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Fagus orientalis (Oriental Beechnut) Seeds are a Good Source of Essential Fatty Acids, Amino Acids and Minerals

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ABSTRACT

Oriental beechnut (*Fagus orientalis* Lipsky) is a decidious tree that is native to Turkey. Although beechnut seeds are widely consumed by the local population, knowledge of their nutrient composition is incomplete. The main purpose of this study was to determine the content of fatty acids, amino acids, and minerals and trace elements in oriental beechnut seeds. Seeds collected from five sites in the Black Sea region and another in the Mediterrenean region were dried, milled and analysed. Whereas the results for the seeds from the five Black Sea sites were similar, those for seeds from the Mediterranean region were slightly different. Fatty acids accounted for 45.0% of the dry weight of the seeds of which 40, 34.1 and 3.66% was contributed by oleic, linoleic and α-linolenic acids, respectively. The average protein content was 22.5%; however, the proportions of the essential amino acids lysine, threonine and tryptophan fell below those of the World Health Organization protein standard. Beechnut seed contained nutritionally significant amounts (μg/g dry weight) of calcium (4821), copper (18.1), iron (41.6), magnesium (2053), manganese (383) and zinc (27.8), but reletively low amounts of molybdenum (0.3) and selenium (0.5). This study demonstrates that seeds of oriental beech are a good source of many nutrients essential to human wellbeing.

Keywords: α-linolenic acid, amino acid, oriental beechnut, *Fagus orientalis*, linoleic acid, minerals

INTRODUCTION

Hunger is increasing worldwide due to rising food prices and food scarcity, which have led populations in many parts of the world to search for alternative food sources that would contribute to satisfying their nutritional needs (Ayaz *et al*. 2009). Consequently, many people collect nuts to supplement their diets. However, since our knowledge of the nutrient content of edible nuts is incomplete, there is a need for studies that will provide this information.

Historically, tree nuts have enjoyed universal acceptance as an important component of human diets globally (Alasalvar and Shahidi 2009). Tree nuts, either in raw or processed forms, are valued for their nutrient content and sensory properties (Alasalvar and Shahidi 2009).

Oriental beechnut (*Fagus orientalis* L.) is a decidious tree that is native to Turkey (Yaltitik 1982). Although oriental beechnut seed is widely consumed by the local population and its use is increasing, knowledge of its nutrient composition is incomplete. The aim of the present study was to determine the amounts of fatty acids, amino acids and essential minerals in these nuts and how their content varied among trees in different locations in Turkey.

Clinical studies have shown that frequent nut consumption is associated with favourable plasma lipid profiles and reduce the risk of cardiovascular diseases, type-2 diabetes and cancer (Ros and Mataix 2006; Kris-Etherton *et al*. 2008; Vassiliou *et al*. 2009; Yang *et al*. 2009). In contrast to saturated fatty acids that are associated with inflamation and are generally unhealthful, the health benefits of polyunsaturated fatty acids and monounsaturated fatty acids are widely acknowledged (Kris-Etherton *et al*. 2008; Yang *et al*. 2009).

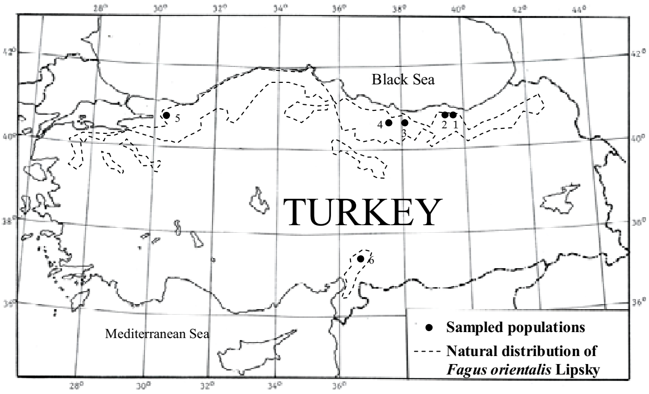

Fig. 1 Natural distribution of *Fagus orientalis* Lipsky and geographic locations where oriental beechnut seeds were collected. 1; Çaykara, 2; Maçka, 3; Giresun, 4; Akkuş, 5; Düzce, 6; Kahramanmaraş.

