

Nutritional, Anti-Nutritional, and Antioxidant Properties of Several Wild Almond Species from Iran

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ABSTRACT

Three different sources of Iranian wild almond (*Amygdalus scoparia* from Beyza, Fars Province, *A. scoparia* from Borazjan, Bushehr Province, and *A. hausknechtii* from Firouzabad, Fars Province) were evaluated for their amino acid compositions and protein nutritive quality attributes. Hydrophobic and acidic amino acids were the most abundant amino acids found in the seed protein. When compared to the (FAO/WHO)-recommended essential amino acid pattern for an adult, lysine, sulphur amino acids (methionine+cysteine) and histidine are considered the first, the second, and the third limiting amino acids, respectively, in the protein obtained from the wild almond sources. Also, the protein and energy values of the studied wild almonds were lower than those of the domestic almond. Wild almonds were also found to be rich sources of minerals; particularly calcium, zinc, and phosphorous. Wild almonds also had higher levels of phenolic compounds and antioxidant activities than those of the domestic almond. Furthermore, amygdalin, a cyanogenic glycoside mainly found in the fruits and seeds of Rosacea family, was obtained at significantly higher levels in the wild species (6.5-7.2%, wet basis) when compared to that in the studied domestic almond (0.9%, w/w). Overall, the results of this study show that there is a great potential for the application of wild almonds in the food industry.

Keywords: Amino acid, Amygdalin, Anti-nutrient, Antioxidant activity, Mineral composition.

INTRODUCTION

Increasing preference of the vegetable-based products on those obtained from animal sources resulted in the use of nuts as the major ingredients in certain manufactured products. Almonds (*Prunus amygdalus* L.) are among the most valuable edible nuts with a global production of about 1.7 million metric tons a year (Mandalari *et al.*, 2014). Almonds are considered to be a valuable source of plant proteins in the human diet (King *et al.*, 2008). In general, protein contents for most

almonds lie within 16-23 g 100 g⁻¹ nut with the limiting amino acids of methionine, followed by lysine and threonine (Yada *et al.*, 2011). High contents of minerals, especially calcium, potassium, magnesium, phosphorus and iron, have also been reported for regular almonds (Özcan *et al.*, 2011). Almonds are also reported for their high antioxidant activities (Esfahlan *et al.*, 2010). Due to the presence of such antioxidants as flavonoids and other phenolic compounds, almonds have a great potential in inhibiting copper-induced oxidation of human LDL cholesterol and

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hydroxyl- and peroxy-radical-induced DNA scission (Wijeratne *et al.*, 2006).

Other than the regular almonds, around twenty wild almond species have been reported in Iran (Sorkheh *et al.*, 2009). These species predominantly have bitter taste, which might be due to the presence of a diglycoside compound (amygdalin) in the seeds (Sánchez-Pérez *et al.*, 2008). However, before having a major industrial utilization for these wild species, it is necessary to have a comprehensive knowledge about their different nutritional and/or anti-nutritional aspects. According to the results of authors' previous studies (Balvardi *et al.* 2015a, b; Moayedi *et al.*, 2011; Chodar-Moghadas and Rezaei, 2017), wild almonds were found to be rich sources of unsaturated fatty acids, especially oleic acid.

To complete those studies, the aim of the current study was to compare the proximate compositions, amino acid profiles, mineral compounds, antioxidant properties and amygdalin contents of several wild almond species grown in Iran.

MATERIALS AND METHODS

Information about the almond seeds (the domestic almond, *Amygdalus dulcis*, AD, from Estahban, Fars, Iran; wild almond *A. hauskenechtii*, AH, from Firouzabad region, Fars, Iran; wild almond *A. scoparia* from Borazjan region, AJ, in the Bushehr province, Iran, and wild almond *A. scoparia* from the Beyza region, AZ in the Fars province, Iran) and all other materials used in the current study have been reported in a previously published article (Moayedi *et al.*, 2011).

