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Research Article

Some Physicochemical Properties of Iranian Native Barberry Fruits (abi and poloei): *Berberis integerrima* and *Berberis vulgaris*

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ABSTRACT

Owing to a combination of medicinal and nutritional values (functional food); barberry plants are of interest to researchers. Barberry is a valuable native Iranian plant which is cultivated as abi and *poloei* varieties (*Berberis integerrima* - *B. vulgaris*). Amounts of ash (1.0671- 0.7363%), fat (2.9674 - 0.6173%), fiber (12.1059 - 2.6222%), protein (0.5043 - 0.1200%), reducing sugars (8.8426 - 6.6671%), total sugar (13.8573 - 9.4827%) and pH (3.160 -3.060) were higher in *integerrima* whereas moisture content (56.27 - 75.01%), Brix (11.1666 - 17.3333) and colour indexes (L^*: 16.8500 - 20.8200, a^*: 5.6866 - 34.8400 and b^*: -1.0066 - 18.9066) were higher in *vulgaris*. The amounts of P, Zn, Fe, Na and K (ICP technique) in *vulgaris* were significantly higher than those of *integerrima* (whole and seedless fruits) and the highest amounts of Mn, Mg, and Cu, Ca were recorded in whole and seedless fruits of *integerrima*, respectively. Total phenolic and total anthocyanin contents were 8530 and 183.51 mg in 100 g fresh fruits of *B. integerrima* (as major anthocyanin delphinidin-3-glucoside equivalent), 3450 and 14.8 mg in 100 g fresh fruits of *B. vulgaris* (as major anthocyanin pelargonidin-3-glucoside equivalent), respectively.

Keywords : *Berberis integerrima, Berberis vulgaris*, physicochemical properties

1. Introduction

Barberry family includes about 650 species of plants and shrubs which are often spiny. Root, stem, leaves and fruits are used in medicine and food industry. Zakaria Razi was probably the first person who knew about the medical properties of barberry. Razi introduced two species of barberry in his book; black barberry that grows in mountains with stronger medicinal properties and red one that grows in valleys. In Iran two important barberry species are *B. Integerrima* (abi) and *B. Vulgaris* (poloei). *B. Integerrima* is a thorny shrub with fragile branches to a height of 1 to 3 meters. Its fruits are small, red, and oval, of 7-10 mm long and 3-4 mm in diameter, with a mild sour taste. There are two or three small oblong seeds inside the fruit. *B. Vulgaris* is a shrub to a height of 2.5 meters with reddish brown to dark brown branches of fruits. It bright red fruits have no seeds and are 8-10mm long. Barberry is an Iranian exclusive plant which is generally cultivated around Birjand, South Khorasan, Ghaen, Tabas, Gonabad and Kashmar. The Berberis *vulgaris* fruit is very useful as tonic for liver and heart; it prevents chronic bleeding, reduces mucus, purifies blood, and also reduces triglycerides, cholesterol and blood pressure. In addition it is effective in treatment of gall bladder, bleeding hemorrhoids, antiparasitic liver, diabetes, gout, kidney stones, colon cancer, prostate inflammation, malaria, fever, asthma (Pouyan, 2008) and neurological diseases (Fatehi *et al.*,

