Insights into the bioactive compounds and physico-chemical characteristics of the extracted oils from *Urtica dioica* and *Urtica pilulifera*

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Abstract

In this work, proximate analysis of nettle seeds varieties of *Urtica dioica* and *Urtica pilulifera* grown in Iran and physico-chemical properties and bioactive contents of the related seed oils were assessed. The results indicated that the seeds of *U. dioica* and *U. pilulifera* were rich sources of oil (34.1% and 29.5%), protein (21.8% and 22%) and fiber (30.2% and 29.3%). Also, significant differences ($p < 0.05$) were observed among some of the other measured characteristics of the oils such as iodine value, saponification value, acid value, peroxide value and total phenolic content. The predominant fatty acids were linoleic, oleic and palmitic acids. *U. dioica* and *U. pilulifera* oils mainly contained γ -tocopherol followed by δ -tocopherol and α -tocopherol. Total amount of phytosterols reached 93.1 and 99.8 mg/100 g of oil, respectively, with a predominance of $\Delta 5,23$ -stigmastadienol. The amount of carotenoid and chlorophyll contents in *U. dioica* seed oil was approximately twice that of *U. pilulifera* oil. The results of the present study revealed that nettle seed is a potential source of oil which can be used as a nutritional dietary substance and has great usage potential for both edible and/or other industrial applications.

Keywords *Urtica dioica* · *Urtica pilulifera* · Tocopherol · Phytosterol · Fatty acids

1 Introduction

Urtica is a genus of flowering plants in the family Urticaceae. They have a long history of use as an herbal remedies. The main varieties of the *Urtica* genus (*Urtica dioica* L., *Urtica urens* L., *Urtica pilulifera* L., *Urtica cannabina* L., *Urtica membranacea* Poir., and *Urtica kiovensis* Rogoff) well known for their stinging hairs found on the leaves and stems of the plants [1].

Urtica pilulifera, also known as Roman nettle, as an annual plant is common in many parts of the world and extensively cultivated in the Mediterranean region [2]. It is widely used in folk remedy to treat hypertension, hyperglycemia and inflammation of some organs [3].

Urtica dioica, also known as stinging nettle, is a perennial plant which is distributed throughout the temperate and tropical areas around the world. The species has been a subject of recent scientific interest and product development due to its traditional usage for treating various ailments such as cancer, rheumatism, eczema, nephritis, anemia, haematuria, etc. [4].

With the increasing demand for novel sources of edible oils, it is necessary to elucidate the fatty acid composition, physicochemical properties and nutritional value of natural oil sources to find the suitable application in different parts of food, pharmaceutical, and cosmetic industries. The nettle seeds are rich in oil. Despite the numerous studies focused on medicinal and antioxidant properties of

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different aerial parts of nettle varieties, however, very little information has been reported on the physicochemical and nutritional properties of the oils extracted from the seeds of the plant species. Therefore, this study provides deeper insights into the physicochemical characteristics and nutritional value of the seed oils of two *Urtica* species (*U. dioica* L. and *U. pilulifera* L.) cultivated in Iran to determine the functional compounds in these plant seeds and improve the economic utility of seeds as a source of edible/non-edible lipids.

2 Materials and methods

2.1 Chemicals

All chemicals and solvents used in the present study were of analytical grade and obtained from Merck (Darmstadt, Germany). Pure fatty acids, phytosterols, and tocopherols as standards were purchased from the Sigma Chemical Co. (St Louis, MO).

2.2 Sample preparation

The *U. dioica* and *U. pilulifera* seeds were collected from Rasht, a city in northern Iran, and central Zagros Mountains Range (Zard-Kuh), respectively. The seeds were identified at Medical Plants Research Center, Chaharmahal and Bakhtiari Province, Shahrekord, Iran. They were manually cleaned to remove all foreign matter and subsequently ground in a laboratory mill and stored in a plastic bag at refrigerator before to analysis.

2.3 Proximate analysis of seeds

Moisture was determined by drying in an oven at 100–105 °C to constant weight. Crude oil (solvent extraction in a Soxhlet apparatus for 8 h using *n*-hexan), crude protein (% total nitrogen $\times$ 6.25), crude fiber and ash content were determined using the AOAC official method [5]. Total of carbohydrate was determined by difference. All determinations were done in triplicate.

