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Phytonutrients, polyphenols and triterpenes in *Taraxacum officinale* Weber ex F.H.Wigg flowers

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Dandelion or *Taraxacum officinale* Weber ex F.H. Wigg is a well-known medical and edible plant that is a source of various nutrients and biologically active substances. Considering the lack of studies of the dandelion flowers justifying their use as food, the present study was done to emphasize the nutritional level for dry and fresh flowers. The chemical composition for 100 g of dry matter was: crude proteins 13.90±0.06% dw (2.17±0.01% fw); crude fat 7.57% dw (1.18±0.01% fw); total sugars 5.99±0.01% dw (0.93±0.00% fw) (fructose, glucose and sucrose); cellulose 11.50±0.12% dw (1.79±0.02% fw); pectin 3.35±0.05% dw (0.52±0.01% fw). The amounts of the yellow-colored pigments total carotenoids (2.51±0.01% dw and 0.39±0.01% fw, respectively) were determined. The amino acid composition of the protein was determined - the results show that dandelion flowers are a potentially good source of the amino acids histidine and lysine. Six phenolic acids were found in dandelion flowers, with chicory acid, protocatechuic acid and chlorogenic acid being in the largest quantities. The triterpene composition of the edible dry and fresh dandelion flowers was determined, α-amyrin, β-amyrin and lupeol were found, and the amount of the phytosterol β-sitosterol was also determined. The results of this study show the nutritional potential of *Taraxacum officinale* flowers as a suitable resource for the preparation of fresh salad and culinary processed foods that are the product of native wild and cultivated plants.

Keywords: dandelion, *Taraxacum officinale* Weber ex F.H. Wigg, nutrients, edible flowers

INTRODUCTION

Herbs have accompanied humanity for centuries, serving important roles in medicine, cosmetology, and culinary practices. In recent years, there has been a growing consumer interest in the wholesomeness of food, with a particular focus on products that are not only nutritious but also biologically active. For millennia, plants have been a rich source of chemical compounds exhibiting various biological activities, including potent antioxidant properties [1].

Dandelion (*Taraxacum officinale* Weber ex F.H. Wigg) is an herbaceous perennial belonging to the *Asteraceae* family. It is non-toxic, often considered a weed, and is widely distributed across the Northern hemisphere [2]. The therapeutic use of dandelion has been mentioned by Arabian, Native American, Chinese, and Ayurvedic medicine [3].

The name of the genus *Taraxacum* means bitter herb in Arabic, while in Greek, it may be derived from the words taraxia (eye disorder) and akeomai (to cure). The common name 'dandelion' probably comes from the French (dent de lion), meaning teeth of the lion, referring to the tooth-like edges of the leaves [3, 4].

In Russia, India, and China, the dandelion has been used in ethnopharmacology as a traditional folk medicine due to its hepatic and hypoglycemic effects [5]. Another interesting aspect reported in ethnopharmacological studies is that immigrants continue their traditional practices for natural medicine even once inserted in highly industrialized countries, indicating the traditional importance of herbal medicine [6].

Dandelion is often consumed as a food (mainly as a salad ingredient), as it is a rich source of micronutrients such as minerals and vitamins [7]. The young leaves are placed in many dishes, and the inulin-rich roots are used as substitutes for coffee or tea [8]. Additionally, the *Taraxacum* leaf extract can be used as a flavoring agent for various foods, including alcoholic and soft drinks, frozen dairy desserts, candies, baked goods, puddings, and cheese [9,10].

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Various dandelion plant parts have been studied both chemically and nutritionally. Apart from being used as a remedy for illness, dandelion petals, leaves, and roots are processed into various food products. The beneficial effects of dandelion are dependent on the chemical compounds contained in the plant [10]. These include sesquiterpene lactones, which have been found to have anti-inflammatory and antibacterial effects, as well as triterpenes or phytosterols, which possess anti-atherosclerotic properties. In addition, dandelions have high levels of phenolic compounds, including phenolic acids with antioxidant properties and coumarins with anticancer, anti-inflammatory, antibacterial, and antithrombotic effects. The roots are also rich in inulin, which has a probiotic, hypoglycemic, and immune-boosting effect [10].