Proximate Composition Analysis

The moisture and ash contents of the almond kernels were determined in accordance with the AOAC (1990) methods. A Soxhlet apparatus was used for the determination of

total lipids (oil) in the almond kernels according to the method described by Zhang *et al.* (2009). Protein content was determined by the Kjeldahl method using a conversion factor of 5.18 (Moodley *et al.*, 2007). Carbohydrate fraction was obtained by subtracting the percentages of all other components (protein, moisture, lipid and ash) from the unity (Alasalvar *et al.*, 2003). The energy values were estimated using the conversion factors of 4, 4, and 9 kcal per gram of proteins, carbohydrates and lipids, respectively (Merril *et al.*, 1973).

Amino Acid Analysis

Amino acids were analyzed using a High Performance Liquid Chromatography (HPLC) system (Waters Chromatography Division, Milford, MA) fitted with a Pico-Tag amino acid analysis column according to the method described by Heinrikson and Meredith (1984). Briefly, wild almond kernels were hydrolyzed using 6 N HCl at 110°C for 23 hours and then treated with a 2:2:1 (v/v/v ratios) mixture of ethanol, trimethylamine and water, and dried. The dried samples were then derivatized using a 7:1:1:1 (v/v/v/v) solution of ethanol-water-triethylamine-phenylisothiocyanate (99.9%), held for 20 min at 25°C in a nitrogen atmosphere and dried. Then, 50 µL of 5 mM sodium acetate buffer (pH 7.6, 40°C) containing 6% (v/v) acetonitrile was added to the dried sample and aliquots were used for the analysis by HPLC system equipped with a Waters 2487 dual-absorbance UV detector (Gilson Inc., Middleton, Wisconsin, USA). The mobile phase was a mixture of acetonitrile-water (6:4, v/v) with flow rate of 1 mL min⁻¹. Norleucine was used as an internal standard to determine percent recoveries of amino acids. The obtained results were expressed as mg amino acid per g of the protein used. The Amino Acid Score (AAS) was determined for the obtained proteins using the following expression (WHO, 2007):

$$AAS = \left(\frac{\text{mg of amino acid in 1 g of test protein}}{\text{mg of amino acid in the requirement pattern}} \right) \times 100$$

Minerals were determined after wet digestion with a mixture of nitric acid (65%, w/w), sulfuric acid (95%) and hydrochloric acid (32%) at 12:2:2 ratios (in mL) by using a method described by Tinggi *et al.* (1997). Ca, Mg, Cu, Zn and Mn were quantified by an atomic absorption spectrophotometer (Shimadzu AA-670, Tokyo, Japan) using specific wavelengths of the elements. Phosphorous was determined spectrophotometrically at 430 nm after wet ashing with concentrated perchloric acid (Cottenie, 1980).

Total Phenolic Contents (TPCs)

TPCs of the samples were determined using the Folin–Ciocalteu reagent as described by Miliauskas *et al.* (2004). Briefly, 0.3 mL of the methanolic extract of the sample (5 g 50 mL⁻¹) was mixed with 0.5 mL of Folin–Ciocalteu reagent. Then, 1.00 mL saturated sodium carbonate (~36 g 100 mL⁻¹) was added and the final volume was adjusted to 10.0 mL using distilled water. The mixture was maintained in a dark place for 30 min and then centrifuged for 8 minutes at 2,100×g. The absorbance of the supernatant was then measured at 760 nm using a Unico spectrophotometer (Model S-2100; S. Plantfield, New Jersey) against a blank containing only Folin–Ciocalteu reagent and saturated sodium carbonate. A standard curve was also prepared using tannic acid (TA) as reference (0.02–0.10 mg TA in 10 mL final solutions). The results were expressed as mg tannic acid equivalent (TAE) 100 g⁻¹ of the sample.

DPPH Radical-Scavenging Activity

A method described by Brand-Williams *et al.* (1995) was applied to evaluate the antioxidant activities of almond samples using their methanolic extracts (equivalent to 10–100 mg nut) and 2 mL of 2,2-DiPhenyl-1-PicrylHydrazyl (DPPH) solution at 2×10⁻⁴M concentration. The absorbances of the solutions were then measured

(constantly) using a spectrophotometer (Unico, Model S-2100) at 515 nm and the results were reported as IC₅₀ values of the almond samples (mg equivalent levels of almond samples needed to scavenge 50% of initial DPPH in the media).