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2005). Owing to its colour and mellow taste *B. vulgaris* fruit is used as a garniture in Persian food. Also barberry fruits are used in preparing flake, honey, sauces, jellies, carbonated drinks, candy, food color powder, jam, marmalade, chocolates and fruit nectars. *B. Integerrima* fruits are used to prepare juices. The use of barberry fruit as a natural food colorant rich in anthocyanins instead of harmful artificial ones was studied by researchers (Sharifi *et al.*, 2008). In natural fiber products barberry fruit's extract used as a colorant shows a mild purple color (Jimenez *et al.*, 2011). Barberry bioactive compounds are widely used in medical and food industry (Fallahi *et al.*, 2010). Barberry fruits contain phenolic compounds with beneficial antioxidant activities which can reduce damages due to free radicals and prevent chronic diseases and cancers (Motalleb *et al.*, 2005). Phenolics antioxidant properties are majorly due to their redox properties which they act as reducing, hydrogen donor and single oxygen quencher agents (Kaur and Kapoor, 2001). Polyphenols health benefits are related to the inhibition of certain enzymes like xanthine oxidase, aldose reductase and protecting food components like carotenoids, vitamin C and also digestive enzymes and gut epithelial cells from oxidative damages produced by free radicals in stomach. Anthocyanins are one of the most important responsible pigments in color of fruits. They act as anti-inflammatory, anti-mutagenic and protecting against A and B hepatitis agents and exert cardioprotection by maintaining the permeability of vascular system so they called vitamin P (Svarcova *et al.*, 2007). They can increase visual acuity (Giusti and Wrolstad, 2001). Anthocyanins are very good antioxidants due to hydroxyl groups in position of 3 C ring and 3',4' B ring by metal ions (Fe, Cu) chelating effects (Svarcova *et al.*, 2007). Differential-pH method is one of the most precise methods measuring anthocyanin content (Giusti and Wrolstad, 2001). Barberry nutritional constituents' affects chemical and sensory properties such as total acidity (pH), microbial stability, sweetness, total acceptance and also can provide useful information concerning optimization of technical processes (Hanachi and Golkho, 2009). Properties of B. *boliviana* fruit such as size, weight, color, fruit juice pH, water, protein, fat, fiber and carbohydrate contents were evaluated (Jimenez *et al.*, 2011). Chemical properties such as moisture, reducing sugars, fat, protein, energy, ash, fiber, pH, acidity and colour indexes with Hanterlab of *B. vulgaris* fruits were evaluated (Akbulut *et al.*, 2009).

It should be noted that there has been no previous studies on physicochemical characteristics of Iranian *B. integerrima*. Therefore owing to beneficial properties of Iranian barberry fruits *integerrima* and *vulgaris* (abi and poloei) species (as a functional food), has attempted to study their physicochemical properties in the first part of the present work. Knowledge of these properties can be used for the coming studies.

2. Materials and methods

2.1. Plant materials

B. integerrima (7 Kg) and *vulgaris* (7 Kg) barberry fruits (ripped completely) were purchased in Nov. 2011 from gardens of Ghaen in north-east of Iran.

To prepare the material barberry fruits were carefully purged of any branches, thorns, leaves, stones and other waste substances. Then cleaned fruits were packed in nylon bags and were kept at -80°C freezer (Jal Teb Lab Equipment, Type J D 300 L). Most of the tests such as Brix, reducing and total sugars, protein, fat, fiber, ash content, mineral elements (Ca, Mg, Na, Fe, Cu, Zn, Mn and P), acidity, pH, total phenolic and anthocyanin contents were done on dried and powdered fruits. Therefore, to prevent discoloration and reduce effects of drying process fruits were dried in the oven at 50°C (48 hours for *B. integerrima* and 72 hours for *B. vulgaris* fruits because of their different amounts of moisture) (Motalleb *et al.*, 2005). Dried fruits were ground by Moulinex grinder (Type DPA 1, CMMF 800W, France).

2.2. Chemicals

Different chemical materials were purchased from authentic companies as follows; ethanol 96° (Parsian Shiraz, Shiraz, Iran), n hexane (Dr. Mojallali Labs Co., Tehran, Iran), glucose, gallic acid standards (Sigma-Aldrich, Taufkirchen, Germany), Kjeldahl catalyzer tablets I (Foss, Hillerod, Denmark), selenium, copper sulfate (II), boric acid, sulfuric acid, disodium hydrogen phosphate. $2H_2O$, sodium dodesyl sulfate, disodium tetraburate.$10H_2O$, sodium hydroxide, potassium sodium tartarate.$4H_2O$, 2-hydroxy, 3 and 5-dinitrobenzoic acid, methyl red and anthrone reagents, Folin-Ciocalteu's phenol reagent, tween-20 and EDTA were obtained from Merck (Darmstadt, Germany). The anthocyanin standards were obtained from Apin Chemicals Co. Ltd. (Oxfordshire, UK). Sodium carbonate, sodium acetate, potassium chloride, Potassium peroxodisulfate and bromocresol green were purchased from Rankem (New Delhi, India).

