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Non-polar phytochemical compounds from dandelion (*Taraxacum officinale* Weber ex F.H. Wigg.) flowers

I. Ivanov[1*], M. Todorova[2], N. Petkova[1], I. Dincheva[3]

[1] *Department of Organic Chemistry and Inorganic Chemistry, University of Food Technologies, 26 Maritza Blvd., 4002 Plovdiv, Bulgaria*

[2] *Faculty of Chemistry, Department of Organic chemistry, 24, Tzar Assen Str., 4000 Plovdiv, Bulgaria*

[3] *Agro Bio Institute, 8 Dragan Tsankov Blvd., 1164 Sofia, Bulgaria*

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Dandelion is a well-known edible and medicinal plant with numerous studies of its health benefits. Interest presents its polyphenolic and carbohydrate composition and its non-polar components in the aerial parts and roots have been identified. There are no studies about the composition of the fatty acid phytocomponents in the flowers of the dandelion. The main purpose of the present study is a comparative investigation of n-hexane, ethanol, and n-hexane/ethanol (1:1 v/v) soluble compounds from dandelion flowers (*Taraxacum officinale* Weber ex F.H. Wigg.) collected during the flowering period. The GC-MS analysis of the non-polar (lipid) fractions showed the presence of 30 biologically active phytocompounds. The fatty acids predominated in the investigated extracts [(50-60 % of total ion current (TIC)], followed by triterpenes (9-11 % of TIC) and phytosterols (7-8 % of TIC). Polyunsaturated fatty acids - linoleic acid and α-linolenic acid (10 – 15 % of TIC) were identified as the major components. Phytosterols were mainly represented by β-sitosterol (3-4 % of TIC) and stigmasterol (above 2% of TIC), while pentacyclic triterpenes from cycloartenol 3-acetate (3-4% of TIC) and β-amyrin (above 2% of TIC) were found. Based on the fatty acid profile, the nutritional indices directly correlated with the lipid metabolites profile responsible for human health were calculated: Index of atherogenicity (IA) – 1.2-1.6; Index of thrombogenicity (IT) – 0,6-0,7; Hypocholesterolemic/hypercholesterolemic (HH) ratio – 1.0-1.3; Health-promoting index (HPI) – 0.6-0.8; Unsaturation index (UI) – 72 and linoleic acid/α-linolenic acid (LA/ALA) ratio – 1.1. The current results reveal the nutritional potential and health benefits of edible dandelion flowers.

Key words: dandelion, edible flowers, lipid profile.

INTRODUTION

Dandelion *Taraxacum officinale* (L.) Weber ex F.H. Wigg. is a medicinal plant member of Asteraceae family, subfamily Cichorioideae, tribe Lactuceae. It is widely distributed in the warmer temperate zones of the Northern Hemisphere as a perennial weed [1]. The dandelion roots and herbs have been utilized for the treatment of various ailments such as kidney disease, dyspepsia, heartburn, spleen, liver complaints, and anorexia, in cases of poor digestion, water retention and against liver diseases including hepatitis (due to its hepatoprotective effect) [1-3]. In Bulgarian traditional herbal medicine, this plant is used for treatment of digestive diseases, prevention of renal gravel and loss of appetite [4, 5]. The main suppliers of dandelion are: Bulgaria, followed by former Yugoslavia, Romania, Hungary and Poland [6]. Dandelion active ingredients were found in both the roots and leaves [7]. Its roots and leaves contain sesquiterpenes, triterpenes, phytosterols (taraxasterols, their acetates and 16-hydroxy derivatives, α- and β-amyrin, β-sitosterol and stigmasterol), several phenolic compounds (chicoric acid, monocaffeoyltartaric, 4-caffeoylquinic, chlorogenic, caffeic, p-coumaric, ferulic, p-hydroxybenzoic, protocatechuic, vanillic, syringic and p-hydroxyphenylacetic acids), as well as three coumarins (umbelliferone, esculetin and scopoletin) [1, 8]. Apart from above mentioned secondary metabolites, the dandelion roots are a rich source of polysaccharides, mainly inulin-type fructans and smaller amounts of pectin, resin, and mucilage [1, 7, 9].