Amygdalin Determination

To determine amygdalin contents, the almond samples (whole) were first lyophilized in a freeze-dryer for 36 hours (Berenguer-Navarro *et al.*, 2002) and then pulverized in a coffee grinder. Then, 1.00 g of finely powdered sample was transferred into a small flask containing 10 mL pure methanol and the extraction process was carried out under stirring conditions by magnetic stirrer for 10 hours. Afterwards, the mixture was centrifuged (at 550 g) for 10 minutes and the clear supernatant was diluted (5 times) with methanol prior to the chromatographic analysis by HPLC. Such dilution was applied only on the wild species, due to higher concentrations of amygdalin. Prior to the analysis, aliquots of the sample solutions were filtered through a 0.2-μm membrane filter. The HPLC system was from Knauer (Berlin, Germany) equipped with a column (Lichrosorb 100 RP18, 250 mm×4 mm×5 μm), a UV-VIS detector (k-2600, Knauer) used at 218 nm and an auto-sampler (Triathlon, type 900, Emmen, Netherland). A 1:1 (v/v) combination of methanol and acetonitrile at the flow rate of 0.5 mL min⁻¹ was used as the mobile phase. The injection volume of the sample solutions were 20 μL. Identification of amygdalin in almond samples was carried out by comparing the retention times of the peaks from their chromatograms to that of pure amygdalin analyzed at the same condition. For quantitative purposes, a calibration curve of amygdalin was obtained by HPLC analysis at different concentrations (0.025, 0.050, 0.070 and 0.100 g 100 mL⁻¹ methanol) of pure amygdalin.



Statistical Analysis

All experiments were performed in triplicate and mean values were compared with each other using the Least Significant Differences (LSD) comparison from Statistical Analysis System (SAS) release 9.1 (SAS Institute, Inc., Cary, NC). Differences were considered significant when the *P* value was < 0.05.

RESULTS AND DISCUSSION

Proximate Composition

The proximate compositions and energy values of the wild and domestic almond species are presented in Table 1. No significant differences ($P > 0.05$) were found in the protein and carbohydrate contents of wild and domestic almond species. The protein levels in the studied almonds (20.7-23.2%, w/w) are consistent with those reported by Calixto *et al.* (1981) and Chen *et al.* (2006) and Moodley *et al.* (2007) on domestic almonds. Considering the fat (oil) contents (44.4-47.8%, w/w), no significant differences were found among the wild species ($P > 0.05$). However, the domestic almond (AD) contained somewhat higher fat content (51.4%) compared to the wild species. In agreement with the data obtained in the current study, Femenia *et al.* (1995)

reported lower levels of fat contents in the bitter genotypes of apricot samples. Balvardi *et al.* (2015a,b) and Moayedi *et al.* (2011) reported that oleic and linoleic acids account for up to 85% (w/w) of wild almond oil, which is desirable considering the nutritional aspects of almonds. In the current study, total carbohydrate contents of wild and domestic almonds varied within 22.8% for AD to 27.6% for AJ. The latter is somewhat higher than that reported by Chen *et al.* (2006) for a commercial almond. Dietary fiber, which is a key element for a healthy diet, is reported to comprise about 11% (w/w) of carbohydrates in almond (Chen *et al.*, 2006).

There are significant differences ($P < 0.05$) in the moisture contents of the studied almond species (Table 1), which can be attributed to their diverse geographical origins and/or other factors such as the irrigation and harvest time (Nanos *et al.*, 2002; Yada *et al.*, 2013). Apart from the minor differences in the moisture levels, such levels of moisture (3.7-4.3%) can remarkably decrease the potential for many undesirable biochemical changes associated with the high moisture contents such as microbial growth, unwarranted fermentation, and premature seed germination (Venkatachalan and Sathe, 2006). One other parameter studied here was the energy value. Overall, the energy values of wild species of almond were slightly lower than that of the domestic almond (603-620 vs. 639 kcal 100

Table 1. Proximate compositions and energy values of wild almond samples studied here in comparison with those of a domestic almond (AD).

