

## CHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF FOXTAIL LILY (*Eremurus spectabilis*)

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**Abstract.** *Eremurus spectabilis* is used as a vegetable in Turkey, especially in Eastern Anatolia region. In this study, eight *E. spectabilis* from different growing areas have been analyzed for its nutrition value and antioxidant properties. The results showed that there were significant differences among samples in terms of all above parameters. The mean values of the parameters investigated were 86.62–91.35% for water content, 4.78–5.15 for pH; 0.42–0.70% for acidity, and 0.61–1.11% for ash content. The antioxidant activity tests evaluated by using 2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging and  $\beta$ -carotene/linoleic acid assays indicated that the extracts of *E. spectabilis* samples had high antioxidant capacity. In the DPPH and  $\beta$ -carotene/linoleic acid systems, average values were 73.69  $\mu\text{g extract} \cdot \text{ml}^{-1}$  and 94.56%, respectively. The average amount of total phenolics in samples was 223 mg GAE  $\cdot 100 \text{ g}^{-1}$  FW. Protein, K, Ca, Mg, Fe and Cu contents of *E. spectabilis* species were found higher than in some other commonly used vegetables. The results suggest that *E. spectabilis* could be a valuable source of antioxidants, phenolics and minerals.

**Key words:** *Eremurus spectabilis*, foxtail lily, antioxidant activity, chemical content

## INTRODUCTION

Nowadays, the world market for functional foods and nutraceuticals has been rapidly expanding. Epidemiological and *in vitro* studies on medicinal plants and horticultural plants strongly supported the idea that plants constituents with antioxidant activity are capable of exerting protective effects against oxidative stress in biological systems [Block and Patterson 1992; Cao et al. 1996; Ness and Powles 1997]. Some natural antioxidants from plants e.g. rosemary and sage are already exploited commercially either as antioxidant additives or nutritional supplements [Schuler 1990]. Many other plant species have been investigated for antioxidative properties [Chu 2000; Koleva et al. 2002; Oke and Hamburger 2002]. However, there is currently a demand to find more information concerning the antioxidant potential in more plant species.

The *Eremurus* genus is one of the important genera of the family *Liliaceae*, including over 40 species. Natural populations of this genus are widely distributed on dry and stony grazed hillsides in particular Central Asia and Middle East, including Afghanistan, Iran, Tajikistan, Lebanon and Turkey [Wandelbo 1982; Kamensky and Akhmetova 1994; Gungor 2002].

Two *Eremurus* species, namely *E. spectabilis* and *E. cappadocicus* naturally grown in Turkey [Tuzlaci 1984], and the country is recognized as one of the main diversity center of *E. spectabilis*. The species are widely distributed in the provinces of Erzurum, Sivas, Yozgat, Bitlis, Usak, Kars, Agri, Erzincan, Van, Artvin and Ardahan of Turkey [Tuzlaci 1984; Gungor 2002]. *E. spectabilis*, locally known as 'Ciris', is widely used in Turkey as a wild edible vegetable and/or has been traditionally used in folk medicine to treat some ailments such as hemorrhoids and diabetics, and also used as antidysuria and antihypertensive [Baytop 1984]. People living in the Eastern Anatolia are extremely experienced with inadequate yields due to adverse climatic and inappropriate topographic conditions. People often use spontaneous wild plants or scarcity foods to supplement their usual diets in the region. The available literature indicated that consumption of various edible parts of wild plants as vegetables to their mineral and other nutrients in Turkey [Yildirim et al. 2001; Turan et al. 2003], in Niger [Freiberger et al. 1998] and in India [Khader and Rama 1998]. However, limited literature is available on the comprehensive mineral and nutrient composition of *E. spectabilis* species. Among the physiological functions, the antioxidative or radical-scavenging property is especially interesting because of its potential to provide health protection against reactive oxygen species and free radicals, which have been implicated in more than 100 diseases [Halliwell 1992].