Edible flowers have been used in the form of food (syrups, jellies, sauces and various desserts) and fine spices for their medicinal properties and nutritional value. The fresh flowers have been consumed for years in many cultures (Ancient Greeks, Romans and Chinese) and have also been used to treat certain ailments [10].

On this basis, in the present study we investigated the non-polar content of 95 % ethanol, n-hexane and 95% ethanol/n-hexane (1:1 v/v) extracts derived from dandelion flowers. The lipid nutritional indices were calculated.

* To whom all correspondence should be sent:
E-mail: *ivanov_ivan.1979@yahoo.com*

EXPERIMENTAL

Plant material and extractions

Aerial parts (flowers) of a wild-growing population of dandelion (*T. officinale* Weber ex F.H. Wigg.) in Plovdiv region, Bulgaria were randomly collected during flowering stages. The samples were dried in the shadow at room temperature and finely ground in a laboratory homogenizer. Twenty-five grams of the dried and ground material was extracted three times (250 ml) with three different solvents ethanol, n-hexane and a mixture of ethanol, and n-hexane ratio (1:1) for 24 hours under maceration. The combined extracts were evaporated on a vacuum evaporator and used for subsequent experiments.

Gas Chromatography-Mass Spectrometry (GC-MS) analysis

The dry extracts obtained from dandelion flowers were saponified with an ethanolic solution of 2 M KOH under reflux for 1.5 h. After cooling, the obtained extracts were separated by triple liquid–liquid extraction with n-hexane. GC-MS analysis was conducted on a gas chromatograph Agilent Technology Hewlett Packard 7890 A, connected with mass detector Agilent Technology 5975 C inert XL EI/CI MSD at 70 eV, under conditions as previously described [11, 12]. The obtained mass spectra were examined using 2.64 AMDIS (Automated Mass Spectral Deconvolution and Identification System), National Institute of Standardization and Technology, USA.

Nutritional Indices Calculation

A polyunsaturated-to-saturated fatty acids (PUFA/SFA) ratio, an index of atherogenicity (IA), an index of thrombogenicity (IT), a hypocholesterolemic/hypercholesterolemic ratio (h/H), a health-promoting index (HPI), and a linoleic acid/linolenic acid (LA/ALA, n-6:n-3) ratio were calculated from the GC-MS composition data following the formulas described by Chen and Liu [13].

RESULTS AND DISCUSSION

The resulting hexane, ethanol, and hexane-ethanol (1:1) extracts were hydrolyzed and the yield of the extract was calculated. Among them, the hexane extract was obtained with the highest yield (5.1 %), while the ethanol fraction (3.7 %) and a mixture of hexane and ethanol (1:1, v/v) (4.4 %) were obtained with significantly lower yields. As a next step, we performed GC-MS analysis of the three extracts obtained. The results are summarized in Table 1. Twenty-eight compounds were detected in different investigated fractions (fatty acids, fatty alcohols, alkanes, phytosterols and triterpenes).

Fatty acids (52 – 62 % of TIC) dominate the three extracts obtained from dandelion flowers. All three extracts contain phytosterols (6 – 7 % of TIC) and triterpenes (9 – 11 % of TIC) in relatively equal amounts. Fatty alcohols were in relatively lower concentrations about 2 % of TIC. The highest content of saturated fatty acids (SFA) was found in the hexane fraction – 32 % of TIC, with 50 % due to palmitic acid $C_{16:0}$. Another interesting finding of the study is that the major unsaturated fatty acid is linoleic acid $C_{18:2}$ and α-linolenic acid $C_{18:3}$ dominate the fractions as linoleic acid $C_{18:2}$ represent more than 50 %.