Specie	Component (% w/w)					Energy value (kcal 100 g ⁻¹ sample)
	Moisture ^a	Ash ^a	Fat ^a	Protein ^a	Carbohydrate ^b	
AZ ^c	4.0 ^b	4.7 ^b	47.1 ^b	22.5 ^a	25.6 ^a	616
AJ ^d	4.3 ^a	4.9 ^a	44.4 ^b	23.2 ^a	27.6 ^a	603
AH ^e	3.8 ^c	4.7 ^b	47.8 ^{ab}	20.7 ^a	26.9 ^a	620
AD ^f	3.7 ^c	4.6 ^b	51.4 ^a	21.2 ^a	22.8 ^a	639

^a Data are expressed as the means of three replicates determined on a dry weight basis. ^b Carbohydrate contents were obtained by subtracting the values of other components from 100. ^c *Amygdalus scoparia* (from Beyza, Fars, Iran), ^d *A. scoparia* (from Borazjan, Bushehr, Iran), ^e *A. Hausknechtii* (from Firouzabad, Fars, Iran), ^f *A. Dulcis* (from Estahban, Fars, Iran). ^{a,b,c} In each column, values with the same letter are not significantly different ($P > 0.05$).

g⁻¹ sample). However, such values are remarkably higher than those reported by Oliveira *et al.* (2011) for exotic almonds (452-485 kcal 100 g⁻¹ sample).

Amino Acid Composition

A chromatographic pattern for the amino acids of the wild almond species in the current study is shown in Figure 1. Sixteen amino acids could be detected in the samples that are reported in Table 2 for the three wild almond species. glutamic acid followed by asparagine and argenin are the most dominant amino acids in the studied wild almond species. In agreement with the results of previous studies on domestic almonds (Ahrens *et al.*, 2005; Fernandes *et al.*, 2010; Venkatachalan and Sathe, 2006), our results indicate that the hydrophobic amino acids (such as alanine, valine, leucine, isoleucine, proline, phenylalanine and

tryptophan) and acidic amino acids (such as aspartic acid and glutamic acid) were the most abundant amino acids of total seed protein in the wild almond species. Calixto *et al.* (1982) reported that globulins and albumins were the major protein fractions in almonds (88–91% of total protein). The essential amino acids of wild almonds contribute 24.6–26.5% of total amino acids (Table 2). Comparison of the amino acids of wild almonds with those of *Prunus dulcis* L. (Ahrens *et al.*, 2005) show some differences in their amino acid values. Considering the requirements imposed by Food and Agriculture Organization (FAO) and World Health Organization (WHO) (WHO, 2007) for essential amino acids for adults, lysine, sulfur amino acids (methionine+cysteine) and histidine were, respectively, the first, the second, and the third limiting amino acids in the studied wild almonds. However, for *P. dulcis* L. (Ahrens *et al.*, 2005), sulfur amino acids were the first and lysine and threonine

