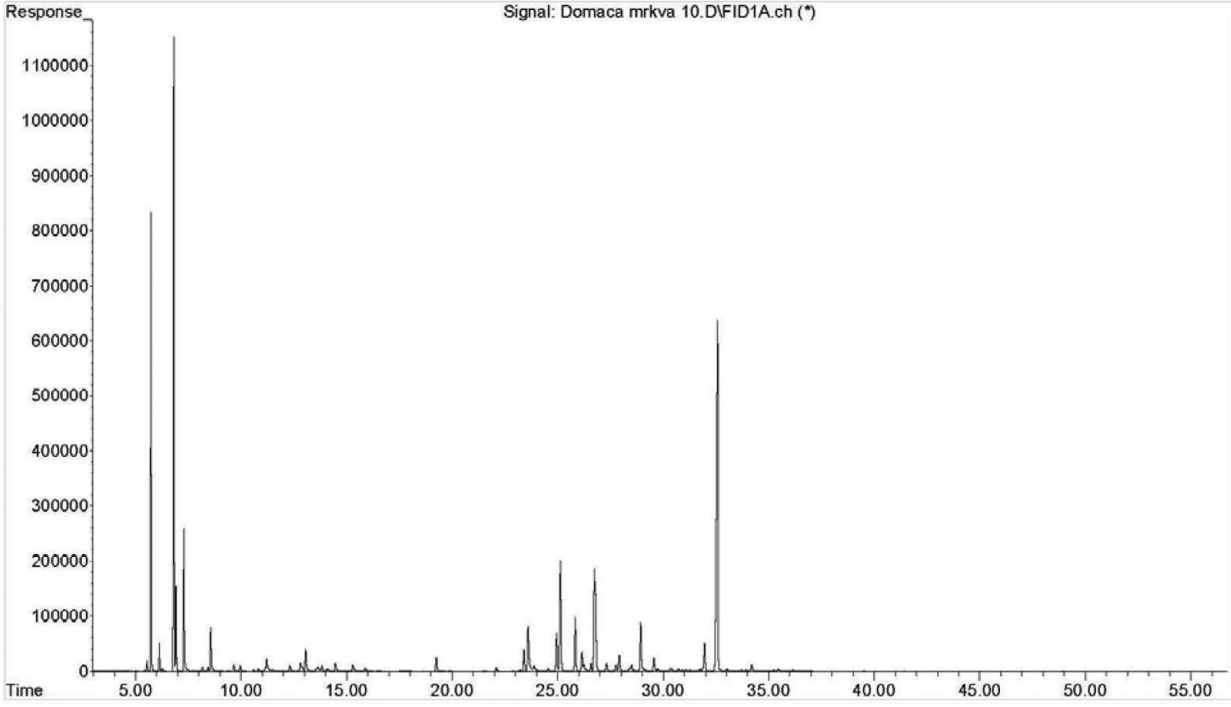

Figure 2. Chromatographic profiles of *Daucus carota* ssp. *sativus* essential oil.

MATERIAL AND METHODS

Plant material: Seeds of *D. carota* ssp. *carota* and *D. carota* ssp. *sativus* were collected during August of 2014 in the South Bačka region of the Vojvodina province in the northern part of Serbia. Wild carrot seeds were collected in the village of Mošorin (41°18'N; 20°09'E) and herbarium specimens are deposited at the Department

of Botany of the Faculty of Agriculture, University of Novi Sad. Cultivated carrot cv. Nantes was grown at the Institute for Field and Vegetable Crops in Novi Sad (45°19'N; 19°51'E).

Isolation procedure. Dried samples of carrot seeds were subjected to hydro-distillation using an all-glass Clevenger-type apparatus to extract essential oils according to the method outlined by the European Pharmacopoeia (2004).

GC/MS analysis. Gas chromatographic-mass spectrometric analysis was performed using an Agilent 6890 gas chromatograph coupled with an Agilent 5973 network mass selective detector (MSD) (both from Agilent, Santa Clara, USA) in the positive ion electron impact (EI) mode. The separation was done using an Agilent 19091S-433 HP-5MS fused silica capillary column with 30 m × 0.25 mm i.d. and 0.25 μm film thickness. The GC oven temperature was programmed from 60 to 285°C at a rate of 3°C/min. Helium was used as the carrier gas; inlet pressure was 20.3 kPa; linear velocity was 1 ml/min at 210°C. The injector temperature was 250°C, the injection mode splitless. The MS scan conditions were as follows: MS source temperature, 230°C; MS Quad temperature, 150°C; energy, 70 eV; mass scan range, 40–550 amu.

Components were identified on the basis of retention index values and by comparison with reference spectra (Wiley and NIST databases).

RESULTS

Wild carrot from northern Serbia contains 1.67% of essential oil in seeds, while cultivated carrot contains 0.55%. The conducted GC-MS analysis of seed essential oil in wild and cultivated carrot resulted in the identification of 34 and 51 components, respectively (Table 1).

