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Wild umbellifers traditionally used for food in Sicily and Bulgaria and their health benefits

E. Kozuharova [1*], G. A. Malfa [2,3], R. Acquaviva [2,3], V. Spadaro [4], D. Batovska [5], Ch. Stoycheva[1], P. Marino[5], F. M. Raimondo[6]

[1]*Medical University-Sofia, Department of Pharmacognosy, Faculty of Pharmacy, 1000 Sofia, Bulgaria*
[2]*Department of Drug and Health Sciences, University of Catania, Viale A. Doria 6, 95125 Catania, Italy*
[3]*Research Centre on Nutraceuticals and Health Products (CERNUT), University of Catania, Viale A. Doria 6, 95125 Catania, Italy*
[4]*Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, Section of Botany, Anthropology and Zoology, University of Palermo, Via Archirafi 38, 90123 Palermo, Italy*
[5]*Institute of Chemical Engineering, Bulgarian Academy of Sciences, Acad. Georgi Bonchev Str., Bl. 103, 1113 Sofia, Bulgaria*
[6]*PLANTA/ Center for Research, Documentation and Training, Via Serraglio Vecchio 28, 90123 Palermo, Italy*

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Numerous studies demonstrate that plant-based foods provide a large spectrum of bioactive compounds with lots of health benefits. The wide spectrum of consumed plants improves the nutritional adequacy of the diet. Ethnobotanical studies provide valuable data about plants used for food for centuries. The aim of this study is 1) to identify wild plants from the family *Apiaceae* traditionally used for food in Bulgaria and in Sicily and 2) to reveal their bioactive compounds and health benefits. As a result of the ethnobotanical review the folowing taxa are listed: *Aegopodium podagraria* L., *Anthriscus cerefolium* (L.) Hoffm., *Anthriscus sylvestris* (L.) Hoffm., *Helosciadium nodiflorum* (L.) W. D. J. Koch, *Carum carvi* L., *Chaerophyllum bulbosum* L., *Daucus carota L.* subsp. *carota, Eryngium campestre* L., *Foeniculum vulgare* Mill. subsp. *vulgare, Kundmannia sicula* (L.) DC., *Smyrnium perfoliatum* L., and *S perfoliatum* subsp. *rotundifolium* (Mill.) Bonnier & Layens (synonym *S. rotundifolium* Mill.). As members of the family *Apiaceae* some of them are popular spices due to the essential oils characterized by some interesting components such as germacrene D, D-limonene, limonene, eucalyptol, 1-nonene, pentadecane, estragole, β-(*E*)-, β-(*Z*)-ocimene, terpinolene, sapthulenol, pcymene-8-ol, p-cymene, myrtenol, (E)-anethole, α-pinene, estragole, p-cymene, etc. Additionally, they contain flavonoids (rutin, cynaroside, apigetrin, luteolin, vanillin, myricetin, quercetin, luteolin, kaempferol and chrysin apigenin and its glycosides); phenolic acids (caffeic, p-coumaric, ferulic, hydroxybenzoic, 3.5-*O*-dicaffeoylquinic acid, protocatehuic, phydroxybenzoic, chlorogenic, p-coumaric, ferulic, rosmarinic acids), carotenoids (β-carotene, α-carotene, lutein, lycopene), polyacetylenes (falcarinol, falcarindiol, falcarindiol-3-acetate) and others. The pharmacological activities and the health benefits are discussed. The sustainable use will include protection of their native habitats and cultivation of some of them.

Keywords: wild umbellifers, bioactive compounds

INTRODUCTION

Numerous studies demonstrate that plant-based foods provide a large spectrum of bioactive compounds with lots of health benefits [1, 2]. The wide spectrum of consumed plants improves the nutritional adequacy of the diet. The traditional Mediterranean diet is known for its health benefits [3, 4], Additionally it is sustainable with interrelated components such as biodiversity, traditions and nutrition [5]. Many umbellifers take important place in the Mediterranean diet [6]. They are domesticated long ago and cultivated for food due to their valuable secondary metabolites [7, 8]. Ethnobotanical studies provide valuable data about plants traditionally used for food for centuries [9]. They can help identifying new candidates for cultivation and domestication that possess powerful health benefits. Some of the umbellifers, which are interesting form this point of view, have restricted distribution either to the Mediterranean or to Sicily [10].