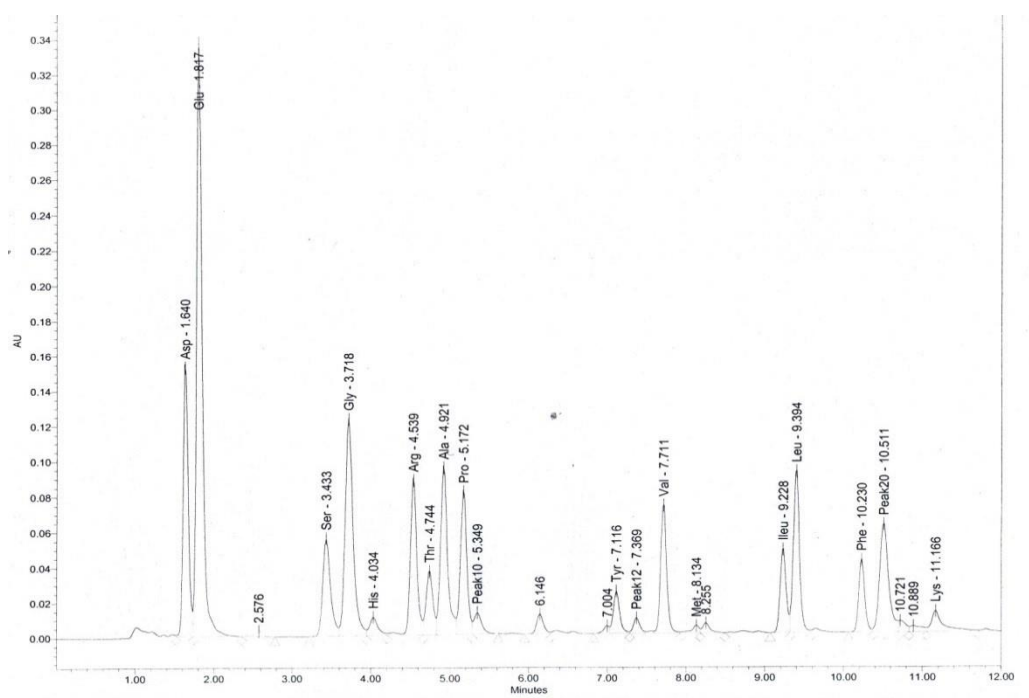


Figure 1. A sample HPLC for the amino acids in the wild almond (*A. hausknechtii*) using an HPLC system equipped with a Pico-Tag amino acid analysis column. Identified amino acids are shown by: Asp for aspartic acid, Glu for glutamic acid, Ser for serine, Gly for glycine, His for histidine, Arg for arginine, Thr for threonine, Pro for Proline, Tyr for tyrosine, Met for methionine, Ileu for isoleucine, Leu for leucine, Phe for phenylalanine and Lys for lysine.

**Table 2.** Amino acid compositions of wild almond species in the current study.

Amino acid	Almond species ^a			Mean	Standard ^e
	AZ ^b	AJ ^c	AH ^d		
Essential ^f					
His	12 ± 0	11 ± 0	8 ± 0	10 ± 0	15
Ile	27 ± 0	26 ± 1	27 ± 1	27 ± 1	30
Leu	56 ± 1	54 ± 2	55 ± 1	55 ± 1	59
Lys	6 ± 0	6 ± 0	5 ± 0	6 ± 0	45
Met + Cys	5 ± 0	5 ± 0	3 ± 0	4 ± 0	23
Phe + Tyr	48 ± 1	47 ± 1	46 ± 2	47 ± 1	30
Thr	30 ± 1	29 ± 1	27 ± 2	29 ± 1	23
Val	44 ± 1	42 ± 2	39 ± 1	42 ± 1	39
Non-essential ^f					
Asp	79 ± 1	83 ± 1	85 ± 1	82 ± 1	-
Glu	264 ± 6	271 ± 5	276 ± 7	270 ± 6	-
Ala	54 ± 2	55 ± 2	51 ± 1	53 ± 2	-
Arg	77 ± 2	79 ± 2	78 ± 1	78 ± 2	-
Gly	62 ± 2	63 ± 1	62 ± 1	62 ± 2	-
Pro	52 ± 1	50 ± 1	50 ± 1	51 ± 1	-
Ser	42 ± 1	39 ± 2	40 ± 1	40 ± 2	-
AAD (%) ^g					
Hydrophobic	329 ± 7	323 ± 4	315 ± 6	322 ± 5	-
Hydrophilic	91 ± 4	87 ± 2	85 ± 3	88 ± 3	-
Acidic	343 ± 5	354 ± 5	361 ± 7	353 ± 6	-
Basic	95 ± 3	96 ± 2	91 ± 3	94 ± 3	-
E/T (%) ^h	26.5 ± 2	25.5 ± 1	24.6 ± 2	26 ± 2	-
AAS (%) ^e	13.3 ± 1	13.3 ± 1	11.1 ± 1	13 ± 1	100
LEAA ^j					
First	Lys	Lys	Lys	-	
Second	Met/Cys	Met/Cys	Met/Cys	-	
Third	His	His	His	-	