As far as we know, only one study has been done on the chemical content of *E. spectabilis* [Gungor 2002]. However, to date, the antioxidant activity of the *E. spectabilis* has not yet been reported. Hence, the purpose of the present study was to investigate the nutritive value and antioxidant activity of *E. spectabilis* which is naturally grown in Turkey.

## MATERIALS AND METHODS

**Collection and preparation of plant material.** The eight plant samples from *E. spectabilis* were collected from different parts of Erzurum city, Turkey. In this re-

gion, only leafy young plants are being consumed by people. For this reason, the aerial parts of plants at juvenile stage were collected. The fresh plant samples were homogenized in a standard food blender and homogenates were used for analysis.

**Extraction.** For extraction, plant homogenates obtained with a blender were extracted with acetone, water, and acetic acid (70:29.5:0.5, v/v/v) for 1 h in darkness [Singleton and Rossi 1965]. This extract was filtered and used for total phenolics and antioxidant tests.

**Water content, protein, ash, acidity and pH.** Water content, protein, ash, acidity and pH of plant aerial parts were determined according to AOAC [2005] standard methods. Aerial parts of ten fresh plant materials for per sample were mixed with 50 ml deionized water and the volume was made up to 100 ml. After waiting 12 hours, it was filtered, and then it was measured by pH meter pH according to Bilgir [1982].

**Total phenolic content.** For total phenolic content, 0.5 mL of each extract was combined with Folin-Ciocalteu's reagent and water 1:1:20 (v/v) and incubated for eight min; 5 mL of 7% (w/v) sodium carbonate were then added. After 2 h, the absorbance was measured by an automated UV-Vis spectrophotometer at 750 nm. Gallic acid was used as standard. The results were calculated as gallic acid equivalents  $\cdot 100 \text{ g}^{-1}$  of sample in fresh weight basis (mg GAE  $\cdot 100 \text{ g}^{-1}$  FW) [Slinkard and Singleton 1977].

**Antioxidant activity.** Total antioxidant capacity of samples was determined by  $\beta$ -carotene bleaching and 2,2-Diphenyl-1-picrylhydrazyl radical (DPPH $^{\cdot}$ ) assays.

In the  $\beta$ -carotene bleaching assay, antioxidant capacity is determined by measuring the inhibition of the volatile organic compounds and the conjugated diene hydroperoxides arising from linoleic acid oxidation]. Antioxidant capacities of the samples were compared with those of the synthetic antioxidant butylated hydroxyanisole (BHA) and the blank.

In DPPH assay, 50  $\mu\text{l}$  of various concentrations of the extracts in methanol were added to 5 ml of a 0.004% methanol solution of DPPH. After a 30 min incubation period at room temperature, the absorbance was read against a blank at 517 nm. DPPH in percent (%) was calculated in following way:  $DPPH\% = (A_{\text{blank}} - A_{\text{sample}}/A_{\text{blank}}) \times 100$ ; where  $A_{\text{blank}}$  is the absorbance of the control reaction (containing all reagents except the test compound), and  $A_{\text{sample}}$  is the absorbance of the test compound.  $EC_{50}$  is the effective concentration in  $\mu\text{g}$  extract/ml ( $\mu\text{g}$  extract for  $EC_{50}$  in 1 ml of DPPH solution) which inhibits the DPPH activity by 50%.  $EC_{50}$  is calculated from the plot of scavenging activity against extract concentration and represent the amount of extract necessary to decrease the initial DPPH concentration by 50%. Tests were carried out in triplicate. Results were expressed as ( $EC_{50}$ ) [Burits and Bucar 2000].

**Determination of minerals.** Plant samples were oven-dried at 68°C for 48 h and ground to pass 1 mm. The Kjeldahl method [Bremner 1996] and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Königswinter, Germany) were used to determine total N. Protein content was obtained by  $\text{Nx}6.25$  [Frank 1975]. Macro (P, K, Ca Mg and Na) and micro elements (Fe and Cu) were determined after wet digestion of dried and ground sub-samples using a  $\text{HNO}_3\text{-H}_2\text{O}_2$  acid mixture (2:3 v/v) with three step (first step; 145°C, 75% RF, 5 min; second step; 180°C, 90% RF, 10 min and third step; 100°C, 40% RF, 10 min) in microwave (Bergof Speedwave Microwave Digestion Equipment MWS-2) [Martens 2005a]. The contents of P, K, Ca, Mg, Fe, and Cu in tissue were determined Inductively Couple Plasma spectrophotometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA) [Martens 2005b].