Comparative phytochemical screening shows that in the non-polar fraction obtained from dandelion flowers, fatty acids predominate over 60 % of TIC, while in similar extracts obtained from dandelion leaves, the relative content of fatty acids is only about 2 % of TIC [11].

A difference was also observed in the lipid profile of the fatty acids and fatty alcohols present in dandelion leaves and flowers. Shorter chain fatty acids from C_5 to C_8 were found in flowers, while in leaves they are from C_{16} to C_{26}, respectively [11]. A similar phenomenon was also observed in the profile of fatty alcohols in the leaves, they ranged from C_{18} to C_{30} [11], while only four fatty alcohols – myristyl alcohol (C_{14}), cetyl alcohol (C_{16}), stearyl alcohol (C_{18}) and diterpene alcohol phytol (C_{20}) were identified in the flowers. About 6 times lower amount of phytosterols (about 7 % of TIC) was also observed in the flowers, compared to about 46 % of the TIC in the leaves. Both plant parts contain β-sitosterol and stigmasterol, but campesterol (about 1 % of TIC) was found only in the flowers (Table 1).

The amounts of pentacyclic triterpenes in the two plant organs were relatively similar (17% of TIC in the leaves and 11% of TIC in the flowers), but no taraxasteryl acetate was identified in the flowers.

The main and predominant components in the extracts obtained from dandelion flowers are fatty acids. The ratio ΣPUFA/ΣSFA, the indices IA, IT, HH, HPI and LA/ALA were calculated, which are indicators of the potential health effect of the flowers (Table 2). The potential health benefits of the various lipid components can be evaluated and compared with those obtained from other raw materials and foods. Due to the relatively similar content of PUFA and SFA, extracts containing hexane (n-hexane and n-hexane/ethanol (1:1) were characterized by the highest ΣPUFA/ΣSFA ratio (≈1.0) compared to the ethanol extract (0.7) (Table 2).

Table 1. Relative percentage of phytochemical compounds in the non-polar [n-hexane, ethanol (EtOH) and n-hexane-ethanol (1:1)] fraction of the dandelion flowers identified by GC-MS. Results are presented as a percentage (%) of the total ion current (TIC).

Retention time	Retention index	Compounds	EtOH	n-Hexane	EtOH/n-Hexane
		Fatty acids			
7.91	980	Valeric acid $C_{5:0}$	0.14	3.01	0.15
12.03	1168	Enanthic acid $C_{7:0}$	0.64	0.69	0.59
7.15	926	Caproic acid $C_{6:0}$	0.17	0.48	0.14
10.84	1124	Caprylic acid $C_{8:0}$	0.44	0.40	0.30
15.60	1324	Capric acid $C_{10:0}$	ND*	0.06	0.04
19.27	1523	Lauric acid $C_{12:0}$	2.69	2.49	2.53
22.50	1724	Myristic acid $C_{14:0}$	4.57	4.92	4.83
29.70	1922	Palmitic acid $C_{16:0}$	16.45	13.00	16.67
32.65	2095	Linoleic acid $C_{18:2}$	14.98	10.29	15.54
32.70	2101	Oleic acid $C_{18:1}$	2.05	1.87	1.96
32.77	2104	Linolenic acid $C_{18:3}$	13.53	9.37	13.21
32.84	2126	Stearic acid $C_{18:0}$	4.71	3.67	3.80
36.47	2328	Arachidic acid $C_{20:0}$	2.14	2.43	2.54
		Alkanes			
12.36	1200	Dodecane	0.04	0.05	0.03
20.45	1600	Hexadecane	0.03	ND	ND
		Fatty alcohols			
22.95	1758	Myristyl alcohol C_{14}	ND	0.18	0.16
25.16	1801	Cetyl alcohol C_{16}	0.20	0.25	0.14
30.71	1943	Phytol C_{20}	1.54	1.61	1.03
31.46	1990	Stearyl alcohol C_{18}	0.61	0.42	0.35
		Tocopherols			
43.23	2885	α-Tocopherol	1.00	2.71	0.93
		Phytosterols			
47.51	3187	Campesterol	0.88	1.12	1.03
47.83	3206	Stigmasterol	2.34	2.22	2.04
48.57	3264	β-Sitosterol	4.31	3.92	3.57
		Triterpenes			
48.81	3275	α-Amyrin	1.71	1.43	1.15
49.30	3313	β-Amyrin	2.30	2.17	1.98
50.41	3321	Lupeol acetate	1.88	1.55	1.69
50.57	3343	Lanosterol	1.83	2.06	1.63
51.46	3402	Cycloartenol 3-acetate	3.42	3.87	2.68
		Total identified	84.60	76.24	80.67
		Fatty acids	62.51	52.67	62.28
		Fatty alcohols	2.35	2.46	1.68
		Phytosterols	7.53	7.27	6.63
		Triterpenes	11.14	11.09	9.13