^a All amino acid values are expressed as mg amino acid g⁻¹ protein and data are means of three replicates. ^b *Amygdalus scoparia* (from Beyza, Fars, Iran), ^c *A. scoparia* (from Borazjan, Bushehr, Iran), ^d *A. Hausknechtii* (from Firouzabad, Fars, Iran). ^e Requirement pattern of essential amino acids for adults (recommended by the joint FAO/WHO expert Consultation; WHO, 2007). ^f Identified amino acids are shown by: Asp for aspartic acid, Glu for glutamic acid, Ser for serine, Gly for glycine, His for histidine, Arg for arginine, Thr for threonine, Pro for proline, Tyr for tyrosine, Met for methionine, Ileu for isoleucine, Leu for leucine, Phe for phenylalanine and Lys for lysine. ^g amino acid distribution. ^h E/T represents essential to total amino acid ratio. ⁱ Amino acid score. ^j Limiting essential amino acids for adult (recommendation by the Joint WHO/FAO/UNU Expert Consultation., 2007).

were the second and the third limiting amino acids, respectively. The AAS values determined for the studied wild almonds are also shown in Table 2. AAS values for the wild almond species lie within 11.1% for AH to 13.3% for AZ. However, that of *P. dulcis* L. was much higher (28.2%) (Ahrens *et al.*, 2005). All of these differences indicate that there are considerable differences between the wild species and domestic almonds in terms of their amino acid profiles and protein values.

Mineral Composition

Mineral compositions of wild and domestic almond are shown in Table 3. The levels of calcium varied within 500-529 mg 100 g⁻¹ in wild almonds, which were somewhat higher than that in domestic almond (460 mg 100 g⁻¹ of almond). In addition, compared to the results of other studies on walnut, peanut, hazelnut, and pistachio (Caglarirmak *et al.*, 2005; Ravai, 1992), wild almond species studied here contain higher amounts of calcium. Similar results were also found for zinc and manganese as the amounts of these elements were significantly ($P < 0.05$) higher in the wild almonds compared to that in the domestic almond. No significant differences ($P > 0.05$) were found for copper, phosphorous, and magnesium levels between wild and domestic almonds. Several factors (such as the nature of the element, its content and form in the soil, the soil type and pH, the crop variety and

proximity to external sources of pollution) can influence the concentration of various elements in the plants (Femenia *et al.*, 1995). High levels of calcium, magnesium, and phosphorous together with higher amounts of essential micro nutrients (zinc, manganese, and copper) make wild almonds a good candidate to be considered as the source of elements for incorporation in the food products.

Total Phenolic Content and Antioxidant Activity

The TPC values and levels of antioxidant activities for wild and domestic almond kernels are given in Table 4. TPC values ranged from 372 to 463 TAE 100 g⁻¹ of the studied almonds. AJ indicated the highest level of TPC, which was significantly ($P < 0.05$) higher than those of other wild species and higher than that of the domestic almond. This is in agreement with the results of Barreira *et al.* (2008) on different almond kernels (both regional and commercial types). The concentrations and compositions of phenolic compounds in plants can be influenced by numerous parameters including climate and agricultural conditions (Barreira *et al.*, 2008). Almond polyphenols can include simple phenols, flavonoids, tannins, and also proanthocyanidins (Bolling *et al.*, 2010). Table 4 also reports on the antioxidant activities (as their IC₅₀ values) of wild and domestic almond kernels investigated in the current study. Consistent

Table 3. Mineral compositions of wild species and domestic almond (AD) investigated in this study.^a