To the best of our knowledge, information in the literature regarding the nutrient composition of oriental beechnut is scant. Furthermore, the few literature citations that do exist often fail to specify the species of *Fagus* that were analyzed. However, a recent study by Demirbas (2009) reported that the lipid fraction of oriental beechnut contained noteable proportions of oleic acid (30.3%) and linoleic acid (48.7%), but a low percentage of α-linolenic acid (0.2%). Since knowledge of the nutrient value of oriental beechnut seed is so incomplete, we collected the specimens from six natural stands which have natural distribution not seeing

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social suppression in Turkey (see, **Fig. 1**) and analyzed them for fatty acids, amino acids, minerals and trace elements. Our findings document that they contain nutritionally valuable amounts of many essential nutrients.

MATERIALS AND METHODS

Collection of seeds and sample preparation

Seeds were collected in Turkey from five locations on the Black Sea coast and one in the southeastern Anatolia near the Mediterranean Sea. Trees were selected using a randomized sampling design and the mean distance between the sampled trees was 150-200 m. The collection sites and their principal geographic characteristics are specified in **Fig. 1** and **Table 1**. At each site 17 trees were sampled and 3-4 kg of healthy, mature dried seeds were gathered from the upper part of the trees. These samples were mixed well and then three separate 10 g seed samples were weighed and ground using a stainless steel mill to a 125 µm particle size (Cole-Parmer Analytical Mill, USA). Immediately prior to performing biochemical analysis, the samples were dried to constant weight using a vacuum desiccator. All results are expressed on a per gram dry weight basis in triplicate extraction and determination.

Fatty acid analysis

Triplicate seed samples from each site were extracted as described by Ayaz *et al*. (2009). Transmethylation of fatty acids to prepare fatty acid methyl esters was performed using the method of Morrison and Smith (1964). Fatty acid methyl esters were separated and quantified using a Hewlett-Packard gas chromatograph (5890 Series II, Palo Alto, CA) equipped with a flame-ionization detector and running conditions described elsewhere (Ayaz *et al*. 2009). The internal standard, heptadecanoic acid (C17:0), and the calibration standards were obtained from NuCheck, Inc. (Elysian, MN). The mean standard deviation for all of the fatty acids was 4%.

Amino acid analysis

Twenty mg of dried milled seed were hydrolyzed *in vacuo* in 6 N HCl containing 0.1% (w/v) phenol at 110°C for 24 h, and the resultant amino acids were seperated and quantified using the Dionex BioLC Chromatographic System configured for *AAA-Direct* analysis according to the manufacturer's instructions (Dionex Corp. Technical Note 50) and published methods (Clarke *et al*. 1999; Jadnik *et al*. 1999). For determination of methionine and cysteine, samples were first oxidized with performic acid (Hirs 1964) prior to acid hydrolysis. Tryptophan was determined using the method of Hugli and Moore (1972). The reproducibility of the method ranged from 0.6-11% for the amino acids reported.

Mineral analysis

Samples (0.02 g) of the dried, powdered seed were weighed into 125 mL Philips beakers and digested with 15 mL concentrated nitric acid and 1 mL perchloric acid. The samples were covered with watch glasses, allowed to stand for 1 h at room temperature, and then placed on a hot plate. The temperature was increased at 50°C/15 min to 150°C where the samples were refluxed for 24 h. The watch-glasses were removed and the samples were brought to near dryness at 150°C. The samples were cooled to room temperature and brought to 10.0 ml with 4% nitric acid: 1% perchloric acid. Samples were analysed for their metal content by ICP-OES as described before (Fernández *et al*. 2003).

Data analysis and statistics

Data were analyzed by analysis of variance (SPSS Version 17) using one-way ANOVA ($P < 0.05$). Analyses of variance were performed for each character studied. Duncan's multiple range test was used to determine the statistical significance of differences and variations among the means of the amino acid, fatty acid and mineral compositions to analyze both within and among the populations.

RESULTS

Table 1 reports the total fatty acid content and composition of the seeds, the mean fatty acid content (45.0%), noteworthy, the relatively high proportions of oleic acid (37.8%) and the essential fatty acids linoleic acid (34.1%) and α-linolenic acid (3.66%). The single specimen of seeds from the Mediterranean region (Site 6, **Fig. 1**) contained a significantly higher proportion of oleic acid compared to the specimens collected from the five Black Sea sites (42.9% versus 36.8%, $P < 0.001$) (**Table 1**, **Fig. 1**). Polyunsaturated fatty acids and unsaturated fatty acids accounted for 37.9 and 83.8%, respectively, of the fatty acid total for the six seeds specimens.