2.3. Methods

The moisture content of both barberry species was evaluated according to Egan, et al. method (Egan *et al.*, 1981); the ash, fat, reducing sugars, dietary fiber and protein contents were evaluated by the James method (James, 1995); the total sugars content was measured using the Yemm & Willis method (Yemm and Willis, 1954); pH was measured with pH meter (Metrohm, 827 pH lab) according to AOAC method (AOAC, 2000); acidity was evaluated according to Fallahi et al (Fallahi *et al.*, 2010) and AOAC methods (AOAC, 2000); percentage of soluble solids (Brix) was measured by Atago N1 refractometer according to Fallahi et al method (Fallahi *et al.*, 2010); colour indexing was done with Hunterlab (Color Flex, USA) colour assessment at 25°C based on indexes of L^* (brightness: 100 = white and 0 = black), a^*

(+ = red and - = green) and b^* (+ = yellow and - = blue) (Rommel *et al.*, 1990); mineral elements amounts were determined by ICP system (AOAC, 2000). The ICP instrument was ICP-OES (Perkin-Elmer, USA) and some of the most important characteristics of system were: RF power: 1.3 KW, plasma gas flow rate (Ar): 1.5 L/Min, auxiliary gas flow rate: 0.2 L/Min, nebulizer gas flow rate: 0.8 L/Min, viewing height 0-15 mm, copy and reading time: 5 s; total phenolic content of both barberry fruits were measured according to Motalleb, et al. procedure (Motalleb *et al.*, 2005) and total anthocyanin content of these barberry fruits were evaluated using Giusti and Wrolstad method (Giusti and Wrolstad, 2001) by means of Scinco spectrophotometer system UV-s 2100 (Seoul, South Korea).

All experiments were done in 3 repetitions and then results were analyzed with t-test by means of SAS software statistically (Dilorio and Hardy, 1995).

3. Results and discussion

Results of some physicochemical properties of two Iranian barberry spices are presented in Table 1.

Table 1. Physicochemical property of *Berberis integerrima* and *Berberis vulgaris* barberry fruits (abi and poloei)

Properties	*B. integerrima*	*B. vulgaris*
Ash (%)	1.0671 ± 0.0175^a	0.7363 ± 0.0027^b
Fat (%)	2.9674 ± 0.0847^a	0.6173 ± 0.0589^b
Fiber (%)	12.1059 ± 0.1271^a	2.6222 ± 0.1438^b
Protein (N*6.25) (%)	0.5043 ± 0.0523^a	0.1200 ± 0.0192^b
Reducing sugar (%)	8.8426 ± 0.0270^a	6.6671 ± 0.2840^b
Total sugar (%)	13.8573 ± 0.0237^a	9.4827 ± 0.0667^b
Acidity (% malic acid)	2.6000 ± 0.0772^a	2.6264 ± 0.1218^a
pH	3.160 ± 0.000^a	3.060 ± 0.000^b
Moisture (%)	56.27 ± 1.07^b	75.01 ± 0.78^a
Solid soluble matter (%)	11.1666 ± 0.2886^b	17.3333 ± 0.3055^a
Colour index (L^*)	16.8500 ± 0.0346^b	20.8200 ± 0.0700^a
Colour index (a^*)	5.6866 ± 0.4215^b	34.8400 ± 0.1637^a
Colour index (b^*)	-1.0066 ± 0.4544^b	18.9066 ± 0.0750^a
Total phenolic content (g/100g ethanolic and aqueous extract)	47.8067±0.0296^a 23.0914±0.9037^a	27.9948±1.0256^b 19.5444±2.9487^b
Total anthocyanin content (mg/100g ethanolic and aqueous extract)	863.2633±1.3750^a 812.0333±23.1650^a	69.0066±1.6500^b 62.1033±1.2050^b

Data is expressed as mean ± SD (n = 3).
Value in the same rows with different superscript letters within a same strain are significantly different ($p < 0.01$).

According to the Table 1the ingredients ash, fat, fiber, protein, reducing sugar, total sugar contents and pH in *B. integerrima* is greater whereas moisture content and colour indexes are significantly higher in *B. vulgaris*. The acidity amounts showed no significant differences between these two barberry species. There were no records of published results on physicochemical properties of *B. integerrima* prior to this research therefore the physicochemical properties of only *B. vulgaris* without any interpretation can be compared and contrasted with other earlier works. The observed differences between our results and previous works in different barberry varieties except *B. integerrima* were attributed to plant species, climate, soil and harvesting date.