Species	Ca	Mg	P	Cu	Zn	Mn
AZ ^b	522 ^a	452 ^a	404 ^a	1.3 ^a	6.1 ^{ab}	3.4 ^a
AJ ^c	500 ^a	389 ^a	403 ^a	1.4 ^a	7.8 ^a	3.0 ^{ab}
AH ^d	529 ^a	428 ^a	400 ^a	1.3 ^a	6.6 ^{ab}	2.7 ^{ab}
AD ^e	460 ^a	445 ^a	418 ^a	1.2 ^a	5.1 ^b	2.2 ^b

^a Values are reported as mg of each mineral in 100 g of the kernel (wet basis). ^b *Amygdalus scoparia* (from Beyza, Fars, Iran), ^c *A. scoparia* (from Borazjan, Bushehr, Iran), ^d *A. Hausknechtii* (from Firouzabad, Fars, Iran), ^e *A. Dulcis* (from Estahban, Fars, Iran).^{a, b} In each column, the values with the same letter are not significantly different ($P > 0.05$).



with its TPC value, AJ showed significantly ($P < 0.05$) higher antioxidant activity than that of the studied domestic almond and that of AZ. The correlation coefficient between the radical scavenging activity and TPC values for the investigated samples was very high ($R^2 = 0.90$) due to the fact that phenolic compounds can contribute to the antioxidant activity, mainly because of acting as hydrogen donor compounds (Wijeratne *et al.*, 2006).

Amygdalin Content

Analysis of the amygdalin contents in the almond species showed that all of the studied samples (both wild and domestic

varieties) contained amygdalin. However, the levels of amygdalin found in the wild almond species were significantly ($P < 0.05$) higher than that in the domestic almond (6.5-7.0 vs. 1.0%, respectively) (Figure 2). No significant differences were found among the wild almond species studied here. Femenia *et al.* (1995) determined amygdalin contents of some apricot species by titration method and found no amygdalin in the sweet apricots, but the amygdalin contents of bitter apricots were reported within 4.5-6.5 g 100 g⁻¹ (on a dry weight basis). Slight amounts of amygdalin were reported in some sweet apricots from Spain (Gomez *et al.*, 1998). Some studies correlated the bitterness of almonds with the presence of

Table 4. Total phenolic contents (TPC) and antioxidant activities (IC₅₀) of whole wild almonds investigated in the current study compared to those of a domestic almond (AD).

Sample	TPC*	IC ₅₀ **
AZ	399 ^b	46.0 ^a
AJ	463 ^a	35.0 ^b
AH	414 ^b	40.0 ^{ab}
AD	372 ^b	44.5 ^a

^{a,b} In each column, means with the same letter are not significantly different ($p > 0.05$). * mg tannic acid equivalent per 100 g kernel (on the wet basis). ** mg almond needed to scavenge 50% of initial DPPH in the media. AD: the domestic almond, *Amygdalus dulcis* from Estahban (Fars, Iran); AH: wild almond *A. hauskenechtii* from Firouzabad region (Fars, Iran); AJ: wild almond *A. scoparia* from Borazjan (Bushehr, Iran); AZ: wild almond *A. scoparia* from the Beyza region (Fars, Iran).

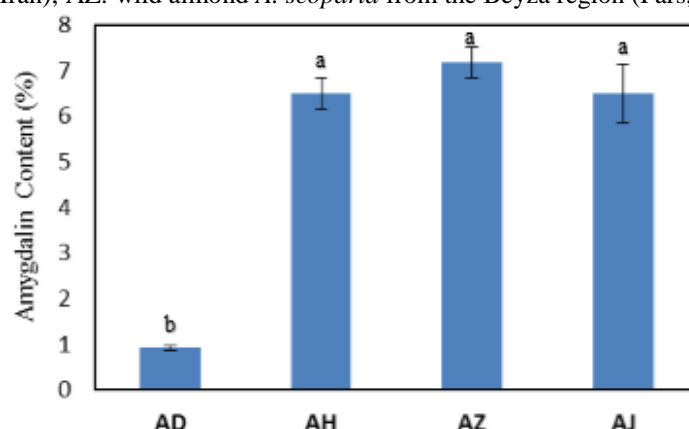


Figure 2. Amygdalin contents (on the wet basis) of almond species investigated in this study.