The oriental beechnut seeds contained large amounts of protein as indicated by the average total amino acid content of 22.5% (**Table 2**). However, in terms of the proportions of essential amino acids in oriental beechnut seed protein, *F. orientalis* fell well below the WHO (1985) standard protein (**Table 3**) in three of eight categories, specificially lysine (65%), threonine (84%) and tryptophan (40%).

As shown in **Table 4**, oriental beechnut seeds collected at all six sites contained nutritionally useful amounts of many essential minerals and trace elements (expressed as µg/g dry weight), including: Ca (4821), Cu (18.1), Fe (41.6), K (9935), Mg (2053), Mn (383), Na (115), P (4683) and Zn (27.8). However, the seeds contained only small amounts of molybdenum and selenium. Several toxic heavy metals, including arsenic, cadmium and lead were present but only in relatively small amounts.

DISCUSSION

Our results document that oriental beechnut seeds contain significant amounts of essential fatty acids, minerals and amino acids that could be nutritionally important for Turkish populations where *F. orientalis* grows. In addition, the seeds represent a dense energy source; one gram of dry oriental beechnut seed contains approximately 1 kcal in lipid alone. Fatty acids accounted for, on average, 20.7% of dry weight. Noteworthy, the seeds from *F. orientalis* trees in the Black Sea region (Sites 1-4, **Fig. 1**) had a fatty acid profile that differed significantly ($P < 0.001$) from the single specimen we collected from South Anatolia near the Mediterranean Sea (Site 6, **Fig. 1**): Seeds from the northern coast contained a smaller proportion of oleic acid (34.2-38.5% versus 42.9%) but higher percentages of linoleic acid (32.1-37.9% versus 30.9%) and α-linolenic acid (2.38-4.42% versus 2.74%) compared to the seeds collected from the south of Turkey. These differences in fatty acid composition could be due to the warmer climate of South Anatolia relative to that of the Black Sea region. Climate in general and temperature in particular are known to influence the fatty acid composition of seeds. Cooler temperatures tend to favor the accumulation of unsaturated fatty acids such as oleic acid, linoleic acid and α-linolenic acid over saturated fatty acids (Tremolieres *et al*. 1982; Deng and Scarth 1998; Thomas *et al*. 2003). The cardiovascular protective effects of oleic acid are widely recognized (Ros and Mataix 2006; Kris-Etherton *et al*. 2008) In addition, there is evidence that high intakes of α-linolenic acid decrease risk of cardiovascular disease (Ros and Mataix 2006). Another potentially beneficial health effect of oriental beechnut seed has to do with the n-6/n-3 fatty acid ratio; it is widely accepted that this ratio should be less than 15/1 (Simopoulos *et al*. 1999). The linoleic acid/α-linolenic acid ratio we found for the six oriental beechnut seed specimens ranged from 7.9 to 11.3 (**Table 1**). We estimate from the data in **Table 1**, that 20 g of oriental beechnut (approx. 100 seeds) would provide 3.1 g of linoleic acid and 0.4 g of α-linolenic acid, which is sufficient to satisfy 40-50% of the recommended daily allowances of these two essential fatty acids.

The fatty acid composition we found for oriental beechnut seeds differs markedly relative to that published by Demirbas (2009). For example, we found much higher per-

Table 1 Fatty acid composition (% of total) in seed of oriental beechnut (*Fagus orientalis* Lipsky) collected from six different geographic locations in Turkey[a] made using the UTM coordinate system[b].