The traditional uses of dandelion that are mentioned in the literature concern its use as a remedy for kidney diseases, diabetes, bacterial infections, diuretic, liver, kidney, and spleen disorders, and anti-inflammatory factors. On the other hand, dandelion parts are used as food, mainly as a salad ingredient, young leaves are placed in many dishes, and the inulin-rich roots are used as substitutes for coffee or tea [8].

Modern research has demonstrated that the therapeutic effects of raw dandelion were ascribed to the bioactivity's constituents, including polyphenols, tocopherols, cinnamic acid derivatives, flavonoids, triterpenoids, polysaccharides, and riboflavin [11, 12].

Even though these food components are not vital for the metabolism of the body, they improve the overall health of consumers by enhancing their physiological activity [13]. For this reason, studies on the secondary metabolites of plants have grown exponentially over the past years, and these compounds are considered potent substances for improving human health.

Taraxacum officinale has been extensively characterized in terms of its biochemical profile and nutritional composition, primarily due to its global distribution and economic importance as both food and feed. Many available data focus on phytonutrients, polyphenols, and triterpenes in the roots and leaves [14], whereas considerably less information is available for the flowers.

The medicinal properties of plants like antidiabetic, antimicrobial, antidiuretic, antioxidant, etc. are mainly dependent on the type, nature and concentration of secondary metabolites present. Reports have shown that some of the most important bioactive compounds are phytochemicals such as alkaloids, saponins, flavonoids, tannins, sterols, and phenolic compounds [14-16]

On this basis, the aim of the present study was to determine the nutritional (macro- and micronutrient) composition of dandelion flowers (carbohydrates, fats and proteins), phenolic acid composition, pentacyclic triterpenes and antioxidant activity, both fresh and dried flowers.

EXPERIMENTAL

Plant materials

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 (on May, 2023). The samples were dried in the shadow at room temperature for 10 days and finely ground in a laboratory homogenizer. Fresh flowers were frozen and stored at -20 °C.

Analysis of moisture content

For the determination of moisture content, the milled sample (~1.5 g) was dried in an automated moisture analyzer (KERN DLB, Germany) at 105 °C until constant weight. Ash content was determined as the pulverized sample (0.5 g) was placed in a crucible and ignited in a muffle furnace at 550 °C until there was no change in the mass of the sample.

Analysis of crude lipid content

For the estimation of crude lipid content, the ground sample (10.0 g) was packed in a cellulose thimble and subjected to an exhaustive extraction with n-hexane (200 ml) for 8 h in a Soxhlet extractor. The obtained crude extract was dried under vacuum, and its weight was used for the calculation of the lipid content.

Analysis of crude protein content

The crude protein content was evaluated by the Kjeldahl method (N × 6.25). The total carbohydrate content of the fruits was analyzed by the phenol–sulfuric acid method [17].

Amino acid composition

For the estimation of amino acid composition, the sample (300 mg) was hydrolyzed (5 ml, 6N HCl) in a sealed glass ampule at 105 ◦C for 24 h. The sample was vacuum-dried, reconstituted in 10 ml of 20 mM HCl, and filtered. A total of 20 µL of the collected filtrate was derivatized using an AccQ Fluor kit (WATO52880, Waters Corp., Milford, NH, USA) according to the manufacturer's instruction manual. The resulting derivatives were

separated on an ELITE LaChrom HPLC system (VWR™ Hitachi, Tokyo, Japan) equipped with a diode array detector and a reversed-phase column C18 AccQ Tag (3.9 mm × 150 mm) operating at 37 ◦C. The volume of the injected sample was 20 µL. The elution was performed at a flow rate of 1.0 ml/min [18]. The different amino acid derivatives were detected at 254 nm.

Total carotenoid and chlorophyll content

The total content of chlorophylls and carotenoids was determined by using 80% acetone as a solvent. Absorbance was measured at three different wavelengths: 662, 644, and 470 nm using Camspec M107 VIS spectrophotometer (Spectronic-Camspec Ltd., Leeds, UK) according to Lichtenthaler and Wellburn [19].