The aim of this study is 1) to identify wild plants from family *Apiaceae* traditionally used for food in Bulgaria and in Sicily and 2) to reveal their bioactive compounds and health benefits.

MATERIAL AND METHODS

We accessed Google Scholar, Web of Science, and PubMed to identify publications using the search string: “Sicily”, “Bulgaria”, “traditionally” “wild”, “food”, “plants”, “ethnobotany”, “compounds”, “metabolites”, “pharmacological”, “health”, etc.

* To whom all correspondence should be sent:
E-mail: *ina_kozuharova@yahoo.co.uk*

Table 1. Wild umbellifers traditionally used for food in Bulgaria and Sicily.

Plant	Used part	Country
Aegopodium podagraria L.	Sprouts, salad raw, soup,	Bulgaria
Anthriscus cerefolium (L.) Hoffm.	Leaves, shoots, salad raw, soup, spice	Bulgaria
Anthriscus sylvestris (L.) Hoffm.	Roots, leaves, shoots, salad raw, soup, pastry	Bulgaria
Helosciadium nodiflorum (L.) W. D. J. Koch (synonym *Apium nodiflorum* (L.) Lag. subsp. *Nodiflorum).*	Tender leaves and stems	Sicily
Carum carvi L.	Fruits, spice	Bulgaria
Chaerophyllum bulbosum L.	Young shoots, corms, salad raw and stew	Bulgaria
Daucus carota L. subsp. *carota*	Tender basal leaves and roots	Sicily
Eryngium campestre L.	Sprouts	Sicily
Foeniculum vulgare Mill. subsp. *vulgare*	Leaves, mericarps, spice	Bulgaria and Sicily
Kundmannia sicula (L.) DC.	Basal leaves	Sicily
Smyrnium perfoliatum L.	Tender leaves and stems	Bulgaria and Sicily
Smyrnium perfoliatum subsp. *rotundifolium* (Mill.) Bonnier & Layens (synonym *S. rotundifolium* Mill.)	Tender leaves and stems	Sicily

RESULTS AND DISCUSSION

Ethnobotanical data

As a result of the ethnobotanical review 12 taxa are listed of which 5 taxa are used for food only in Bulgaria [9, 11-15], 5 taxa only in Sicily [16-19] and 2 taxa in both regions (Table 1).

Bioactive compounds and pharmacological effects

The wild umbellifers consumed for food are source of various bioactive compounds. The essential oils are characterized by some interesting components such as germacrene D, D-limonene, limonene, eucalyptol, 1-nonene, pentadecane, estragole, β-(*E*)-, β-(*Z*)-ocimene, terpinolene, sapthulenol, p-cymene-8-ol, p-cymene, myrtenol, (E)-anethole, α-pinene, estragole, p-cymene, etc. The contents of unique or highly abundant components are pointed as markers to distinguish certain species, e.g., selinene is typical of *Apium graveolens* while *Helosciadium nodiflorum* (*A. nodiflorum*) is rich of limonene [7]. Coumarins and furanocoumarins are found in many of the species listed above. Moreover, the wild members of *Apiaceae* consumed for food contain flavonoids such as rutin, cynaroside, apigetrin, luteolin, vanillin, myricetin, quercetin, luteolin, kaempferol, chrysin apigenin and their derivates. The phenolic acids reported in the listed umbellifers are caffeic, p-coumaric, ferulic, hydroxybenzoic, 3.5-*O*-dicaffeoylquinic acid, protocatehuic, p-hydroxybenzoic, chlorogenic, p-coumaric, ferulic, rosmarinic acids. The terpenoids obtained from these plants are carotenoids (β-carotene, α-carotene, lutein, lycopene), polyacetylenes (falcarinol, falcarindiol, falcarindiol-3-acetate) and others.

Aegopodium podagraria L. is a perennial plant (Fig. 1) widespread in shady habitats of the Temperate Eurasia [20]. The composition of the essential oil varies depending on the geographical and ecological factors with main components α-pinene, β-pinene, myrcene, α-thujone, dehydro-p-cymene, and β-phellandrene, limonene, germacrene D, spatulenol, (E)-β-caryophyllene, γ-terpinene. The plant also contains phenolic acids such as hydroxycinnamic acid, and flavonoids such as quercetin, kaempferol and derivatives of quercetin (hyperoside, isoquercetin), derivatives of kaempferol (trifoline). Coumarins (angelicin) and furanocoumarins, as well as carotenoids (β-carotene, xanthophyll neoxanthin) are identified in this plant [21]. *A. podagraria* is known for its calming, diuretic, anti-inflammatory and antimicrobial properties, cytotoxic and antioxidant activities [21, 22]. The dry extract obtained from goutweed (standardized on hydroxycinnamic acids) has a low toxicity level, normalizes metabolic processes and protects the liver and the kidneys [23].