**Statistical analysis.** The experiment was randomly designed with five replications. Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test at  $P < 0.01$  significant level.

## RESULTS AND DISCUSSION

**Water content, protein, ash, acidity and pH of samples.** The results on chemical composition (water content, protein, ash, acidity and pH) of eight *E. spectabilis* samples are shown in Table 1. There were statistical differences among samples in terms of all above mentioned parameters.

Table 1. Water, protein and ash content, pH and acidity of *Eremurus spectabilis* samples  
Tabela 1. Zawartość wody, białka i popiołu, pH oraz kwasowość próbek *Eremurus spectabilis*

Samples Próbki	Water content Zawartość wody (%)	Protein Białko (%)	Ash Popiół (%)	pH	Acidity Kwasowość (%)
1	91.35a	1.14c	0.79c	5.14a	0.51c
2	88.79ab	1.27ab	0.99b	4.89bc	0.63b
3	88.34ab	1.16bc	0.98b	5.08ab	0.70a
4	86.62b	1.21ab	1.11a	5.15a	0.57bc
5	90.82ab	1.28a	0.78c	4.96b	0.61bc
6	89.23ab	1.18c	0.61d	4.94bc	0.42d
7	87.80ab	1.20bc	0.93bc	5.05ab	0.59bc
8	90.05ab	1.19bc	0.80c	4.78c	0.54bc
Mean – Średnio	89.13	1.20	0.87	4.99	0.57

\*Values in the same column with different lower-case letters are significantly different at  $P < 0.01$ .

\*Wartości w tej samej kolumnie z różnymi małymi literami różnią się istotnie przy  $P < 0,01$

Water and protein content of *E. spectabilis* samples were between 86.62 and 91.35% and 1.14 and 1.28%, respectively. The pH of samples ranged between 4.78 and 5.15 (tab. 1). The titratable acidity was the highest in sample 3 as 0.70%, whereas the lowest in sample 6 (0.42%). Ash were between 0.61% (sample 6) and 1.11% (sample 4). In previous study [Gungor 2002], the protein and pH of *E. spectabilis* sample have been reported as 1.45% and 4.7%, respectively. These findings were usually in agreement with our results. The information shows that the plant is a valuable source of food.

**Total phenolic content.** The amount of the total phenolics was highest in sample 1 (259 mg GAE · 100 g<sup>-1</sup> FW), followed by sample 3 (250 mg GAE · 100 g<sup>-1</sup> FW) and sample 2 and 6 (228 mg · 100 g<sup>-1</sup> FW). As far as our literature investigation could ascertain, there were no results on total phenolic content of *E. spectabilis*. Therefore, this study may have provide new findings on this plant. According to this results the plant

has higher phenolic content than most of the other vegetables. Previously total phenolic content of several vegetables were found between 27 (leek) -246 (green pepper) mg GAE · 100 g<sup>-1</sup> FW [Marinova 1984].

**Antioxidant activity.** In DPPH assay, the highest free-radical scavenging capacity was observed in sample 7 as 86.66 µg extract · ml<sup>-1</sup>. The other samples had also high free radical-scavenging capacity between 53.43 and 83.09 µg extract · ml<sup>-1</sup>, respectively (tab. 2). Hydroxyl radicals are biologically relevant and extremely reactive oxygen species, which can rapidly react and degrade with susceptible food and biologically relevant substrates, such as polyunsaturated fatty acids, proteins, carbohydrates and DNA [Halliwell 1992]. DPPH is a stable free radical and accepts hydrogen radical to become a stable diamagnetic molecule, yellow coloured diphenylpicrylhydrazine [Soares et al. 1997]. The synthetic nitrogen-centred DPPH is not biologically relevant, but it is often used as an indicator compound in testing of hydrogen donation capacity and thus antioxidant activity.