Pectin and cellulose

For the estimation of the pectin content of dandelion flowers the method described by Ivanov *et al.* [20] was used. The quantitative estimation of cellulose was performed gravimetrically. Briefly, a sample (0.5 g) was gently boiled (30 min) with 25 ml of acetic acid-HNO_3 reagent (acetic acid: H_2O: HNO_3 8:2:1 v/v/v) in a round-bottom flask fitted with a reflux condenser. After cooling, the insoluble residue was filtered through a sintered glass filter (G3) under vacuum, washed with deionized water to neutral pH, then with ethanol (96% v/v), and finally with an excess of petroleum ether. The obtained residue was dried in a laboratory oven at 50 °C to a constant weight. The resulting cellulose was corrected for its ash content [17].

High-performance liquid chromatography analysis of available carbohydrates, phenolic acids, pentacyclic triterpenes and phytosterols.

In a plastic centrifuge tube, about five g of dry dandelion flowers were weighed out. To this, distilled water (25 ml) for sugars; 50% ethanol for phenolic acids; and n-hexane for terpenes was then added. The tube was placed in an ultrasonic bath (Siel UST 5.7-150, Gabrovo, Bulgaria), and ultrasound-assisted extraction was performed with a frequency of 35 kHz (300 W) at 40 °C. After heating for 20 min, the tube was cooled in running water, then filtered successively through a paper and a PTFE filter (0.45 µm). The quantitative chromatographic separation of free sugars was carried out on a Shodex® Sugar SP0810 (300 mm × 8.0 mm i.d.) column having Pb^{2+} as a counter ion and a Shodex SP-G guard column (5 µm, 6 mm × 50 mm) (Shodex Co., Tokyo, Japan) according to method described by Ognyanov *et al.* [17]. The quantitative chromatographic separation of phenolic acids was carried out on a Supelco Discovery® HS C18 column (5 µm, 250 mm × 4.6 mm) according to the method described by Stoyanova *et al*. [18]. The quantitative chromatographic separation of pentacyclic triterpenes and phytosterols was carried out on a Supelco Discovery® HS C18 column (5 µm, 250 mm × 4.6 mm) according to the method described by Vrancheva *et al.* [21].

Total phenolic content and total flavonoid content

The total phenolic content was determined according to the method with Folin–Ciocalteu's reagent [17]. Gallic acid (10–200 µg/ml) was employed as a calibration standard ($Y=12.557X – 0.0871$, $R^2=0.9983$). The total flavonoid content was determined according to the method of Vrancheva *et al*. [21]. The calibration curve was constructed with quercetin dihydrate (10–200 mg/L, $Y=0.0119X – 0.0467$, $R^2=0.9895$).

In vitro antioxidant activity assays

1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging ability and cupric ion reducing antioxidant capacity (CuPRAC) were determined. The preparation of extracts was carried out as described by Ivanov *et al*. [22].

Statistical analysis

The experimental data (three replicates, n=3) are presented as mean value ± standard deviation. For analysis Microsoft Excel 2013 was used.

RESULTS AND DISCUSSION

Traditional medicinal plants exert their therapeutic effects due to the bioactive compounds they contain. *Taraxacum officinale* (dandelion) is highly valued for its unique biological properties and significant pharmacological activity [23]. Modern research has demonstrated that the therapeutic effects of raw dandelion are attributed to its bioactive constituents, including tocopherols, cinnamic acid derivatives, flavonoids, triterpenoids, polysaccharides, and fatty acids [24-27].

In our study, both fresh and dried dandelion flower samples were analyzed for their chemical composition, based on 100 g of dry matter (dw) and 100 g of fresh weight (fw), as presented in Table 1. The comparative nutritional analysis of fresh and dried *T. officinale* flowers revealed notable differences. The results showed that dried flower samples were nutritionally superior to their fresh counterparts. The moisture content in fresh flowers

was 84.39 ± 0.05 g/100 g, which decreased to 11.25±0.02 g/100 g dw after drying, representing an 86.7% reduction. The ash content increased from 0.15±0.02 g/100 g in fresh flowers to 7.01 g/100 g in dried samples, reflecting an increase of approximately 40 times. Similarly, the total carbohydrate content increased from 11.00±0.02 g/100 g in fresh flowers to 70.52±0.14 g/100 g in dried flowers, corresponding to an increase over 5 times. The results show that there are no significant nutrient losses during drying.