The greater amounts of ash, fat, fiber, protein contents in *B. integerrima* were attributed to the presence of 1-3 seeds inside the fruit. Therefore, they contents in *B. integerrima* fruits were evaluated after separating seeds. The results were as follow: ash= 1.3803 ± 0.0002, fat= 1.6970 ± 0.02, fiber= 9.7399 ± 0.0765 and protein= 1.3707 ± 0.008. These changes indicate that the ash and protein contents are mainly in the flesh of fruit (whole fruit 1.0671 ± 0.0175, seedless fruit 1.3803 ± 0.0002 for ash and 0.5043 ± 0.0523, 1.3707 ± 0.008 for protein contents, respectively). In other word mineral compounds and nitrogen (as representative of ash and protein, respectively) are accumulated in flesh but about for fat and fiber contents findings are the reverse (whole fruit 2.9674 ± 0.0847, seedless fruit 1.6970 ± 0.02 for fat and 12.1059 ± 0.1271, 9.7399 ± 0.0765 for fiber contents, respectively).

The highest contents of ash on wet weight basis (WW) were in the seedless 1.3803 ± 0.0002% of (*B. integerrima*), followed by 1.0671 ± 0.0175% (whole *B. integerrima*) and 0.7363 ± 0.0027% (*B. vulgaris*) fruits, respectively. The vastly used methods in ash evaluation are founded on the principle that mineral elements among other constituents are resistant to heat destruction and volatilization (Shahnavaz *et al.*, 2009). The ash content is inorganic residue after incineration of the organic matter (Egan *et al.*, 1981). The composition of ash depends on agroclimatic and environmental conditions (Zolfaghari *et al.*, 2010)). Another important factor in ash evaluation is combustion temperature which affects the ash yield. Incineration at higher temperatures (less than 600°C) ensures complete combustion however; the suitable temperature depends on the particle size and original material of the sample. Higher temperatures may lead to decomposition of some inorganic compounds and weight loss (Babayemi *et al.*, 2010).

The fat content of both samples in decreasing order was as follow: 2.9674 ± 0.0847% (whole *B. integerrima*), 1.6970 ± 0.02% (seedless *B. integerrima*), and 0.6173 ± 0.0589% (*B. vulgaris*). Fats are the main energy source and essential lipids providers in a human diet. Besides, fats have a considerable effect on physical properties for instance (Ercisli and Orhan, 2007) reported a reverse relation between fat and moisture contents in fruits of rose and mulberry species as present study results.

The highest amounts of fiber was 12.1059 ± 0.1271% (in whole *B. integerrima*), followed by 2.6222 ± 0.1438% (*B. vulgaris*), respectively. A great amount of fiber in whole *B. integerrima* fruits was attributed to the presence of 1-3 woody seeds inside them. The fiber amounts in some other members of berry fruits such as raspberries (7.4%) and cranberry (4.2%) are in similar range (2.6-12.1%) (Egan *et al.*, 1981). Dietary fibers (DF) have beneficial physiological effects, such as laxation, blood cholesterol and glucose reduction. The beneficial influences of fibers on lipid metabolism are well-known (Gorinstein *et al.*, 2001). DF is valid to exert a significant impress in the prevention of chronic and degenerative diseases (Jimenez-Escrig *et al.*, 2001).

The protein content in both varieties of Iranian native barberry fruits were1.3707 ± 0.008% (*B. integerrima* seedless), 0.5043 ± 0.0523% (whole *B. integerrima*) and 0.1200 ± 0.0192% (*B. vulgaris*). This amount in some other member of berry fruits in the same family, like bilberry, raspberry and cranberry were 0.625%, 0.875% and 0.375%, respectively (Egan *et al.*, 1981). Proteins are a major source of energy, essential amino-acids and for the main structural constituents of many natural foods (Shahanavaz *et al.*, 2009). Fruits are the poor sources of protein (0.2-1.3%) and oil (Egan *et al.*, 1981).

About reducing sugars content, 8.8426 ± 0.0270% (*B. integerrima*), 6.6671 ± 0.2840% (*B. vulgaris*) cultivars had the highest to lowest amount, respectively, and in total sugars the mentioned sequence were as follow 13.8573 ± 0.0237% (*B. integerrima*) and 9.4827 ± 0.0667% (*B. vulgaris*), respectively. Carbohydrate content of berry fruit in the same family of bilberry, raspberry and cranberry has been reported to be 14.3%, 5.6% and 3.5%, respectively (Egan *et al.*, 1981). Carbohydrates play an effective role in sensory and textural properties like the sweetness, appearance, etc. of many foods. Fruits have diverse sugars in reducing and non-reducing forms. Reducing sugars with their free aldehyde groups can reduce compounds such as glucose, galactose, mannose and fructose (Shahanavaz *et al.*, 2009). Some believe in the role of sugars, as natural ingredients in vitamin C stability (Navarro *et al.*, 2006; Vicente *et al.*, 2002).