2.4 Oil extraction

Seeds were coarsely ground by an electrical home grinder. The ground seeds were extracted with *N*-hexane (at a ratio of 1:3) in a round bottom flask with magnetic stirrer for 8 h at room temperature. The air inside the flask was removed by sending a stream of nitrogen gas. After filtration through a paper filter, the extracted oil was separated from the organic solvent using a rotary vacuum evaporator. The

oil samples were frozen and stored in brown glass bottle under a nitrogen atmosphere at -18 °C.

2.5 Fatty acids profile

The gas chromatographic analysis of fatty acid methyl esters was performed on an Agilent 6890N gas chromatography (GLC) equipped with a CPsill 88 (100 m, 0.25 mm i.d., and 0.2 mm film thickness) column. Fatty acid methyl esters were prepared based on the procedure reported by Goli et al. [6]. The column temperature programming was initially held at 170 °C for 1 min, then increased to 190 °C at the rate of 5 °C/min and maintained for 2 min and finally increased to 225 °C at 5 °C/min and maintained for an extra 8 min. The flame ionization detector (FID) and injector were maintained at 280 °C and 260 °C, respectively. Helium, the carrier gas used, was maintained at a flow rate of 1 ml/min.

2.6 Physicochemical analysis of crude oils

AOCS official methods [7] were used for the determination of the specific gravity (Cc 10a-25), peroxide value (method Cd 8b-90), iodine value (method Cd 1-25), saponification value (method Cd 3-25), free fatty acids content (method Ca 5a-40) and thiobarbituric value (Cd 19-90) of oils.

2.7 Total phenolic content (TPC)

Determination of the TPC was done spectrophotometrically at 760 nm using Folin–Ciocalteu's reagent as described by Cappanesi et al. [8]. A calibration curve of gallic acid in methanol was performed in a concentration range of 0.04–0.40 mg/ml.

2.8 Instrumental determination of color

The color of the extracted oils was analyzed using the Lovibond Tintometer Model F, Lovibond PFX 995 series and L^* , a^* , b^* values were determined.

2.9 Total carotenoid and chlorophyll contents

The chlorophyll and carotenoid contents in each oil samples were measured by the method of Abedi et al. [9]. Briefly, 7.5 g oil was dissolved in cyclohexane up to the final volume of 25 ml. Then, the carotenoid and chlorophyll concentrations were measured by a UV–VIS spectrophotometer (Shimadzu UV-2100) at 670 and 470 nm, respectively. Total chlorophyll and carotenoid contents based on mg/kg oil was calculated according to the following equations:

$$\text{Total chlorophyll} = (A_{670} \times 10^4) / (D \times 613)$$

$$\text{Total carotenoid} = (A_{470} \times 10^4) / (D \times 2000)$$

where A_{670} , A_{470} , and D are absorbance at 670 and 470 nm and density (g/L), respectively.

2.10 Chromatographic analysis of α -, β -, γ -, δ -tocopherols

Tocopherol composition was analyzed by an HPLC system (Yong Lin Acme 9000, Korea) equipped with a UV-Visible detector and Lichrospher-Rp 100 C18 column (250 $\times$ 4.6 mm i.d. with 5 μ m pore). Preparation of the oil samples was done according to the method of Lee et al. [10].

2.11 Gas chromatography analysis of sterols

After isolation of unsaponifiable fraction by solid-phase extraction on an aluminum oxide column and extra purification on TLC with n-hexane/diethyl ether 1:1 (V/V) as developing solvent, the sterol profile was analyzed on an Agilent 6890N gas chromatograph equipped with a 30 m $\times$ 0.25 mm i.d., 0.2 μ m Rtx-5 column. The temperatures of the injector and the detector were both 320 $^{\circ}$ C. The column temperature was 240 $^{\circ}$ C and programmed to increase at a rate of 4 $^{\circ}$ C/min to 260 $^{\circ}$ C. The carrier gas used was hydrogen with a flow rate of 36 cm/s. The split ratio was 1:20, and the injected volume was 1 μ l.

2.12 Statistical analysis

All experiments were replicated three times. Analysis of variance (ANOVA) was carried out with the SAS software package (SAS Institute, Cary, NC, software version 9.1) and the average values were compared with Duncan's test. Differences were considered statistically significant at a level of $p < 0.05$.

3 Results and discussion

3.1 Proximate analysis of seeds

Proximate composition of seeds was represented in Table 1. Significant differences ($p < 0.05$) were observed in crude oil and carbohydrate contents.