Taraxacum officinale herbs and root are rich sources of polysaccharides, which consist of monosaccharides such as arabinose, glucose, galactose, fructose, xylose, mannose, and their glycoside and inulin [27, 28]. In dandelion flowers only glucose, fructose and sucrose were identified in concentrations of total sugars 5.99±0.01 g/100 g dw, glucose 1.91±0.01 g/100 g dw fructose, 2.39±0.01 g/100 g dw and sucrose 1.58±0.01 g/100 g dw. The fresh flowers contain about 5 times less sugar than dried flowers (Table 1). In comparison, in other parts of the dandelion, such as the leaves, similar sugars were found in different concentrations as well - glucose 30.9 μg/g, fructose, rhamnose 5.9 μg/g, and sucrose 8.2 μg/g [29].

The content of crude protein in dandelion flowers (2.17±0.01 g/100 g fw and 13.90±0.06 g/100 g dw) (Table 1) is much lower as compared to that identified in leaves (3.82 g/100 g fw and 16.01 g/100 g dw) [30]. Although there is more protein in the leaves (about 25%) than in the flowers, the amount of lipids is higher in the flowers (about 43%, 7.57±0.07 g/100 g dw) compared to their amount in the leaves (4.29 g/100 g dw) [30]. In comparison, dandelion flowers are a good source of the nutritional components crude protein, crude lipids and carbohydrates compared to other known edible flowers (*Calendula officinalis*, *Etlingera elatior*, *Hedychium forrestii*, *Helianthus annuus*, *Hibiscus rosa-sinensis*, *Rhododendron arboretum*, *Rosa* spp., *Spilanthes oleracea*, *Tagetes erecta*, *Tropaeolum majus*). The amounts of these components are in the upper range in dandelion for crude proteins (from 1.20% to 2.38% fw); for crude fat (from 0.2% to 1.52% fw) and carbohydrates (from 2.15% to 14.15% fw) [32].

The content of chlorophyll A and B in the dried flowers was 34.12 mg/100 g dw and 17.16 mg/100 g dw, respectively. These values are higher than those previously reported for the flowers and roots (4.72±0.05 mg/100 g dw) [31] but lower compared to the leaves and stem (239.51 ± 0.015 mg/100 g dw) [30].

HPLC qualitative and quantitative analysis of phenolic compounds

Phenolic compounds (polyphenols) are secondary metabolites synthesized in plants and possess one or more phenolic rings with one or more attached hydroxyl groups.

Table 1. Nutritional values of dandelion flowers.

Compounds	Dry dandelion flowers, g/100g dw	Fresh dandelion flowers, g/100g fw
Moisture	11.25±0.02	84.39±0.05
Crude fat	7.57±0.07	1.18±0.01
Crude protein	13.90±0.06	2.17±0.01
Ash	7.01 ±0.11	0.15±0.02
Carbohydrates	70.52 ±0.14	11.00±0.02
Cellulose	11.50±0.12	1.79±0.02
Pectin	3.35±0.05	0.52±0.01
Total sugars	5.99±0.01	0.93±0.00
Glucose	1.91±0.01	0.29±0.00
Fructose	2.39±0.01	0.37±0.00
Sucrose	1.58±0.01	0.24±0.00
Sweetness index	9.54±0.01	1.46±0.00
Chlorophyll A (mg/100g)	34.12 ± 1.01	5.3 ±0.01
Chlorophyll B (mg/100g)	17.16 ± 1.04	2.6 ±0.01
Total carotenoids	2.51 ± 0.01	0.39±0.01

All data are presented as mean value ± standard deviation (n=3)

Generally, more than half of the phenolic compounds have antibacterial, antifungal, anti-inflammatory, and anti-tumor properties [33].