Findings showed that acidity percentage in both barberry fruits in accordance with malic acid were 2.6000 ± 0.0772% (*B. integerrima*) and 2.6264 ± 0.1218% (*B. vulgaris*).

The pH values were 3.160 (*B. integerrima*) and 3.060 (*B. vulgaris*). Delayed harvest causes an increase in Brix, pH values and fruit sweetness taste but declines titratable acidity. There is a negative regression between acidity and pH (Fallahi *et al.*, 2010).

Water is the largest constituents of edible parts of fresh fruits (75 - 95% for most types) as our results. The moisture contents of both varieties were as follows: 56.27 ± 1.07% (*B. integerrima*) and 75.01 ± 0.78% (*B. vulgaris*). The moisture content of the other berry fruits in the same family such as bilberry, raspberry and cranberry were 84.9%, 87% and 83.2%, respectively (Egan *et al.*, 1981).

The total soluble solids (Brix) of both barberry fruits in present were as follows: 17.3333 ± 0.3055% (*B. vulgaris*), 11.1666 ± 0.2886% (*B. integerrima*). It is a secure indicator of fruit maturation. Besides is relevant to both specific conductance and turbidity characteristics. Soluble dry matter, including carbohydrates, organic acids, proteins, lipids and mineral compounds which in most fruits the sugars are the most important components of soluble dry matter (Chandra and Todaria, 1983).

The samples color evaluated by Hunter lab and results were reported as L^*, a^* and b^* indexes. The results of present study were in following path: L^*16.8500 ± 0.0346, a^* 5.6866 ± 0.4215 and b^*-1.0066 ± 0.4544 (*B. integerrima*) and L^* 20.8200 ± 0.0700, a^*34.8400 ± 0.1637 and b^* 18.9066 ± 0.0750 (*B. vulgaris*).

Total phenolic content of *B. vulgaris* fruits methanolic followed by aqueous extracts had the highest amounts of polyphenol concentrations. The results were 28000 and 10000 mg/100 g extract total phenolic as gallic acid equivalents for extracts in methanol 80% and water, respectively (Motalleb *et al.*, 2005). In extraction procedures by two different solvents water and aqueous methanol approximately the same concentrations of polyphenol were observed in *B. vulgaris* and other wild edible Bulgarian extracts (Kiselova *et al.*, 2005). Total phenolic content of B. *vulgaris* fruits were reported as 789.32 ± 88.50 mg/100 g fresh fruits in Turkey (Akbulut *et al.*, 2009). In this work total phenolic contents were studied in aqueous and ethanolic extracts of *B. vulgaris* and *B. integerrima* fruits. According to the results total phenolic contents of B. *integerrima* fruits were 48000 and 23000 mg/100 extract in ethanolic and aqueous extracts, respectively. The results of *B. vulgaris* fruits were 28000 and 19500 mg/100 extract in ethanolic and aqueous extracts, respectively. The results were reported as gallic acid equivalents. ANOVA statistical analysis showed significant differences between the amounts of phenolic extracted in two different solvents and varieties ($p<0.05$). In both fruits the amounts of extracted polyphenol were higher in ethanolic extracts than aqueous ones significantly as the results of Motalleb et al. study (2005) (Motalleb *et al.*, 2005). Total phenolic contents were 8530 and 3450 mg in 100 g of *B. integerrima* and *B. vulgaris* fresh fruits, respectively.

Total anthocyanin content in *B. vulgaris* fruits were reported as 931.05 ± 31.21 mg/kg fresh fruit (Akbulut *et al.*, 2009). The monomeric anthocyanin content was measured averagely 7 g anthocyanin in 100 g dry fruits as major anthocyanin cyaniding-3-glucoside equivalent in *B. boliviana* fruits which is equivalent to 1.47 g in 100 g fresh fruits (Jimenez *et al.*, 2011). Anthocyanin content of some common fruits and vegetables are reported as follows: apple 10, bilberries 300 - 320, black berries 83 - 326, black currants 130 - 400, blackberries 25 - 495, red cabbage 25, black chokeberries 560, cherries 4 - 450, cranberries 60 - 200, elderberry 450, grapes 6-600, kiwi 100, red onions 7 - 21, plum 2 - 25, red radishes 11 - 60, black raspberries 300 - 400, red raspberries 20 - 60 and strawberries 15 - 35 mg/100 g fresh fruit (Giusti and Wrolstad, 2001).