The moisture content of both varieties was low and about 6% without significant difference ($p < 0.05$) among them. Such low moisture content is considered as a positive feature in nettle seeds that provides long-term storage

Table 1 Proximate analysis (g/100 g) of *U. dioica* and *U. pilulifera* seeds

Component	<i>U. dioica</i>	<i>U. pilulifera</i>
Moisture	6.37 $\pm$ 0.32 ^a	6.67 $\pm$ 0.23 ^a
Ash	4.47 $\pm$ 0.31 ^a	4.07 $\pm$ 0.12 ^a
Crude oil	34.12 $\pm$ 0.36 ^a	29.50 $\pm$ 0.16 ^b
Crude protein	21.89 $\pm$ 0.95 ^a	22.06 $\pm$ 0.48 ^a
Crude fiber	30.24 $\pm$ 0.60 ^a	29.37 $\pm$ 0.44 ^a
Carbohydrate	2.92 $\pm$ 0.97 ^b	8.03 $\pm$ 0.92 ^a

Results are mean of three determination $\pm$ SD and means within the same row followed by different letters are statistically different ($p < 0.05$)

without worrying about spoilage through increasing microbial activities, fungi growth, and enzymatic action.

Ash content is an index of the meal quality after oil extraction for poultry and cattle feeding [11]. This parameter is affected by soil and geographical conditions. According to Table 1, amount of ash in *U. dioica* seeds (4.47%) was slightly greater than the amount of ash in *U. pilulifera* seeds (4.07%) without significant difference ($p > 0.05$). This value was lower than that of some commercial oil seeds such as soybean (7%) [12].

Crude oil content as an important nutritional and industrial factor was significantly different ($p < 0.05$) among these two seed samples may be due to the differences in the variety of plant, ripening stages, environmental conditions and the harvesting time of the seeds [13]. The oil content of *U. dioica* (34.1%) was found higher than that of *U. pilulifera* (29.5%). However, both varieties showed a quite high level of oil which is comparable with commercially oil seeds such as soybean (20%), cotton seed (14%) and safflower seeds (32.4–35.1%) and maybe introduce them as suitable vegetable oil sources for both industrial and commercial uses [14, 15].

According to Table 1, both varieties showed high content of protein without significant difference ($p > 0.05$) in the seeds (21.8% and 22% for *U. dioica* and *U. pilulifera*, respectively) which is similar to the reported values for some legumes in previous studies (18–24% dry matter) [16, 17]. This finding may suggest that the nutritional values of the seeds appear to derive from the protein and oil contents.

Urtica dioica and *U. pilulifera* seeds showed high level of crude fiber in seeds (30.2% and 29.3%, respectively) which was much higher than values reported for sesame (4.6%), sunflower (3.4%), Iranian pumpkin varieties (0.5–3.2%) and cottonseed (10.8%) [18], but close to those reported for melon seeds (33.1%), dragonhead seed (28.3%), chia seeds (34%), safflower varieties (25–29%) and *D. kotschy* seeds (36%) [12]. Crude fiber could play an important role in increasing volume in the gastrointestinal tract

and facilitates its peristaltic movements and prevents constipation.

Results showed the carbohydrate content of *U. dioica* and *U. pilulifera* seeds to be 2.9% and 8%, respectively. Thus, both samples could not be considered as a good source of carbohydrates.

3.2 Fatty acids analysis

The results for the fatty acid composition of the seed oils were shown in Table 2. The fatty acid profiles in both varieties were highly similar. The major unsaturated fatty acid was linoleic acid (overall mean value of 63.2%), followed by oleic acid (overall mean value of 22.1%). α -Linolenic acid was present only in very low quantities (less than 1%). Therefore, tested oils can be classified in the oleic-linoleic acid group. In terms of saturated fatty acids (SFAs), palmitic and stearic acids had higher levels than other SFAs (sum of 12.3% and 13.4% in *U. dioica* and *U. pilulifera* oils, respectively). The high ratio of unsaturated fatty acids/saturated fatty acids (USFAs/SFAs) in tested oils revealed that these samples were nutritionally valuable and rich

sources of essential fatty acids. Therefore, the oils may be used as edible cooking oil, salad oil, or for the manufacture of margarine [13]. On the other hand, the precautions necessary for the transfer and storage of the oils should be considered because of the high percentage of polyunsaturated fatty acids (PUFAs), especially linoleic acid. Linoleic acid content in nettle seed oils was higher than that rice bran, almond, rapeseed, peanut and olive oils but less than safflower and grape seed oils [15, 19].