Table 2. Antioxidant activity and total phenolic content in *Eremurus spectabilis* samples  
Tabela 2. Działanie przeciwutleniające i całkowita zawartość związków fenolowych w próbkach *Eremurus spectabilis*

Samples Próbki	DPPH µg extract · ml <sup>-1</sup> µg ekstraktu · ml <sup>-1</sup>	β-carotene linoleic acid (inhibition, %) β-karoten kwas linoleinowy (hamowanie, %)	Total phenolic content (mg GAE · g <sup>-1</sup> FW) Zawartość związków fenolowych (mg GAE · g <sup>-1</sup> św.m.)
1	68.12c	95.35ab	259a
2	65.67c	96.04ab	228b
3	53.43d	96.36ab	250ab
4	78.87b	97.54a	178c
5	82.10ab	92.39ab	207bc
6	71.57bc	95.40ab	228b
7	86.66a	91.59b	205bc
8	83.09ab	91.85b	225b
BHA	18.90e	97.16a	
Mean – Średnia	73.69	94.56	223

\*Values in the same column with different lower-case letters are significantly different at  $P < 0.01$ .

\*Wartości w tej samej kolumnie z różnymi małymi literami różnią się znacząco przy  $P < 0,01$

Previously, a large variation in antioxidant content by using DPPH method of vegetables such as kale, chili pepper, red cabbage, pepper, parsley, artichoke, brussels sprouts and wild edible vegetables were found [Halvorsen et al. 2002; Huang et al. 2007]. In β-carotene/linoleic acid assay, oxidation of linoleic acid was effectively inhibited by *E. spectabilis* extracts (between 91.59 and 97.54%) even sample 4 had higher value than BHA. β-carotene undergoes rapid discoloration in the absence of an antioxidant. This is because of the coupled oxidation of β-carotene and linoleic acid, which generates free radicals. The linoleic acid free radical formed upon the abstraction of a hydrogen atom

from one of its diallylic methylene groups, attacks the highly unsaturated  $\beta$ -carotene molecules. As a result,  $\beta$ -carotene will be oxidized and broken down in part: subsequently, the system its chromophore and characteristics orange colour, which can be monitored spectrophotometrically. The presence of different antioxidants can hinder the extent of  $\beta$ -carotene bleaching by neutralizing the linoleic-free radical and other free radicals formed in the system [Jayaprakasha et al. 2001].

**Mineral content of *Eremurus spectabilis* samples.** The mineral content of *E. spectabilis* samples are shown in Table 3. The statistical differences among the genotypes were observed based on all searched minerals, except sodium (Na) and copper (Cu) (tab. 3).

Table 3. Mineral content in *Eremurus spectabilis* samples

Tabela 3. Zawartość związków mineralnych w próbkach *Eremurus spectabilis*

Samples Próbki	P	K	Ca	Mg	Na	Fe	Cu
(mg · 100 g <sup>-1</sup> )							
1	47ab	463a	30.7d	42.2a	21 <sup>NS</sup>	8.2a	1.8 <sup>NS</sup>
2	39ab	327d	31.1c	38.5ab	27	7.1b	2.4
3	43ab	369c	34.2a	36.4b	26	7.0b	2.2
4	41ab	407b	29.0de	38.2ab	30	6.3bc	1.6
5	36b	441a	28.2e	39.5ab	24	6.9bc	1.2
6	51a	463a	30.7d	36.2b	21	5.8c	1.0
7	44ab	395bc	32.2b	40.7ab	21	7.7ab	0.8
8	40ab	367c	31.4bc	40.1ab	24	8.0a	1.4
Mean – Średnia	43	404	30.9	39.0	24	7.1	1.6

<sup>NS</sup> Not significant – Różnice nieistotne

\*Values in the same column with different lower-case letters are significantly different at  $P < 0.01$ .