In present study total anthocyanin contents of Iranian *B. vulgaris* and *B. integerrima* fruits were studied. Total anthocyanin content in *B. integerrima* fruits were 863.2633 ± 1.3750 mg in 100 g ethanolic extract and 812.0333 ± 23.1650 mg in 100 g aqueous extract. In *B. vulgaris* these amounts were 69.0066 ± 1.6500 and 62.1033 ± 1.2050, respectively. Total anthocyanin content in *B. integerrima* was 183.51 mg in 100 g fresh fruit as major anthocyanin delphinidin-3-glucoside equivalent and was 14.8 mg in 100 g fresh fruit as major anthocyanin pelargonidin-3-glucoside equivalent in *B. vulgaris*. It should be mentioned that there weren't any data about total phenolic and anthocyanin contents of Iranian *B. integerrima* fruits before this study.

The physicochemical properties of barberry fruit in present study and previous researches in other countries, without any interpretation, are presented in Table 2.

Table 2. The representation of physicochemical properties of barberry fruits in present study and other earlier research

Physicochemical properties	Barberry spices	Present study	Previous studies	References
	Berberis integerrima	1.0671 ± 0.0175	-	
Ash (%)	*Berberis vulgaris*	0.7363 ± 0.0027	1.12 ± 0.03	(Akbulut *et al.*, 2009)
	Berberis integerrima	2.9674 ± 0.0847	-	
	Berberis vulgaris	0.6173 ± 0.0589	0.84 ± 0.07	(Akbulut *et al.*, 2009)
Fat (%)	*Berberis boliviana*	-	0.52	(Jimenez *et al.*, 2011)
	Berberis integerrima	12.1059 ± 0.1271	-	
	Berberis vulgaris	2.6222 ± 0.1438	-	
Fiber (%)	*Berberis boliviana*	-	7.40	(Jimenez *et al.*, 2011)
	Berberis integerrima	0.5043 ± 0.0523	-	
	Berberis vulgaris	0.1200 ± 0.0192	10.32 ± 0.91	(Akbulut *et al.*, 2009)
Protein (N*6.25) (%)	*Berberis boliviana*	-	0.94	(Jimenez *et al.*, 2011)
	Berberis integerrima	8.8426 ± 0.0270	-	
Reducing sugar (%)	*Berberis vulgaris*	6.6671 ± 0.2840	6.52 ± 0.48	(Akbulut *et al.*, 2009)
	Berberis integerrima	13.8573 ± 0.0237	-	
	Berberis vulgaris	9.4827 ± 0.0667	-	
Total sugar (%)	*Berberis boliviana*	-	40	(Jimenez *et al.*, 2011)
	Berberis integerrima	3.16 ± 0.000	-	
	Berberis vulgaris	3.06 ± 0.000	3.35 ± 0.07	(Akbulut *et al.*, 2009)
pH			2.93-3.19	(Fallahi *et al.*, 2010)
	Berberis boliviana	-	3.81-3.84	(Jimenez *et al.*, 2011)
	Berberis buxifolia	-	2.93-3.14	(Arena and Curvetto, 2008)
	Berberis integerrima	2.6000 ± 0.0772	-	
	Berberis vulgaris	2.6264 ± 0.1218	3.10 ± 0.19	(Akbulut *et al.*, 2009)
			2.52	(Fallahi *et al.*, 2010)
Acidity (%)	*Berberis buxifolia*	-	2.56-3.88	(Arena and Curvetto, 2008)
	Berberis integerrima	56.2700 ± 1.0700	-	
	Berberis vulgaris	75.0133 ± 0.7750	71.42 ± 1.05	(Akbulut *et al.*, 2009)
Moisture (%)	*Berberis boliviana*	-	56.30	(Jimenez *et al.*, 2011)
	Berberis integerrima	11.1666 ± 0.2886	-	
	Berberis vulgaris	17.3333 ± 0.3055	19.4 ± 0.56	(Akbulut *et al.*, 2009)
Brix (%)			16.5-22	(Fallahi *et al.*, 2010)
	Berberis buxifolia	-	9.38-24	(Arena and Curvetto, 2008)
	Berberis integerrima	16.8500 ± 0.0346	-	
	Berberis vulgaris	20.8200 ± 0.0700	17.05 ± 0.25	(Akbulut *et al.*, 2009)
Colour index L^*	*Berberis boliviana*	-	3.26	(Jimenez *et al.*, 2011)
	Berberis integerrima	5.6866 ± 0.4215	-	
	Berberis vulgaris	34.8400 ± 0.1637	2.06 ± 0.99	(Akbulut *et al.*, 2009)
Colour index a^*	*Berberis boliviana*	-	0.19	(Jimenez *et al.*, 2011)
	Berberis integerrima	-1.0066 ± 0.4544	-	
	Berberis vulgaris	18.9066 ± 0.0750	-0.20 ± 0.17	(Akbulut *et al.*, 2009)
Colour index b^*	*Berberis boliviana*	-	-0.90	(Jimenez *et al.*, 2011)