3.3 Physicochemical analysis of seed oils

Table 3 shows the physico-chemical characteristics of the oil samples. In most of the investigated properties, significant differences ($p < 0.05$) were observed between the two varieties of seed oil.

According to Table 3, the oils showed to have specific gravities of 0.922 (*U. dioica*) and 0.921 kg/m³ (*U. pilulifera*) without significant difference ($p > 0.05$) which was close to the values reported for some other oleic-linoleic acids oils such as sunflower and sesame oils.

Iodine value (or iodine number) is a measure of the average degree of unsaturation in the oil samples which reflects the nutritional value and also the susceptibility of oil to oxidation. This parameter could be used as an indicator of the oils and fats adulteration. Iodine value of the *U. dioica* and *U. pilulifera* seed oils were 147.6 and 127.3 g of I₂/100 g of oil, respectively. This relatively high level of iodine value reflected that both samples contained a substantial amount of unsaturated fatty acids as shown by high levels of linoleic and oleic acids in their fatty acids profile (Table 2). The iodine values obtained here were comparable to the values of some conventional oils such as sunflower, soybean, corn and safflower oils but lower than the values reported for *D. kotschy* oil (203.4) and flaxseed oil (195) [12]. The iodine value obtained places the two oils in the semi-drying groups because of iodine value more than 100 but less than 180 [20].

Table 2 Fatty acids composition (%) of *U. dioica* and *U. pilulifera* seed oils

Fatty acids	<i>U. dioica</i>	<i>U. pilulifera</i>
Myristic acid	0.07 ± 0.00 ^a	0.09 ± 0.00 ^a
Palmitic acid	8.12 ± 0.80 ^b	9.02 ± 0.51 ^a
Stearic acid	4.23 ± 0.15 ^a	4.42 ± 0.12 ^a
Oleic acid	21.60 ± 0.72 ^b	22.60 ± 0.43 ^a
Linoleic acid	64.63 ± 1.05 ^a	61.81 ± 0.96 ^b
Linolenic acid	0.36 ± 0.01 ^a	0.33 ± 0.01 ^a
SFAs	12.78 ± 0.31 ^b	13.86 ± 0.21 ^a
USFAs	86.82 ± 0.59 ^a	84.98 ± 0.46 ^b

Results are mean of two determination ± SD and means within the same row followed by different letters are statistically different ($p < 0.05$)

Table 3 Physicochemical characteristics of *U. dioica* and *U. pilulifera* seed oils

Properties	<i>U. dioica</i>	<i>U. pilulifera</i>
Specific gravity (kg/m) (25 °C)	0.921 ± 0.00 ^a	0.920 ± 0.00 ^a
Iodine value (g of I ₂ /100 g of oil)	147.66 ± 0.21 ^a	127.37 ± 0.18 ^b
Free fatty acids (% oleic acid)	0.73 ± 0.17 ^a	0.42 ± 0.02 ^b
Peroxide value (meq of O ₂ /kg of oil)	2.99 ± 0.05 ^a	1.64 ± 0.11 ^b
Saponification value (mg of KOH/g of oil)	183.30 ± 1.21 ^a	176.20 ± 1.11 ^b
Total phenolic content (mg gallic acid/kg oil)	231.67 ± 1.75 ^a	202.67 ± 2.66 ^b
L*	42.33 ± 0.10 ^b	67.71 ± 2.30 ^a
a*	9.15 ± 0.05 ^a	6.14 ± 0.09 ^b
b*	72.23 ± 0.15 ^b	97.41 ± 0.06 ^a

Results are mean of three determination ± SD and means within the same row followed by different letters are statistically different ($p < 0.05$)

The acid value represents free fatty acids (FFAs) content in fats and oils and usually is considered as an important parameter to monitor the quality of edible oils and degree of hydrolytic and enzymatic spoilage. There was a significant difference ($p < 0.05$) between oil samples on acid value and low concentration of free fatty acids (0.73% and 0.42% for *U. dioica* and *U. pilulifera* oils, respectively) showed that they could have a long shelf life even though the oils were unrefined. Acid values obtained were within the ranges recommended by Codex Alimentarius commission [21] for virgin and refined oils (2 and 0.3% free fatty acids, respectively).