Phenolic acids contribute to the overall health improvement, primarily because of antioxidant and anti-inflammatory actions [34] which help in the prevention of cardiovascular diseases and various cancers [35], protect against oxidative damage diseases; and exhibit antimicrobial, antimutagenic, hypoglycemic, and anti-platelet aggregating activities [36]. More than 30 phenolic compounds have been identified and isolated in the different dandelion plant parts [37].

The contents of five organic acids - protocatechuic acid, chlorogenic acid, caffeic acid, ferulic acid, and chicoric acid in dandelion (*Taraxacum officinale*) flower samples were quantified using HPLC (Table 2). Among the identified compounds, chicoric acid was present in the highest concentration, 575.14±0.31 mg/100 g dw. It was followed by protocatechuic acid and chlorogenic acid, with concentrations of 452.21±0.13 mg/100 g dw and 377.45±0.21 mg/100 g dw, respectively. Our results are in good agreement with a previous report showing that

chicoric acid and chlorogenic acid (120.0 ± 0.50 mg/ 100 g dw) [38] were the predominant compounds in different parts of the dandelion. A similar trend was observed in fresh flower samples, with chicoric acid being the most abundant, followed by protocatechuic acid and chlorogenic acid. Chen *et al.* [39] reported that the extracts obtained from dandelion flower grown in China contained from 75 to 98 mg/100 g dw of chicoric acid and from 10 to 12 mg/100 g dw of chlorogenic acid. These concentrations are comparatively lower (over 4 times) than those found in the flower samples analyzed in our study. Ferulic acid was detected at a moderate level in our study, similar to the concentration in other authors' studies on flowers [40]. Caffeic acid was found at a concentration of 31.24±0.05 mg/100 g dry weight, which is about 3 times higher than previously reported concentrations of dandelion extracts obtained from flowers (9.47±0.29 mg/100 g dry weight) [39,40].

Table 2. Phenolic acids, total polyphenols, total flavonoids and antioxidant activities of dandelion (*T. officinale*) flowers

Compounds	Dry dandelion flowers, mg/ 100 g dw	Fresh dandelion flowers, mg/ 100 g fw
Phenolic acids		
Protocatechuic acid	452.21±0.13	70.59±0.02
Chlorogenic acid	377.45±0.21	58.92±0.03
Caffeic acid	31.24±0.05	2.87±0.01
Ferulic acid	140.69±0.12	21.96±0.02
Chicoric acid	575.14±0.31	89.77±0.05
p-Coumaric acid	262.23±0.11	40.93±0.02
Total polyphenols	2346.21±0.93	366.24±0.14
Total flavonoids	982.36±0.33	153.34±0.05
Antioxidant activity		
DPPH method	14521.07±78.18	2266.74±12.20
CuPRAC method	28808.30±127.41	4496.97±19.88

All data are presented as mean value ± standard deviation (n=3).

The total polyphenol content in dandelion flowers in our study was 2346.21±0.93 mg GAE/100 g dw and 366.24±0.14 mg GAE/100 g fw, while the total flavonoid content was 982.36±0.33 mg QE/100 g dw and 153.34±0.05 mg QE/100 g fw (Table 2). The antioxidant capacity of dandelion (*T. officinale*) flowers was assessed using two established methods - CuPRAC and DPPH radical scavenging method. The results are presented in Table 2. Thus, the high antioxidant activity observed in the flower extract might be a result of the high amount of chicoric acid, chlorogenic acid and other phenolic acids in the flower extract (Table 2). As shown in the table, the CuPRAC method revealed the highest antioxidant activity in dandelion flowers, with values approximately twice higher than those obtained by the DPPH method. According to the research of another author [31], in different parts of the plants (leaves, flowers, roots) the results indicated that total phenolics, DPPH and CuPRAC values were higher in *Taraxacum officinale* flowers: 2346.21 mg GAE/100 g dw, 14521.07 mM TE/100 g dw (DPPH method), and 28808.30 mM TE/100 g dw (CuPRAC method). The antioxidant capacity of the different parts of the plant positively correlated with their phenolic content.

Amino acid composition

The amino acid composition can determine the nutritional quality of foods. Amino acids are building blocks of proteins in muscle fibers and other structures in the body. They help to transport nutrients, prevent illness, and perform other functions. Their deficiency can result in decreased immunity, digestive problems, depression, slowed growth in children, and many other health issues [41].