Fatty acid	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	ANOVA
C14:0	0.18 ± 0.02 ND	0.16 ± 0.03 ND	0.18 ± 0.03 ND	0.21 ± 0.04 ND	0.22 ± 0.09 ND	0.21 ± 0.04 ND	F:0.678, S<0.649
C15:0	0.10 ± 0.03 ND	0.09 ± 0.02 ND	0.09 ± 0.03 ND	0.12 ± 0.02 ND	0.11 ± 0.05 ND	0.11 ± 0.03 ND	F:0.617, S<0.690
C16:0	10.2 ± 0.08 d	8.77 ± 0.2 b	9.75 ± 0.44 cd	8.37 ± 0.32 b	8.96 ± 0.37 bc	6.98 ± 1.04 a	F:14.29, S<0.000
C18:0	5.81 ± 0.40 a	5.82 ± 0.18 a	5.86 ± 0.46 a	6.25 ± 0.66 ab	7.12 ± 0.78 b	5.85 ± 0.25 a	F:3.19, S<0.046
C20:0	0.47 ± 0.03 a	0.54 ± 0.03 bc	0.53 ± 0.02 ab	0.67 ± 0.08 e	0.64 ± 0.02 de	0.59 ± 0.02 cd	F:12.56, S<0.000
C22:0	0.61 ± 0.14 ND	0.62 ± 0.06 ND	0.64 ± 0.08 ND	0.74 ± 0.1 ND	0.83 ± 0.00 ND	0.65 ± 0.1 ND	F:2.70, S<0.074
C16:1n-7	0.25 ± 0.02 ND	0.23 ± 0.01 ND	0.29 ± 0.02 ND	0.27 ± 0.06 ND	0.30 ± 0.05 ND	0.22 ± 0.03 ND	F:2.21, S<0.121
C18:1n-9	37.2 ± 0.23 c	37.9 ± 0.29 cd	34.2 ± 0.12 a	36.0 ± 0.9 b	38.5 ± 1.1 d	42.9 ± 0.33 e	F:69.19, S<0.005
C18:1n-7	0.76 ± 0.02 ND	0.70 ± 0.03 ND	0.79 ± 0.12 ND	0.75 ± 0.13 ND	0.87 ± 0.03 ND	0.85 ± 0.06 ND	F:1.88, S<0.171
C20:1	5.63 ± 0.11 b	5.93 ± 0.11 bc	5.06 ± 0.3 a	6.26 ± 0.35 c	6.45 ± 0.34 cd	6.95 ± 0.4 d	F:15.23, S<0.000
C22:1	0.83 ± 0.12 ab	0.92 ± 0.06 ab	0.60 ± 0.09 a	1.46 ± 0.63 c	1.00 ± 0.1 abc	1.13 ± 0.05 bc	F:3.48, S<0.036
C18:2n-6	34.1 ± 0.08 c	34.2 ± 0.08 c	37.9 ± 0.35 d	35.3 ± 1.2 e	32.1 ± 0.81 b	30.9 ± 0.1 a	F:47.04, S<0.000
C18:3n-3	4.10 ± 0.05 c	4.31 ± 0.1 d	4.42 ± 0.05 d	3.56 ± 0.17 b	2.83 ± 0.09 a	2.74 ± 0.09 a	F:164.41, S<0.000
C20:2n-6	0.17 ± 0.01 a	0.19 ± 0.01 a	0.19 ± 0.01 a	0.25 ± 0.02 b	0.21 ± 0.03 a	0.17 ± 0.02 a	F:8.73, S<0.001
SFA*	17.3 ± 0.7 bc	16.0 ± 0.1 b	16.6 ± 0.3 bc	16.4 ± 1.2 bc	17.9 ± 1.3 c	14.4 ± 1.5 a	F:6.08, S<0.005
MUFA*	44.7 ± 0.5 b	45.7 ± 0.5 bc	41.1 ± 0.7 a	44.7 ± 2.1 b	47.2 ± 1.6 c	52.1 ± 0.9 d	F:48.68, S<0.000
PUFA*	38.3 ± 0.1 c	38.7 ± 0.2 c	42.5 ± 0.4 d	39.2 ± 1.4 c	35.2 ± 0.9 b	33.8 ± 0.2 a	F:85.24, S<0.001
UFA*	82.9 ± 0.6 ab	84.4 ± 0.7 bc	83.4 ± 1.1 ab	83.9 ± 3.5 ab	82.3 ± 2.55 a	85.9 ± 1.1 c	F:4.43, S<0.016
LA/α-LA*	8.32	7.94	8.58	9.92	11.3	11.3	
Total[c]	217	209	208	204	201	201	
Total[d]	100	100	100	100	100	100	

[a]Collection sites: Site 1:Çaykara (Trabzon), [b]Altitude-North Coordinate-South Coordinate: 920-1485; 600887-603008; 4503695-4506099; Site 2: Maçka (Trabzon), 1550-1645; 536104-537264; 4502315-4502863; Site 3: Kulakkaya (Giresun), 1400-1460; 442625-452537; 4503642-4504163; Site 4: Akkuş (Ordu), 1230-1315; 331483-331845; 4519805-4520234; Site 5: Düzce, 1330-1370; 4039278-4039574; 3121362-3122332; Site 6: Andırın (Kahramanmaraş), 1395-1740; 269188-272115; 4175208-4185518.
[c]mg of fatty acid /g dry weight; [d] total percentage. ND, not different. Abbreviations*: SFA: total saturated fatty acids, MUFA: total monounsaturated fatty acids, PUFA: total polyunsaturated fatty acids, UFA: total unsaturated fatty acids, LA/α-LA: linoleic/α-linolenic acid ratio

Table 2 Amino acid composition (μg/mg dry weight) of protein in seeds of oriental beechnut (*Fagus orientalis* Lipsky) collected from six different geographic locations in Turkey[a].