Figure 1. First row *Aegopodium podagraria* (left), *Anthriscus cerefolium* (middle left) *A. sylvestris* (middle right) and *Carum carvi* (right); Second row *Heloscidium nodiflorum* (left), *Foeniculum vulgare* subsp. *vulgare* (middle) and *Daucus carota* (right); Third row *Chaerophyllum bulbosum* (left), *Eryngium campestre* (middle left), *Kundmannia sicula* (middle right) and *Smyrnium perfoliatum* (right)

Anthriscus cerefolium (L.) Hoffm. is an annual or biennial plant (Fig. 1) native to the temperate biome of Central and Eastern Europe to Northern Iran [20]. The plant contains essential oil rich of D-limonene, eucalyptol, 1-nonene, pentadecane, estragole, and germacrene D, flavonoids such as rutin, cynaroside, apigetrin, luteolin, apigenin and its glycosides, as well as phenolic acid (caffeic, p-coumaric, ferulic, hydroxybenzoic, 3.5-*O*-dicaffeoylquinic acid); [24, 25]. *A. cerefolium* has antimicrobial, antioxidant, and anticancer activities [24]. The extract of *A. cerefolium* aerial parts decrease proliferation rate of glioblastoma cells while being non-toxic to the control cell line [9]. Neither acute nor subacute toxicity is reported.

Anthriscus sylvestris (L.) Hoffm. is a biennial or perennial (Fig. 1) which grows in Temperate Eurasia to Tropical African Mountains [20]. It is related and alike to *A. cerefolium.* The umbels of *A. sylvestris* have mostly 6-15 primary branches, ultimate segments of leaf blades mostly 15-50 mm long, and bracteoles of umbellets narrow-ovate while *A. cerefolium* has umbels with 2-6 primary branches, ultimate segments of leaf blades mostly 5-10 mm long, and bracteoles of umbellets linear) (Fig. 1). *A. sylvestris* is the most common species of the genus *Anthriscus* [26]. One of the main compounds of *A. sylvestris is* deoxypodophyllotoxin. It has wide-ranging effects, including antitumor, antiproliferative, antiplatelet aggregation, antiviral, anti-inflammatory, and insecticidal properties. Additionally, it serves as a pivotal precursor to epipodophyllotoxin, crucial in the semisynthesis of cytostatic agents like etoposide and teniposide. The cytotoxic effect of *Anthriscus* extracts is due to podophyllotoxin-related lignans, which are currently of interest due to the high availability of these ruderal species [26].

Helosciadium nodiflorum (L.) W. D. J. Koch (synonim *Apium nodiflorum* (L.) Lag.) is a perennial plant (Fig. 1) which grows in the Mediterranean [20]. The typical subspecies is consumed in Sicily [16-19]. The essential oil of *H. nodiflorum* is rich of germacrene D, limonene, β-(Z)-ocimene, terpinolene and phenylpropanoids (dillapiol, myristicin) identified in this plant [27, 28]. The plant contains phenolic acids such as 3,4-diccaffeoylquinic and chlorogenic acids as well as flavonoids such as quercetin-3-O-glucoside which are also reported [28]. The plant is not reported toxic, on the contrary, it has antitoxic effect and reduces aflatoxins production by *Aspergillus parasiticus* [29].

Carum carvi L. is a perennial plant (Fig. 1) which grows in meadows. It is native to Temperate Eurasia [20]. The main components of the "seed" essential oil (yields 0.6% - 5.4%) are carvone limonene (with negative correlation between these two), β-myrcene, *E*-dihydrocarvone, and *E*-carveole, α-pinene, sabinene, n-octanal, *E*-β-ocimene, γ-terpinene, linalool, *Z*- and *E*-limonene oxide, *Z*-dihydrocarvone, *Z*-carveol, perillaldehyde, E-anethole, and *E*-β-caryophyllene [30, 31]. The plant substance (mericarps or fruits, called often seeds) is known for its carminative effect and is cultivated as a spice [32] but the essential oil has also antibacterial, antifungal and anticancer activity [31] and lower level of blood glucose [33]. The plant substance contains flavonoids [31, 33]. It is not reported toxic.