The identified amino acids contribute to the overall pharmacological effects of this type of medicinal plant material. However, the existing literature lacks sufficient studies on the individual amino acid composition in *Taraxacum officinale* flowers. In our study, seventeen amino acids were identified and quantified. The composition and content of essential, semi-essential and nonessential amino acids in our sample are presented in Table 3.

The content of essential amino acids is significantly higher for four specific acids, which have relatively close values. The highest content was found for L-histidine (19.83±0.01 mg/g dw), followed by L-lysine (13.73±0.01 mg/g dw), L-isoleucine (10.93±0.01 mg/g dw). The isoleucine value corresponds to the value reported for the dandelion root [44]. Histidine facilitates growth, creation of blood cells, and tissue repair. It also helps to maintain the special covering over nerve cells, which is called myelin sheath [41]. Isoleucine is of great interest as a nutritional and dietary supplement, as well as for enteral and parenteral protein nutrition. It affects the replenishment of the deficit of proteins, carbohydrates, and amino acids, and has an antitoxic effect [45, 46]. The third most predominant amino acid was L-phenylalanine

(8.66±0.01 mg/g dw), followed by L-valine (8.51±0.01 mg/g dw). Phenylalanine helps the body to use other amino acids, as well as proteins and enzymes. It is needed in treating brain disorders and for normal functioning of the central nervous system. Its deficiency can lead to poor weight gain [47]. The nonessential amino acid proline is present in *Taraxacum officinale* flowers in the greatest amount (18.79±0.01 mg/g dw). Proline accumulation is a common physiological response to salinity and osmotic stress in many plant species [43].

Table 3. Amino acids content in *Taraxacum officinale* flowers

Amino acid	Concentration, mg/g dw	Ref. protein mg/g [42]	AAS* % [41]
Essential amino acids			
L-Valine, Val	8.51±0.01	15	56.7
L-Leucine, Leu	1.61±0.01	21	7.7
L-Isoleucine, Ile	10.93±0.01	15	72.8
L-Methionine, Met	1.05±0.01	20	6.2
L-Threonine, Thr	0.77±0.01	11	7.0
L-Lysine, Lys	13.73±0.01	18	76.3
L-Phenylalanine, Phe	8.66±0.01	21	62.4
Semi essential amino acids			
L-Histidine, His	19.83±0.01	15	132.2
L-Arginine, Arg	6.06±0.01	-	-
Nonessential amino acids			
Glycine, Gly	2.59±0.01	-	-
L-Alanine, Ala	14.36±0.01	-	-
L-Serine, Ser	7.59±0.01	-	-
L-Aspartic acid, Asp	10.75±0.01	-	-
L-Glutamic acid, Glu	8.85±0.01	-	-
L-Cysteine, Cys	0.20±0.01	-	-
L-Tyrosine, Tyr	4.46±0.01	-	-
L-Proline, Pro	18.79±0.01	-	-

All data are presented as mean value ± standard deviation (n=3); * AAS - Amino acid score

In dandelion, pentacyclic triterpenoids and phytosterols are of many types such as gigantursenol A, taraxasterol, β-sitosterol, β-sitosterol-3-*O*-β-D-glucoside, stigmasterol, and β-sigmasterol-3-*O*-β-D-glucoside. lupane-, bauerane-, and euphane-type triterpenoids were isolated from the roots and leaves [24, 26, 48]. In dandelion flowers, beta-sitosterol predominates, and of the triterpenes, alpha- and beta-amyrin and lupeol have also been determined in concentrations of about 100 μg/100g dw (Table 4). In dandelions, triterpenoids and sterols exhibit remarkable anti-oxidative and anti-inflammatory activities [48].

Table 4. Pentacyclic triterpenes and phytosterols in dandelion flowers.