*ND – not detected.

The type of fatty acids has a greater influence on the risk of cardiovascular disease than the total amount of fat. There is some evidence that AI and TI can be used as indicators of risk factors or predictors of cardiovascular disease, with AI and TI values higher than 1.0 indicating a greater risk of disease.

As a result, it is important to maintain a low level of these indices in a healthy diet on a daily basis [13, 14].

If a food's IA and IT are lower than 1.0, it has a lower atherogenic and thrombogenic potential [13, 14]. Our results showed variability between the samples as regards both the atherogenic index and the thrombogenic index. The obtained results from dandelion flower show that the IA is near up to 1.0 while the IT is below 1.0 (Table 2).

Also, studies have found that oils with (h/H) ratio (hypocholesterolemic/ hypercholesterolemic) relatively high over 1.0, and with low IA and IT indices, contribute to reducing the incidence of cardiovascular disease and cholesterol levels [15]. Based on the fatty acid composition of the oils obtained from dandelion flowers, it was found that the (h/H) ratio) was above 1.0. The polyunsaturated fatty acids in the extracts are in a very well-balanced ratio of n-6/n-3 (1:1) (Table 2), which is highly recommended for the normal functioning of various physiological processes. The optimal n-6/n-3 PUFA ratio should be in the range of 1:1 to 2:1 for normal physiological functions in the body due to the competitiveness of n-6 and n-3 PUFA [16].

These results for lipid indices define fresh dandelion flowers as a suitable component of rational nutrition in humans. Their consumption can lead to a reduction in the risk of cardiovascular diseases [13, 14].

Table 2. Nutritional health indices of lipid compounds obtained from dandelion flowers.

Nutritional indices	EtOH	n-Hexane	EtOH/n-Hexane
Saturated fatty acid (SFA)	31.95	31.14	31.59
Unsaturated fatty acid (UFA)	30.56	21.53	30.69
UFA/SFA	0.96	0.69	0.97
Index of atherogenicity (IA)	1.22	1.63	1.26
Index of thrombogenicity (IT)	0.61	0.72	0.61
Hypocholesterolemic/ hypercholesterolemic (h/H) ratio	1.29	1.06	1.28
Health-promoting index (HPI)	0.82	0.61	0.80
Unsaturation index (UI)	72.6	50.6	72.6
Linoleic acid/α-linolenic acid (n-6/n-3) ratio	1.11	1.10	1.17

CONCLUSION

The lipid composition of dandelion flowers has been determined. Fatty acids above 62 % are mainly identified, the ratio of saturated and unsaturated fatty acids is in a balanced ratio of 1:1; in addition, dandelion flowers are a source of short-chain fatty acids C_5-C_8 as well. The lipid fraction is also rich in triterpenes (over 11 %) and phytosterols (over 7 %) which have a beneficial effect on the lipid profile of the humans, reduce and balance blood cholesterol levels [14, 15]. Lipid indices such as atherogenicity and thrombogenicity, h/H ratio, n-6/n-3 ratio were calculated and they are all in their optimal values for human health [13-16]. All these results show that edible dandelion flowers are a suitable nutritional resource for rational human nutrition.

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