Peroxide value as a qualitative factor is commonly used to determine the level of oxidative rancidity of the oils. This value measures the lipid peroxides and hydroperoxides formed during the initial primary stages of oxidation. Peroxide values of the *U. dioica* and *U. pilulifera* seed oils were low (2.9 and 1.6 meqO₂/kg of oil, respectively) and in the range of maximum acceptable value defined by the Codex Alimentarius Commission for crude oils (10 meqO₂/kg of oil) [21]. Low peroxide value was indicative of suitable oxidative stability of the tested oils (maybe due to low content of linolenic acid and a high level of natural antioxidants). However, this index is usually affected by the condition of oil extraction and seed and oil storage.

The saponification value is related to the average molecular weight of fatty acids esterified in triglycerides structure. The greater molecular weight (the longer carbon chain) points out the smaller saponification number. The saponification number of *U. dioica* and *U. pilulifera* seed oils (183.3 and 176.2, respectively) were comparable to the reported range for other common vegetable oils such as soybean oil, melon seed oil, olive oil, and pumpkin oil [20].

Phenolic compounds as natural antioxidants possess significant effects on food quality and nutritional values in addition to extending the oil stability up to 30% [22]. Extraction system, cultivar and the condition of processing and storage are important factors for the content of phenolic compounds. Total phenolic content of the seed oils were determined to be 231.6 and 202.6 mg GAE/kg oil for *U. dioica* and *U. pilulifera*, respectively. These values were close to those reported in literature for some stable oil such as olive oil (254 mg/kg) [23], but higher than those reported for some other common vegetable oils, for example, groundnut, sunflower and sesame oils [24]. Therefore, tested oils are expected to be more stable than the mentioned oils.

Color is an important indication of edible oil quality, purity, and degree of deterioration and this parameter is used as an indicator to monitor each stage of the refining process to maintain a consistent quality [25]. Each oil has its own characteristics color due to the presence of chlorophyll and/or carotenoid pigments. According to Table 3,

significant differences were found among the L*, a*, and b* values of the tested oils. *U. pilulifera* seed oil showed significantly ($p < 0.05$) more lightness and yellowness (67.7 and 97.4 for *U. pilulifera* versus 42.3 and 72.2 for *U. dioica*, respectively), while *U. dioica* seed oil showed more redness than the other variety (9.1 vs. 6.1). Therefore, it could be concluded that *U. pilulifera* oil had light yellowness compared to *U. dioica* oil in color.

3.4 Total chlorophyll and carotenoid contents

Chlorophyll pigments present in oil seeds are important quality factors because of their adverse effects on oil oxidative stability, hydrogenation and bleachability. The main factors affecting the pigment profile are the variety (or cultivar), the climate, the ripening degree, and growing conditions. Removal of these pigments and other color bodies is necessary during oil processing in the bleaching step. According to the data of Table 4, there was a significant difference ($p < 0.05$) between chlorophyll content in *U. dioica* (15.62 mg/kg) and *U. pilulifera* oils (6.84 mg/kg) as the amount of chlorophyll in *U. dioica* seed oil was about twice the amount in *U. pilulifera* oil. Therefore, the appearance of this oil was even greener than the other variety. The chlorophyll content in *U. dioica* oil was lower than crude rapeseed oil obtained by expeller pressing and crude rapeseed oil obtained by solvent extraction (48 mg/kg and 52.6 mg/kg, respectively) [26] and some of Greece varieties of olive such as Athinolia (29.4–38.7 mg/kg) [27].

Carotenoids are found in common foods and vegetables such as carrots, pumpkins, tomatoes, and other deep yellow, red, green, orange fruits, common vegetables and some numerous vegetable oils, especially palm oil and palm oil products. Carotenoids found in vegetable oils, have antioxidants (potent quenchers of singlet molecular oxygen) and anti-carcinogenic properties [28]. Carotenoid content in *U. dioica* and *U. pilulifera* seed oils were 5.63 and 2.33 mg/kg, respectively (Table 4). Similar to the chlorophyll content, the carotenoid content was also twice as much in *U. dioica* as the *U. pilulifera* oil. Total carotenoid content in both varieties was similar to reported values for sunflower oil (3.06 mg/kg), olive oil (6.2 mg/kg), and peanut oil (about 2 mg/kg) [29].