Chaerophyllum bulbosum L. is a biennial plant (Fig. 1) native to Europe, Northern Türkiye and Central Asia [20]. Phenolic acids (protocatehuic, p-hydroxybenzoic, chlorogenic, p-coumaric, ferulic, rosmarinic acids); flavonoids (vanillin, myricetin, quercetin, luteolin, kaempferol and chrysin); essential oils (with main components β-(*E*)-, β-(*Z*)-ocimene, terpinolene, sapthulenol, p-cymene-8-ol, p-cymene, myrtenol) and sugars are reported for this species, as well as antioxidant, antidiabetic anticholinesterase, anti-urease, anti-tyrosinase, activities [34]. Toxicity is not reported but possibly not studied enough.

Daucus carota L. subsp. carota is a biennial plant (Fig. 1). The wild carrot is a polymorphic taxon widespread in the temperate zone but native to Macaronesia, Europe and Western Asia. *D. carota* has 13 subspecies, with one being cultivated (*D. carota* L. ssp. subsp. *sativus* (Hoffm.) Arcang.) [35]. Even though the cultivated carrot is famous for its high content of carotenoids (β-carotene, α-carotene, lutein, lycopene), the wild one is also a source of such compounds, but in much less quantity [35-37], polyacetylenes (falcarinol, falcarindiol, falcarindiol-3-acetate), phenolic acids (chlorogenic acid, p-hydroxybenzoic acid, caffeic acid) [38]. The essential oil is rich of β-caryophyllene, geranyl acetate, bicyclogermacrene, β-bisabolene, E-α-bisabolene, δ-cadinene, isoelemicin, carotol, daucol, α-asarone [39]. The wild carrot subspecies possess antioxidant, anticancer, antipyretic, analgesic, antibacterial, antifungal, hypolipidemic, and hepato- and gastroprotective properties [35]. The plant is not reported toxic in the published research papers.

Eryngium campestre L. is a wide spread perennial plant (Fig. 1) native to Europe to Caucasus and Northwestern Africa [20]. It is a perennial plant and grows primarily in the temperate biome. The plant is rich of flavonoids (quercetin-3-O-rutinoside (rutin), kaempferol 3,7-di-O-α-L-rhamnopyranoside, kaempferol 7-O-α-L-rhamnopyranoside, isoquercitrin, luteolin 7-O-β-D-glucopyranoside, quercitrin, astragalin, naringenine 7-O-α-L-rhamnopyranosyl-(1→2)-O-β-D-glucopyranoside, tiliroside, 3'-O-methyl quercetin 3-rutinoside, 4'-methoxy-3-(β-D-glucopyranosyl) kaempferol) and phenolic acids (chlorogenic acid, caffeic acid, rutoside, p-coumaric acid, ferulic acid, R-(+)-3'-O-β-D-glucopyranosyl rosmarinic acid, rosmarinic acid) [40]. It is used for various urinary tract conditions including kidney and bladder stones, kidney pain and swelling, and difficult urination. *E. campestre* has antioxidant and anti-inflammatory activity and protective effect against mycotoxins [41]. *Eryngium* spp. are considered a prospective ally for treating metabolic syndrome and diabetes [42]. Toxicity is not reported.

Foeniculum vulgare Mill. subsp. *vulgare* is a perennial plant (Fig. 1) native from Mediterranean to Ethiopia and Western Nepal [20]. It contains fatty acids, phenolic acids (rosmarinic, neochlorogenic, chlorogenic, caffeoylquinic, feruloylquinic); flavonoids (rutin, kaempferol, isorhamnetin, quercetin, apigenin); essential oil (with main components E-anethole, α-pinene, limonene, estragole, p-cymene). The fennel (in particular its essential oil) is known for its anti-inflammatory, anticancer, antioxidant, cardioprotective, antidiabetic, antithrombotic, antidiabetic activities [43-45] but most of all expectorant (due to the anethole) and carminative effects [46, 47]. It is also used as a galactagogue agent for lactating mothers [44]. *In vitro* study shows that *F. vulgare* juice is toxic to mice (hepatocytic degeneration and necrosis, congestion with perivascular mononuclear cell infiltrations and peribiliary mononuclear cell aggregations) when administered in a dose of 9.772 mg/kg/BW but harmless in doses less than 0.98

ml/kg BW. Also, estragole (methylchavicol) is associated with malignant tumors *in vitro* [45].