Compounds	Dry dandelion flowers, μg/100 g dw	Fresh dandelion flowers, μg/100 g fw
α-Amyrin	176.20 ±0.09	27.50±0.02
β-Amyrin	105.37±0.05	16.45±0.01
Lupeol	100.22±0.07	15.64±0.02
β-Sitosterol, mg/100 g	16.29±0.10	2.54±0.02

CONCLUSION

Dandelion flowers combine macronutrient value (proteins, fibers, healthy fats) with exceptionally high levels of polyphenols, triterpenes, and phytosterols - making them one of the most nutritionally potent and health-promoting commonly eaten floral foods. Dandelion flowers are a suitable source of the essential amino acids histidine and lysine, as well as polyphenolic compounds (chicoric acid and protocatechuic acid) with high antioxidant potential. Their regular intake (fresh or processed) can bolster antioxidant defenses, support cardiovascular and liver function, aid digestion, and contribute to overall dietary variety [30, 32, 34].

REFERENCES

1. T.A. Jiang, *J AOAC Int.*, **102**(2), 395 (2019).
2. Z. Jinchun, C. Jie, Afr. J. Tradit. *Complement. Altern. Med.*, **8**, 128 (2011).
3. E. Yarnell, K. Abascal, *Int. Med.*, **8** (2), 35 (2009).
4. S. Qureshi, S. Adil, M. E. Abdel-Hack, M. Alagawany, M. R. Farag, *J. World's Poult. Sci.,* **73**, 591 (2017).
5. K. J. Kemper, *Pedia. Educ. Res.,* 1 (1999).
6. M. Ceuterick, I. Vandebroek, B. Torry, A. Pieroni, *J. Ethnopharmacol*., **120**, 342 (2008)
7. N. L. Escudero, M.L. de Arellano, S. Fernandez, G. Albarracin, S. Mucciarelli, *Plant Foods Hum Nutr*, **58**(3), 1 (2003).
8. D. Esiyok, S. Ötles, E. Akcicek, *Asian Pac. J. Cancer Prev*., **5**, 334 (2004).
9. Y. Huang, P. Wu, X. D.Chen, *Food Hydrocoll*., **130**, 107714 (2022).
10. L. Bernadetta, B. Olas, *J. Funct. Foods*., **59**, 40 (2019).
11. P. C. Mu, H. J. Youn, H. K. Chang, Y. S. Song, *Food Chem. Toxicol*., **48**(5), 1255 (2010).
12. P. C. Mu, C. W. Cho, Y. S. Song, *Food Chem. Toxicol.*, **66**, 56 (2014).
13. A. Munawar, F. Saeed, F. Saeed, F. Anjum, F. Muhammad, *Int. J. Food Prop*., **20**(8), 1689 (2017).
14. M. V. Tanasa, T. Negreanu-Pirjol, L. Olariu, B. S. Negreanu-Pirjol, A.C. Lepadatu, L. Anghel, N. Rosoiu, *Int. J. Mol. Sci*., **26**, 450 (2025).