The studied mineral elements in this work are including; main minerals (Ca, K, Mg, Na and P) and trace elements (Fe, Cu, Zn, and Mn) which are essential in biological processes. The differences in mineral composition can be attributed to the genetic factor of the studied cultivars and growing conditions such as soil type and environmental conditions (Zolfaghari *et al.*, 2010; Ercisli and Orhan, 2007). Statistical results revealed that the amounts of P, Zn, Fe, Na and K in *B. vulgaris* were significantly higher than those of the *B. integerrima* (whole and seedless fruits). But the amounts of Mn, Mg, and Cu, Ca in *B. integerrima* (whole and seedless fruits) were higher than B. *vulgaris*. It seems that Cu and Ca are accumulated in flesh of fruits more than in seeds.

The results showed that the contents of Ca and Mg of 3 studied samples were 4455 ± 39.5 and 1467 ± 20 in seedless *B. integerrima* fruit, 2664 ± 103.8 and 1279 ± 96.2 in whole *B. integerrima* fruit and 1758 ± 25.3 and 855.8 ± 21.27 in *B. vulgaris* fruits, respectively. Calcium is the major component of bone and teeth health and has a key role in the functioning of myocardium and heart vessels (Gorinstein *et al.*, 2001). Its recommended dietary allowance (RDA) is 1500 mg/day. Magnesium occupies a key role in all reactions with phosphate. The cells also require it for cell division and enzyme production. The RDA for Mg is 2000 mg/day (Pirestani *et al.*, 2009).

The content of K, Fe and Na were14110 ± 128.2, 455.8 ± 2.32 and 475.6 ± 5.31 in *B. vulgaris* fruit, 13440 ± 422.9, 236.8 ± 2.04 and 80.92 ± 2.469 in *B. integerrima* seedless fruit and 13000 ± 56.5, 189.3 ± 2.64 and 33.40 ± 3.056 in *B. integerrima* whole fruit, respectively. Potassium is required for the normal functioning of the nerves, heart and muscles, the sugar metabolism, acid-base balance and oxygen metabolism in the brain. Most people have a K intake of between 2-4 g/day on the average (Pirestani *et al.*, 2009). Mg and K are effective in the suppression and remedy of coronary atherosclerosis. Iron is an integral part of hemoglobin and its deficiency causes anemia. The average intake of Fe is too low, although many people receive more than 18 mg/day, which is the RDA. New studies demonstrate that high Fe amounts stored in body contribute in early atherogenesis and expand lipid peroxidation, but high levels of Fe in experimental animals reduce aortic arch lesion formation (Gorinstein *et al.*, 2001). The importance of Mg and Fe elements as many enzyme cofactors are undeniable (Ozcan and Haciseferogullari, 2007). Sodium regulates the electrolyte and acid-alkali balances, the conductivity capacity of the nerves, muscle contractions and the production of adrenaline and amino acids. The human sodium requirement is about 3 g/day (Pirestani *et al.*, 2009).

The amounts of P and Zn were: 3318 ± 70.4 and 136 ± 1.21 in *B. vulgaris* fruits, 1957 ± 153.3 and 98.61 ± 3.867 in *B. integerrima* whole fruits and 1233 ± 67.8 and 78.36 ± 0.861 in *B. integerrima* seedless fruits, respectively. P is a cofactor for many enzymes (Ozcan and Haciseferogullari, 2007). RDA for P is 300-450 mg/day. Zinc is a vital element with daily RDA 15 mg (Pirestani *et al.*, 2009).