Amino acid	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	ANOVA
Cysteic acid	6.73 ± 0.30 a	6.25 ± 0.35 a	6.43 ± 0.29 a	6.74 ± 0.19 a	8.20 ± 0.25 c	7.64 ± 0.38 b	F:19.13, S<0.000
Aspartic acid	25.4 ± 0.94 b	22.0 ± 1.19 a	22.9 ± 0.91 a	26.8 ± 0.68 bc	28.3 ± 0.69 c	26.8 ± 1.31 bc	F:18.93, S<0.000
Threonine	6.29 ± 0.31 ab	6.10 ± 0.23 a	6.10 ± 0.42 a	6.56 ± 0.28 ab	6.81 ± 0.22 c	6.71 ± 0.31 c	F:3.12, S<0.000
Serine	10.6 ± 0.44 b	9.54 ± 0.45 a	9.58 ± 0.36 a	11.1 ± 0.36 bc	11.6 ± 0.33 c	11.2 ± 0.53 bc	F:13.59, S<0.000
Glutamic acid	50.1 ± 1.05 b	40,2 ± 3.14 a	43.0 ± 0.73 a	52.0 ± 1.31 bc	54.4 ± 1.44 c	50.8 ± 2.74 bc	F:24.31, S<0.000
Proline	7.51 ± 0.40 b	6.83 ± 0.27 a	8.16 ± 0.42 bc	8.0 ± 0.36 bc	8.30 ± 0.27 c	7.66 ± 0.41 bc	F:6.70, S<0.003
Glycine	9.34 ± 0.42 ab	9.06 ± 0.31 a	8.79 ± 0.33 a	9.87 ± 0.34 bc	10.3 ± 0.31 c	10.4 ± 0.53 c	F:8.88, S<0.001
Alanine	9.38 ± 0.47 b	8.37 ± 0.33 a	9.64 ± 0.58 b	9.92 ± 0.34 b	9.95 ± 0.32 b	9.96 ± 0.52 b	F:5.93, S<0.005
Valine	8.83 ± 0.42 b	7.60 ± 0.24 a	8.06 ± 0.57 a	9.15 ± 0.29 bc	9.72 ± 0.31 c	9.36 ± 0.49 bc	F:12.02, S<0.000
Methionine	3.76 ± 0.17 d	2.89 ± 0.16 b	3.06 ± 0.14 bc	2.52 ± 0.07 a	3.30 ± 0.10 c	3.70 ± 0.18 d	F:33.84, S<0.000
Isoleucine	7.63 ± 0.40 bc	6.74 ± 0.26 a	7.07 ± 0.41 ab	8.07 ± 0.25 cd	8.66 ± 0.29 d	8.21 ± 0.40 cd	F:13.34, S<0.000
Leucine	17.0 ± 0.75 b	14.7 ± 0.83 a	14.8 ± 0.66 a	17.9 ± 0.51 bc	19.1 ± 0.57 c	18.4 ± 0.92 c	F:19.62, S<0.000
Tyrosine	6.24 ± 0.38 b	5.74 ± 0.34 a	5.73 ± 0.26 a	6.73 ± 0.15 bc	6.75 ± 0.16 c	6.38 ± 0.23 bc	F:8.84, S<0.001
Phenylalanine	12.6 ± 0.46 d	10.4 ± 0.82 a	14.5 ± 0.74 e	12.1 ± 0.34 cd	11.5 ± 0.24 bc	11.0 ± 0.59 ab	F:18.84, S<0.000
Histidine	5.13 ± 0.20 ab	4.90 ± 0.16 a	4.98 ± 0.19 a	5.44 ± 0.17 bc	5.62 ± 0.17 c	5.66 ± 0.28 c	F:8.12, S<0.001
Lysine	8.26 ± 0.44 ND	8.29 ± 0.55 ND	8.34 ± 0.74 ND	8.36 ± 0.37 ND	8.90 ± 0.29 ND	8.69 ± 0.46 ND	F:0.831, S<0.552
Trytophan	0.93 ± 0.04 a	0.92 ± 0.05 a	1.24 ± 0.06 c	0.92 ± 0.02 a	0.87 ± 0.03 a	1.01 ± 0.05 b	F:26.86, S<0.000
Arginine	24.3 ± 1.06 b	21.0 ± 0.75 a	21.1 ± 0.30 a	25.4 ± 0.73 bc	27.3 ± 0.86 d	26.1 ± 1.19 cd	F:27.92, S<0.000
Amino acid total	226 ± 10	198 ± 9	210 ± 6	234 ± 6	245 ± 7	234 ± 12	F:19.13, S<0.000