15. H. S. Abdillahi, G. I. Stafford, J. F. Finnie, J.V. Staden, *South Afric. J. Bot*., **76**, 1 (2010).
16. S.S. Garboui, A. K. Borg-Karlson, K. Palsson, *J. Med. Entomol*., **46**, 1415 (2009).
17. M. Ognyanov, P. Denev, N. Petkova, Z. Petkova, M. Stoyanova, P. Zhelev, G. Matev, D. Teneva, Y. Georgiev, *Plants*, **11**, 1832 (2022).
18. M. A. Stoyanova, M. N. Perifanova-Nemska, *IOP Conf. Ser. Mater. Sci. Eng.* **1031**, 012103 (2021).
19. H. K. Lichtenthaler, A. R. Wellburn, *Biochem. Soc. Trans*., **11**, 591 (1983).
20. I. Ivanov, N. Petkova, P. Denev, *Industrial Technologies*, **4**, 21 (2017).
21. R. Vrancheva, I. Ivanov, I. Dincheva, I. Badjakov, A. Pavlov, *Plants*, **10**, 94 (2021).
22. I. G. Ivanov, R. Z. Vrancheva, A. S. Marchev, N. T. Petkova, I. Y. Aneva, P. P. Denev, V. G. Georgiev, A. I. Pavlov, *Int. J. Curr. Microbiol. Appl. Sci.,* **3**, 296 (2014).
23. M. I. Dias, L. Barros, Alves, R. C. Oliveira, M. B. Santos-Buelga, I.C. Ferreira, *Food Res. Int*., **56**, 266 (2014).
24. I. Ivanov, M. Todorova, N. Petkova, I. Dincheva, *Bulg. Chem. Commun*., **56**(D2), 96 (2024).
25. I. Petrova, N. Petkova, I. Ivanov, Int. *J. Pharm. Phytochem. Res.,* **8**(4), 604 (2016).
26. I. Ivanov, N. Petkova, J. Tumbarski, I. Dincheva, I.Badjakov, P. Denev, A. Pavlov, *Z Naturforsch. C. J. Biosci.,* **73**, 41 (2018).
27. N. Petkova, I. Hambarliyska, I. Ivanov, M. Ognyanov, K. Nikolova, S. Ibryamova, T. Ignatova-Ivanova, *Appl. Sci.* **15**, 4091 (2025).
28. Y. Qingzi, Q. Xing, Z. Liu, Y. Zou, X. Liu, H. Xia, *Biomedicine & Pharmacotherapy*, **179**, 117334 (2024).
29. G. Laura, S. Emrick, B. de Falco, V. Lanzotti, G. Bonanomi, *Phytochem. Rev*., **18**, 1115 (2019).
30. M. Imtiyaz, O. Laila, I. Drabu, A. Ahmad, W. Charifi, S. M. Popescu, S. Mansoor, *Molecules*, **24**, 2 (2022).
31. S. Dedić, A. Džaferović, H. Jukić, *Food in Health and Disease*, **11**(1), 8 (2022).
32. P. Kumari, Ujala, B. Bhargava, *Journal of Functional Foods*, **78**, 104375 (2021)
33. H. Rasouli, M. H. Farzaei, R. Khodarahmi, *Int. J. Food Prop*., **20**(2), 1700 (2017).
34. E. B. Tresserra-Rimbau, A. Rimm, M. A. Medina-Remon, R. Martinez-Gonzalez, D. de la Torre, *Nutr. Metab. Cardiovasc. Dis.*, **24**(6), 639, (2014).
35. M. Goleniowski, M. Bonfill, R. Cusido, J. Palazon, Phenolic Acids, in: Natural Products (Phytochem, Bot. Metabol. Alkal, Phenol. Terp.), Springer, Berlin, 2013.
36. M. Saxena, J. Saxena, A. Pradhan, *Int. J. Pharm. Sci. Rev. Res.,* **16**(2), 130 (2012).
37. M. Gonzalez-Castejon, F. Visioli, A. Rodriguez-Casado, *Nut. Rev.*, **70**(9), 534 (2012).
38. R. Domitrovic, H. Jakovac, Z. Romic, D. Rahelic, Z. Tadic, *J. Ethnopharm*., **130**(3) 569 (2010).
39. J. Chen, Q. Lei, W. Yang, *Journal of Food Biochemistry*, March (2025).
40. Y. Xue, S. Zhang, M. Du, M. J. Zhu, *Journal of Functional Foods*, **29**, 10 (2017).
41. J. Berry, *Medical News Today*, **1**,1 (2019).
42. World Health Organization. Protein and Amino Acid Requirements in Human Nutrition: (WHO technical report series, no. 935), United Nations University, Geneva, 2007.
43. M**.** Ashraf, M. R. Foolad, *Environ. Exp. Bot*., **59**, 206 (2007).
44. A. O. Suschenko, E. V. Kompantseva, *Aspir. Vest. Povol*., **20**(5-6),184 (2020).
45. L. Slobodianiuk, L. Budniak, S. Marchyshyn, R. Basaraba, *Pharmacology*, **3**, 310 (2020).
46. S. Sánchez, A. Demain, Fermentation (industrial) Production of Amino Acids, in: Encyclopedia of Food Microbiology, Academic Press, 2014.
47. M.J. Toth, M. M. Lewinter, P.A. Ades, D. E. Mathews, *Clinical Sci.,* **119**, 467 (2010).
48. M. Fan, X. Zhang, H. Song, Y. Zhang, *Molecules*, **28**(13), 5022 (2023).