^{a,b} Different letters on the bars indicate that the amygdalin contents are significantly different ($p < 0.05$). AD: the domestic almond, *Amygdalus dulcis* from Estahban (Fars, Iran); AH: wild almond *A. hauskenechtii* from Firouzabad region (Fars, Iran); AJ: wild almond *A. scoparia* from Borazjan (Bushehr, Iran); AZ: wild almond *A. scoparia* from the Beyza region (Fars, Iran).

amygdalin (Sánchez-Pérez *et al.*, 2008), which needs to be verified. Remaud *et al.* (1997) reported that the benzaldehyde produced upon the hydrolysis of amygdalin was responsible for the bitterness in almonds. The concentrations of cyanogenic compounds such as amygdalin in plant seeds primarily depend on the genotype and maturation levels of the seeds (Gomez *et al.*, 1998). Ecological factors, nitrogen concentration and its availability in the soil, and sudden temperature changes can also influence the level of amygdalin (Vetter, 2000). Our results suggest that the wild almond species studied here should be detoxified prior to use in any food applications.

CONCLUSIONS

Based on the obtained results, it can be concluded that there are considerable differences between the wild and domestic almond species in terms of energy values and amino acid compositions. Also, the high contents of minerals, phenolic compounds, and antioxidant activities in wild almonds make them good candidates to be considered for preparing healthy food products for human consumption. However, higher levels of amygdalin contents in the wild almonds compared to that in the domestic almond necessitates some (pre)treatments to deactivate or eliminate amygdalin in the seeds. Overall, this study showed that there are some differences in the content of nutrient elements and anti-nutrient components among different almond species.

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خصوصیات تغذیه ای، ضد تغذیه ای و آنتی اکسیدانی چند گونه بادام وحشی از ایران

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چکیده

سه منبع مختلف از بادام وحشی (*Amygdalus scorparia* از بیضای فارس؛ *A. scoparia* از بزازجان، استان بوشهر و *A. hausknechtii* از منطقه فیروزآباد، استان فارس) به منظور بررسی ترکیب اسیدآمینه و خصوصیات تغذیه‌ای پروتئین مورد بررسی قرار گرفتند. میزان چربی با روش سوکسله و میزان پروتئین با روش کلدال به دست آمد. ضمناً، اسیدهای آمینه با روش HPLC آنالیز شدند. اسیدهای آمینه هیدروفوبیک و اسیدی فراوان‌ترین اسیدهای آمینه موجود در پروتئین دانه بودند. در مقایسه با الگوی اسید آمینه ضروری توصیه شده توسط (WHO/FAO) برای یک فرد بزرگسال، لیزین، اسیدهای آمینه گوگرددار (متیونین + سیستئین) و هیستیدین به ترتیب اولین، دومین و سومین اسیدهای آمینه محدود کننده در پروتئین به دست آمده از منابع وحشی بودند. همچنین، کیفیت تغذیه‌ای و ارزش انرژی زایی پروتئین‌های بادام‌های وحشی مورد مطالعه کمتر از بادام اهلی بودند. همچنین مشخص شد که بادام وحشی یک منبع غنی از مواد معدنی؛ به خصوص کلسیم، روی و فسفر



می‌باشد. بادام‌های وحشی سطوح بالاتری از ترکیبات فنلی و فعالیت آنتی‌اکسیدانی نسبت به بادام اهلی را دارا بودند. علاوه بر این، مقدار آمیگدالین، یک گلیکوزید سیانوژنیک که به طور عمده در میوه و دانه‌های خانواده Rosacea یافت می‌شود، به طور قابل توجهی در گونه های بادام وحشی (۶/۵-۷/۲٪، براساس وزن مرطوب) نسبت به بادام اهلی (۰/۹٪، وزنی / وزنی) بیشتر بود. به طور کلی، نتایج این مطالعه نشان می‌دهد که بادام وحشی قابلیت بالقوه‌ای برای استفاده در صنعت مواد غذایی دارد.