[a] The collection sites are described in **Table 1**. ND, not different

centages of oleic acid and α-linolenic acid, but a much lower proportion of linoleic acid compared to Demirbas (2009). This discrepancy could be accounted by differences in sampling, stage of maturation of the seeds or analytical procedures.

With regard to amino acids, although the total amino acid content of oriental beechnut seeds was high (19.8-24.5% dry wight), three of the essential amino acids (lysine, threonine and tryptophan) had scores that fell significantly below the WHO protein standard (**Table 3**). Therefore, oriental beechnut seeds alone would not be a good source of high-quality protein for humans. Lysine, threonine and tryptophan would have to be provided by other foods. The protein content of oriental beechnut seeds was similar to that of almond (21.3%), pistachio (20.6%) and cashew (18.3%) (Alasalvar and Shahidi 2009). Oriental beechnut seeds contain amounts of Ca that are essential to healthy teeth and bones, Cu which plays a role in energy metabolism (Pelkonen *et al*. 2008), Fe which is an essential component of hemoglobin, myoglobin and cytochromes, and Zn which is essential for normal immume function. On the other hand, oriental beechnut seeds do not appear to contain nutrition-

Table 3 Essential amino acid content of beechnut (*Fagus orientalis* Lipsky) compared to the WHO ideal protein[a].

	WHO ideal protein		
Amino acid	**% of total amino acids**	**% of total[b] amino acids in beechnut**	**% of total in beechnut / % in ideal protein**
Isoleucine	2.8	3.44	123
Leucine	6.6	7.55	114
Lysine	5.8	3.76	65
Methionine+cysteine	2.5	4.5	181
Phenylalanine+tyrosine	6.3	8.1	129
Threonine	3.4	2.86	84
Tryptophan	1.1	0.43	40
Valine	3.5	3.9	112

[a]WHO (1985).
[b]Total protein, 225 μg/mg dry weight.

Table 4 Mineral composition (μg/g dry weight) of seeds of oriental beechnut (*Fagus orientalis* Lipsky) collected from six different geographic locations in Turkey[a].