\*Wartości w tej samej kolumnie z różnymi małymi literami różnią się istotnie przy  $P < 0,01$

The average P, K, Ca and Mg values of samples were 43, 404, 30.9 and 39.0 mg · 100 g<sup>-1</sup>, respectively. The results concur with the findings of previous study [Gungor 2002]. Data obtained from the current study show that *E. spectabilis* samples have very high nutritional potential, and their nutritional value is greater than that of most cultivated vegetables [www.healthalternatives2000.com].

There is a growing interest in the mineral content of foods and diets. Experiments in cell culture and in intact organisms reveal the importance of macro and trace elements in many metabolic processes and functions throughout the life cycle. Human as well as animal studies originally showed that optimal intakes of elements such as sodium, potassium, magnesium, calcium, manganese, copper, zinc, and iodine could reduce individual risk factors, including those related to cardiovascular disease [www.healthalternatives2000.com]. Many studies suggest a relationship between high dietary potassium (K) intake and lower

blood pressure and protection from the risk of stroke [Mertz 1982; Splittstoessetop 1990]. Due to the high content of K, P, Ca and Mg of *Eremurus spectabilis* it can be concluded that it could meet the daily K, P, Ca and Mg requirements of an adult.

## CONCLUSIONS

As a conclusion, this study revealed that *E. spectabilis* had a high nutritional value in terms of chemical composition. From a nutritional point of view, *E. spectabilis* consumption as well as other vegetables is an appropriate strategy to increase intake of antioxidants and minerals. On the other hands, *E. spectabilis* samples exhibited different levels of antioxidant activity in all the models studied, which are attributed to different local conditions, such as climate and soil properties. The results from DPPH, free radical scavenging system revealed that the *E. spectabilis* had significant antioxidant and free radical scavenging activity. The free radical-scavenging property may be one of the mechanisms by which this plant notable can be used as natural antioxidants. Obtained results indicated that *E. spectabilis* may provide a potential source of dietary antioxidant and mineral nutrition and therefore consumption should be stimulated.

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**SKŁAD CHEMICZNY I DZIAŁANIE PRZECIWUTLENIAJĄCE  
PUSTYNNIKA OKAZAŁEGO (*Eremurus spectabilis*)**

**Streszczenie.** *Eremurus spectabilis* używany jest w Turcji jako warzywo, zwłaszcza w regionie Wschodniej Anatolii. W niniejszej pracy przeanalizowano wartość odżywczą i właściwości przeciwutleniających ośmiu roślin *E. spectabilis* z różnych obszarów uprawowych. Wyniki wykazały, że pomiędzy próbkami wystąpiły znaczące różnice we wszystkich powyższych parametrach. Średnie wartości badanych parametrów wynosiły: 86,62–91,35% dla zawartości wody, 4,78–5,15 dla pH; 0,42–0,70% dla kwasowości oraz 0,61–1,11% dla zawartości popiołu. Badania właściwości przeciwutleniających z wykorzystaniem strącania oczyszczającego wolnych rodników 2-difenylo-1-pikrylhydrazylem (DPPH) oraz próby z  $\beta$ -karotenem/kwasem linoleinowym wykazały, że wyciągi z *E. spectabilis* mają silne zdolności przeciwutleniające. W systemach DPPH i  $\beta$ -karotenowych/z kwasem linoleinowym wartości średnie wynosiły odpowiednio 73.69  $\mu\text{g}$  wyciągu  $\cdot \text{ml}^{-1}$  i 94,56%. Średnia ogólna zawartość fenoli w próbkach wynosiła 223 mg GAE  $\cdot 100 \text{ g}^{-1}$   $\dot{\text{s}}\text{w.m.}$  Stwierdzono, że zawartość białka, K, Ca, Mg, Fe i Cu w roślinach gatunku *E. spectabilis* jest wyższa niż w innych powszechnie wykorzystywanych warzywach. Wyniki sugerują, że *E. spectabilis* może być cennym źródłem przeciwutleniaczy, fenoli i związków mineralnych.

**Słowa kluczowe:** *Eremurus spectabilis*, pustynnik okazały, działanie przeciwutleniające, skład chemiczny

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