The observed contents of Mn were 56.57 ± 0.823 in *B. integerrima* whole fruits, 54.38 ± 1.788 in *B. integerrima* seedless fruits and 34.66 ± 0.686 in *B. vulgaris* fruits, respectively. Deficiency of Mn can cause nervous system problems. The RDA for Mn is 3.8 mg, and a number of studies have indicated 5-6 mg (Pirestani *et al.*, 2009).

The highest amounts of Cu: 40.09 ± 0.667 in *B. integerrima* seedless, 24.11 ± 0.204 in *B. integerrima* whole and 22.65 ± 0.736 in *B. vulgaris* fruits. Copper very high intakes can cause health problems such as liver and kidney damage because it can catalyze LDL-C oxidation (Gorinstein *et al.*, 2001). The RDA for Cu is 2 mg (Pirestani *et al.*, 2009). High serum copper and low zinc contents are important factors which can increase cardiovascular mortality (Gorinstein *et al.*, 2001). Table 3 and Figure 1 show the main amounts of mineral elements and the shape of *B. integerrima* (whole and seedless fruits) and *B. vulgaris* fruits, respectively.

Table 3. The representation of mineral element contents (ppm) in present and previous studies

Mineral elements	*Berberis integerrima** (whole fruits)	*Berberis integerrima** (seedless fruits)	*Berberis vulgaris**	*Berberis vulgaris*	References
Ca	2664 ± 103.8^{b}	4455 ± 39.5^{a}	1758 ± 25.3^{c}	2744 ± 235.46	(Akbulut *et al.*, 2009)
K	13000 ± 56.5^{b}	13440 ± 422.9^{ab}	14110 ± 128.2^{a}	12111.19 ± 616.52	(Akbulut *et al.*, 2009)
Mg	1279 ± 96.2^{b}	1467 ± 20^{a}	855.8 ± 21.27^{c}	1193.30 ± 111.35	(Akbulut *et al.*, 2009)
Na	33.40 ± 3.056^{c}	80.92 ± 2.469^{b}	475.6 ± 5.31^{a}	2569.33 ± 157.69	(Akbulut *et al.*, 2009)
Fe	189.3 ± 2.64^{c}	236.8 ± 2.04^{b}	455.8 ± 2.32^{a}	323.86 ± 19.65	(Akbulut *et al.*, 2009)
Cu	24.11 ± 0.204^{b}	40.09 ± 0.667^{a}	22.65 ± 0.736^{b}	4.75 ± 0.35	(Akbulut *et al.*, 2009)
Zn	98.61 ± 3.867^{b}	78.36 ± 0.861^{c}	136.0 ± 1.21^{a}	7.95 ± 0.47	(Akbulut *et al.*, 2009)
Mn	56.57 ± 0.823^{a}	54.38 ± 1.788^{a}	34.66 ± 0.686^{b}	6.54 ± 0.08	(Akbulut *et al.*, 2009)
P	1957 ± 153.3^{b}	1233 ± 67.8^{c}	3318 ± 70.4^{a}	2715.51 ± 51.74	(Akbulut *et al.*, 2009)

Data is expressed as mean ± SD (n = 3).
Value in the same rows with different superscript letters within a same strain are significantly different ($p < 0.01$)
*Present study by ICP.

Figure 1. Two species of Iranian native *B. integerrima* and *B. vulgaris* fruits and its inside seeds

4. Conclusion

Contents of ash, fat, fiber, protein, reducing sugars, total sugars, pH, total phenolics and total anthocyanin contents were significantly higher in *B. integerrima* (abi), than *B. vulgaris (poloei)*, but moisture and colour in *B. vulgaris* were significantly higher than in *B. integerrima*. Acidity didn't show significant differences between these 2 varieties. There were no data in previous studies about *B. integerrima* physicochemical properties. The present information is published for the first time. In the mineral elements evaluation by ICP technique, the most amounts of P, Zn, Fe, Na and K were measured in *B. vulgaris* which were significantly higher than the samples of *B. integerrima* (whole and seedless fruits). In addition, the largest amounts of Mn, Mg, and Cu, Ca were recorded in whole *B. integerrima* and seedless fruits, respectively.

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