Element	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	ANOVA
Aluminum, Al	20.3±2.88 ND	23.0±1.54 ND	20.7±2.54 ND	23.4±1.64 ND	21.5±2.03 ND	20.4±0.38 ND	F:9.33, S<0.316
Arsenic, As	0.71±0.02 c	0.50±0.09 b	0.53±0.12 ab	0.42±0.06 a	0.58±0.06 bc	n.d.	F:5.47, S<0.013
Barium, Ba	9.58±0.32 b	34.6±0.61 c	4.66±0.03 a	55.1±1.39 d	56.5±1.43 d	4.30±0.12 a	F:2450.4, S<0.000
Calcium, Ca	4680±151.3 b	4790±65.6 b	4100±134.5 a	4167±11.6 a	5793.3±144.3 d	5393±117.2 c	F:100.88, S<0.000
Cadmium, Cd	0.42±0.30 ND	0.34±0.13 ND	0.46±0.37 ND	0.3±0.08 ND	0.26±0.10 ND	0.19±0.07 ND	F:0.72, S<0.622
Cobalt, Co	0.04±0.00 a	0.05±0.00 b	0.06±0.01 c	0.03±0.00 a	0.08±0.01 d	n.d.	F:42.58, S<0.000
Chromium, Cr	3.21±0.26 c	2.96±0.23 bc	2.73±0.05 ab	2.60±0.03 a	2.52±0.12 a	2.60±0.19 a	F:7.15, S<0.003
Copper, Cu	20.4±0.54 e	14.5±0.24 b	15.5±0.43 c	13.6±0.18 a	19.5±0.38 d	24.9±0.29 f	F:355.93, S<0.000
Iron, Fe	42.2±0.83 ND	43.3±1.07 ND	35.8±0.52 ND	43.1±0.59 ND	49.5±19.8 ND	35.4±0.80 ND	F:1.29, S<0.332
Potassium, K	9617±293 b	10970±15 c	10630±58 c	9927±237 b	9720±205 b	8747±203 a	F:44.51, S<0.000
Lanthanum, La	n.d.	n.d.	n.d.	n.d.	0.06±0.01	n.d.	
Lithium, Li	0.06±0.03 ND	0.04±0.01 ND	0.07±0.05 ND	0.05±0.01 ND	0.04±0.01 ND	0.03±0.01 ND	F:0.936, S<0.492
Magnesium, Mg	1963±32.2 a	2020±55.1 b	1580±10 b	2250±55.7 c	2290±52.9 c	2213±28.9 c	F:116.7, S<0.000
Manganese, Mn	433±12.7 d	219±4.62 c	176±5.52 b	218±3.68 c	634.7±12.5 e	618.9±0.85 a	F:1732.5, S<0.000
Molybdenum, Mo	0.15±0.04 b	0.49±0.03 c	0.09±0.01 a	0.10±0.01 a	0.09±0.00 a	0.77±0.01 d	F:462.5, S<0.000
Sodium, Na	110±8 ab	110±17.3 ab	100±13.2 a	120±20 ab	130±4.16 b	120±10 ab	F:1.909, S<0.166
Nickel, Ni	13.4±0.26 f	7.08±0.29 d	3.73±0.11 b	6.70±0.20 c	9.84±0.17 e	2.49±0.03 a	F:1238.5, S<0.000
Phosphorus, P	4370±65.6 b	4793±90.2 c	4210±43.6 a	4897±101 cd	5023.3±90.7 d	4803±80.8 c	F:46.78, S<0.000
Lead, Pb	4.78±3.95 ND	2.56±1.27 ND	6.05±5.5 ND	2.76±0.49 ND	2.37±0.93 ND	1.90±0.56 ND	F:0.983, S<0.467
Selenium, Se	0.78±0.09 b	n.d.	n.d.	0.55±0.03 a	0.99±0.11 c	0.61±0.16 ab	F:10.64, S<0.004
Strontium, Sr	13.0±0.46 d	9.27±0.12 c	7.57±0.09 a	23.7±0.50 e	9.78±0.2 c	8.23±0.13 b	F:1226.7, S<0.000
Zinc, Zn	29.1±0.82 b	23.4±1.17 a	23.5±0.60 a	28.1±0.74 b	29.4±1.04 b	33.5±0.76 c	F:54.47, S<0.000

[a] The collection sites are described in **Table 1**. ND, not different; n.d. = not detected

ally significant amounts of Se, which is a component of many selenoenzymes including glutathione peroxidase.

Consumption of 20 g of oriental beechnut seed would provide about 6% of the recommended daily intake (RDA) of Zn, and the following percentages of the RDAs for Mn (25%), Cu (20%), Fe (6%), and Mo (8%).

The presence of lead in the range 1.90-6.05 μg/g dry weight (**Table 4**) in oriental beechnut seed requires comment. Lead is toxic to humans in large measure because of its pathophysiologic effects on energy metabolism in the brain and inhibition of heme synthesis in reticulocytes which can result in anemia. The maximum permissible daily intake of Pb for adults is 0.25 mg/day (FAO/WHO 1993). Consumption of 20 g of oriental beechnut seeds from Kulakkaya (Site 3, **Fig. 1**) which contained the highest amount of lead (6.05 μg/per dry weight) would amount to only one-half of the maximum permisable lead intake.

In assessing the nutritional value of the seeds of *F. orientalis*, it is important to know the bioavailability of the essential minerals and amino acids. Therefore, future studies should aim to provide information about the content of proteinase inhibitors, chelating agents (e. g., tannins, phytic acid) and other antinutrients.

In conclusion, the present study highlights the potential of seeds of oriental beechnut as a nutritious plant food because of their high content of oleic acid, the two essential fatty acids, several essential amino acids and a number of essential minerals. Future studies should be concerned with the conservation of *Fagus orientalis* trees whose seeds contain high amounts of these nutrients.

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