In the case of wild carrot, GC-MS analysis of seed essential oil shows that sabinene (40.9%) and α-pinene (30.1%), followed by β-bisabolene (6.2%), β-pinene (5.7%) and *trans*-caryophyllene (5.3%), are the dominant compounds (Table 1, Fig. 1).

The major constituents of essential oil from seeds of cultivated carrot are carotol (22.0%), sabinene (19.6%) and α-pinene (13.2%). The mixture of aromadendrene, β-farnesene and sesquisabinene comprises 8.2%, the content of *trans*-caryophyllene is 5.7% while that of myrcene is 4.7% (Table 1, Fig. 2).

DISCUSSION

It seems that composition of the oil of seeds from wild carrot depends on geographic origin. Analysis of essential oils from flowering and mature umbels of plants growing wild shows that β-bisabolene and 11-α-(H)-himachal-4-en-1-β-ol dominate in the Mediterranean, while geranyl acetate and α-pinene predominate in plants from the Atlantic coast (Maxia *et al.* 2009). Chemical analysis of the essential oils of wild carrot from Serbia revealed 48 compounds in ripe fruits, with dominance of sabinene (21.16%), α-pinene (21.30%), α-muurolene (8.23%), β-caryophyllene (6.82%) and α-ylangene (5.21%) (Sokovic *et al.* 2009). In the fruits of wild carrot from Austria, the oil yield ranged from 0.8 to 1.6% and the dominant compounds likewise were α-pinene (23.5-30.4%) and sabinene (21.5-46.6%) (Chizzola 2010).

The essential oil yield of carrot seeds cultivated in Turkey was 0.83% and the main compound was carotol (66.78%), followed by daucene (8.74%) and α-farnesene (5.86%) (Özcan & Chalchat 2007). Analysis of essential oil from different cultivars of carrot in Poland showed that the content of carotol in umbels depends on the cultivar and varies between 23 and 48% (Kula *et al.* 2006). However, in Chinese *D. carota* ssp. *sativa* seeds the dominant compounds are β-bisabolene (80.49%), α-asarone (8.8%) and *cis*-α-bergamoten (5.51%) (Imamu *et al*. 2007).

CONCLUSION

Seeds of wild *Daucus carota* ssp. *carota* and cultivated *D. carota* ssp. *sativus* from Serbia differ significantly in the quantity and chemical composition of their essential oils. This influences their different usage. Essential oil from wild carrot seeds posesses strong biological activity, probably due to the high content of sabinene and α-pinene, which have great pharmacological potential. However, the essential oil of cultivated carrot seeds is used as a flavouring agent in food products and in the cosmetics industry because of its common component carotol, which has a pleasant spicy aroma and taste.

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REZIME

Hemijska karakterizacija etarskih ulja semena divlje i gajene mrkve poreklom iz Srbije

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Seme divlje mrkve (*Daucus carota* L. ssp. *carota*) se koristi u lekovite svrhe od antičkog doba. U današnje vreme dokazano je da ono poseduje antinociceptivno, antiinflamatorno, hipoglikemijsko, antidiabetično, antioksidativno i antikancerogeno dejstvo. Gajena mrkva (*D. carota* L. ssp. *sativus* (Hoffm.) Arcang.) se uglavnom koristi kao korenasto povrće, dok se etarsko ulje semena retko koristi, i to kao poboljšivač ukusa u prehrambenoj industriji i kozmetici. Imajući u vidu veoma različitu upotrebu, cilj našeg istraživanja je bio da se identifikuju hemijske komponente etarskog ulja semena ove dve vrste *D. carota* sakupljenog tokom 2014. godine u severnoj Srbiji. Tom prilikom je ustanovljeno da divlja mrkva sadrži 1,67% etarskog ulja u semenu, a gajena mrkva 0,55%. Analizom etarskog ulja primenom gasne hromatografije-masene spektrometrije (GC-MS) ustanovljeno je da etarsko ulje divlje mrkve u najvećem procentu sadrži sabinen (40,9%) i α-pinen (30,1%), a potom slede β-bisabolen (6,2%), β-pinen (5,7%) i *trans*-kariofilen (5,3%). Glavne komponente etarskog ulja gajene mrkve su karotol (22,0%), sabinen (19,6%) i α-pinen (13,2%), dok mešavina aromadendrena, β-farnezena i seskvisabinena čini 8,2%, *trans*-kariofilen 5,7% i mircen 4,7%. Analizama semena ove dve vrste mrkve ustanovljena je značajno drugačija karakterizacija etarskih ulja što utiče na njihovu različitu upotrebu.

Ključne reči: *Daucus carota* L. ssp. *sativus* (Hoffm.) Arcang., *Daucus carota* L. ssp. *carota*, GC/MS, sabinen, α-pinen, karotol