Kundmannia sicula (L.) DC. is a perennial plant (Fig. 1) which grows primarily in the subtropical biome. The native range of this plant is the Mediterranean coastal area where it occurs in arid places [10, 20]. It contains hexadecanoic acid and essential oil rich of isocurcumenol, spathulenol, 10-epi-γ-eudesmol, α-cubebene E-dihydro occidentalol [48]. Also, the plant is a rich source of germacrene D [49]. Germacrene D shows antibacterial and antifungal activities, the mechanism of antimicrobial action of it may be related to permeabilization of the cells and disruption of the membrane integrity [50]. *K. sicula* is reported non-toxic [51].

Smyrnium perfoliatum L. is a biennial plant (Fig. 1) which grows in shady places. It is native to Eastern and Central Europe, Mediterranean and Caucasus. The plant contains flavonoids (quercetin 3-β-D glucoside, kaempferol, kaempferol 3-β-D-glucoside, kaempferol 3,4'-β-D-diglucoside) [52]; The main components of the essential oils are arornadendrene, neryl isovalerate, γ-muurolene, α-santalene [53]. The toxicity and pharmacological activities are poorly studied and only broad spectrum of antimicrobial effects is confirmed [54]. *Smyrnium rotundifolium* Mill. is now accepted as a subspecies of *S. perfoliatum* [20, 55]. Its native distribution is narrower, namely Western Central Mediterranean to Western Türkiye and Cyprus. The bioactive compounds and the pharmacological effects of this plant are poorly studied but it is known for the content of the flavonoids kaempferol, kaempferol 3-β-D-galactoside, kaempferol 3-methyl ether 7-β-D-glucoside, kaempferol 3-diglycoside [52] and germacrane derivatives [56]. The essential oil is dominated by furanosequiterpenes, curzerene, and isofuranodiene [57].

Pharmacological effects

Wild umbellifers used for food in Bulgaria and Sicily have anti-inflammatory and antioxidant activity, neuroprotective effect and other valuable activities, as shown above. They can be attributed to particular compounds found in the listed umbellifers. For example, luteolin has significant anti-inflammatory, antioxidant, and neuroprotective activity [58] Kaempferol exhibits anti-oxidative stress, anti-inflammatory properties and alleviates neurodegenerative disorders [59, 60]. Ferulic acid is a powerful antioxidant and anti-inflammatory agent that is non-steroidal in nature [61, 62]. It also has anti-thrombosis, and anti-cancer activities and protects against coronary disease, lowers cholesterol and increases sperm viability [63]. P-coumaric acid also demonstrates anti-inflammatory activity [64-67]. Falcarinol, and falcarinol-type polyacetylenes are potent proliferation inhibitors of human glioblastoma cancer cell line DBTRG-05MG [68].

Toxicity

Family *Apiaceae* is popular with spices such as dill, celery and parsley. However, it is also known for some poisonous members such as *Aethusa cynapium* L., *Cicuta virosa* L., and *Conium maculatum* L. [69]. Therefore, caution is needed when used for food. As mentioned above, some species from the family such as *Anthriscus cerefolium, Foeniculum vulgare* subsp. *vulgare, Daucus carota, etc.,* contain furanocoumarins. These can cause a phototoxic reaction when they come in contact with skin which is exposed to UV-A light [70]. However, this is not a toxicity related to the use for food. Additionally, fennel seed oil rich of estragole (considered cancerogenic) *in vitro* is proven to not cause any primary or fixed DNA damage or any sign of toxicity in human hepatoma cells [71]. Some of these plants deserve further research regarding the subacute toxicity, for example *Chaerophyllum bulbosum, Smyrnium perfoliatum* and *Eryngium campestre.*

CONCLUSION

The listed wild umbellifers are prospective candidates for more extended consumption with health benefits. They are sources of valuable bioactive compounds. Their consumption is beneficial for the human health. The sustainable use will include protection of their native habitats and cultivation of some of them.

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