Table 4 Total chlorophyll and carotenoid contents in *U. dioica* and *U. pilulifera* seed oils

Properties	<i>U. dioica</i>	<i>U. pilulifera</i>
Total chlorophyll content (mg/kg)	15.62 ± 0.15 ^a	6.84 ± 0.04 ^b
Total carotenoid content (mg/kg)	5.63 ± 0.09 ^a	2.58 ± 0.14 ^b

Results are mean of three determination ± SD and means within the same row followed by different letters are statistically different ($p < 0.05$)

Fig. 1 The amount of total and individual tocopherols in analyzed seed oils. Average values of two determination $\pm$ SD

3.5 Tocopherol quantification

Tocopherols are important lipid oxidation inhibitors in food and biological systems. They possess vitamin E function and present in oilseeds in four different forms: α , β , γ , and δ -tocopherols. Total and individual tocopherol contents of analyzed oils were given in Fig. 1. In this study, β -tocopherol was integrated into the γ -tocopherol due to insufficient separation of β and γ -tocopherol. The amount of beta tocopherol in vegetable oils is negligibly low (in the range of 0–2.8 mg/100 g) [30]. Therefore, the sum of β and γ -tocopherol fraction mainly consists of γ -tocopherol and lack of separation does not introduce a significant error into the quantification of this fraction. According to Fig. 1, the concentration of total tocopherols in *U. dioica* oil was significantly ($p < 0.05$) higher than *U. pilulifera* oil (661.8 and 590.6 mg/kg, respectively). Based on present results, nettle seed oils were good sources of tocopherols compared to some other oils such as virgin olive oil (177 mg/kg), linseed oil (367 mg/kg), refined grape seed oil (121 mg/kg) and peanut oil (226 mg/kg) [30]. However, total tocopherols content in these two varieties was less than values reported for crude corn oil (1006 mg/kg), soybean oil (1328 mg/kg), sunflower oil (737 mg/kg) [31] and canola oil (710 mg/kg) [32]. ($\gamma + \beta$) followed by δ -tocopherol were the most abundant fractions in both tested oils and showed higher concentration in *U. dioica* oil (613 and 48.8 mg/kg, respectively) than *U. pilulifera* oil (532 and 44.5 mg/kg, respectively). γ -tocopherol and δ -tocopherol have shown the highest efficiency in oxidative stability of vegetable oils in frying applications while α -tocopherol is considered to have the nutritional value [33]. According to previous studies, ($\gamma + \beta$)-tocopherols were also

dominant fractions in soybean, rapeseed, sesame and corn oils, while α -tocopherol was the major fraction in sunflower, olive, wheat germ and coconut oils [30, 32].

3.6 Sterols content

Plant Sterols (phytosterols) are known to have a wide range of biological activities and nutritional properties due to their potential to lower both LDL cholesterol and total serum cholesterol [30, 34]. For *U. dioica* and *U. pilulifera* oils, the most abundant sterol components present in the sterol fractions were $\Delta 5,23$ -Stigmastadienol (33.1 and 36.8 mg/100 g, respectively) and β -sitosterol (16.5 and 18.2 mg/100 g, respectively). These are followed by $\Delta 7$ -otasterol, $\Delta 7$ -stigmastenol, $\Delta 5,24$ -stigmastadienol and stigmastanol in abundance. All other sterols were present in small amounts (Fig. 2). Although phytosterols are much less abundant in nature than phytosterols, nettle oils examined were good sources of these sterols. However, based on the present results, total phytosterols level in investigated seed oils were significantly lower than some conventional seed oils such as corn oil (909 mg/100 g), sunflower oil (411 mg/kg), sesame oil (968 mg/100 g), cotton seed oil (324 mg/100 g) and soybean oil (250 mg/100 g) [34, 35].

4 Conclusions

In summary, given the few studies on the nettle varieties seed composition, and also inadequacy reports of the detailed bioactive composition of these seed oils, improved knowledge on the composition and properties of nettle seeds would assist in efforts to achieve edible and/or industrial application of these plants. According to the results of this study, it can be concluded that the seeds are a good source of oil, protein and fiber. The qualities of the tested oils are highly comparable with those of some conventional seed oils. Both varieties showed high PUFAs content which may be assigned to high linoleic acid content. So, the seeds are suitable oil sources either for edible purposes or pharmaceutical and oleochemical industries. High level of linoleic acid and low linolenic acid content make the oils nutritionally valuable and stable to oxidative deterioration, respectively. Total phenolic compounds, tocopherols, and sterols composition and relatively suitable oxidative stability in addition to other desirable characteristics imply the potential uses of these seed oils in pharmaceuticals, cosmetics and foods.

Fig. 2 Sterols content in analyzed seed oils. Average values of two determination $\pm$ SD

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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