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MORPHOLOGICAL CHARACTERISTICS OF DIFFERENT WILD *Berberis sphaerocarpa* Kar. et Kir. GENOTYPES GROWN IN JETI-OGUZ DISTRICT (ISSYK-KUL PROVINCE) OF NORTH EASTERN KYRGYZSTAN

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ABSTRACT

Today, several fruit species are used for different purposes in alternative medicine. Among those species, barberry species are commonly used in treatment of various diseases. Jeti-Oguz District of Issyk Kul located around Issyk Lake in North-east of Kyrgyzstan has a unique flora and wild *Berberis sphaerocarpa* Kar. et Kit. (spherical-fruited barberry) species have a great place in regional flora. The fruits, leaves and roots of these species are commonly used by local people as functional products in alternative medicine. The most significant parameter in this wild population is the morphological variation in fruits and leaves. In this study, pomological analyses were performed on ripened black fruits of 26 wild genotypes. Pomological analyses yielded the fruit weights as between 0.23 g (01-JO-006) and 0.61 g (01-JO-025); total soluble solids as between 16.67% (01-JO-014) and 18.73% (01-JO-010 and 01-JO-018). Fruit shapes of genotypes were identified as long, long-spherical, spherical and oblate spherical. Significant variations were observed in morphological characteristics of spherical-fruited barberry genotypes through pomological analyses and field observations.

Key words: Barberry, *Berberis sphaerocarpa*, Kyrgyzstan, Jeti-Oguz District, pomological variation

INTRODUCTION

Kyrgyzstan is a significant country of Central Asia. Tian Shan mountains covers more than 65% of the country and Issyk-Kul lake, the second largest mountain lake of the world, is located in northeast of the country. These high-altitude mountains with harsh climate conditions have a quite rich flora. There are forests including wild species of various culture fruits like apple, pear and walnut. Highlands are rich in annual anthophyta and perennial shrubs, thus apiculture is also quite common in the country.

Within this rich flora, *Berberis sphaerocarpa* Kar. et Kit. (spherical-fruited barberry) of Berberidaceae family is an important shrubbery species. These species are quite widespread under local ecological conditions in Jeti-Oguz district of Issyk-Kul city at over 2000 meter altitude, around the Jeti-Oguz village with cold and snowy winters, over the plains between Jeti-Oguz rocks and pine forests, along the river and stream banks (figs 1, 2, 3). Pozharskiy and Chekalin [2015] mentioned about *Berberis iliensis* M. Pop.,

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B. sphaerocarpa Kar. et Kit. and *B. oblonga* Schneid in Kazakhstan, the northern neighbor of Kyrgyzstan, Squires and Safarov [2013] mentioned about the existence of *B. sphaerocarpa* and *B. integerrima* shrubbery species as a part of natural flora at high altitude mountains and over the stream and river banks of Tajikistan. The relevant sites have almost identical ecologies. In these regions, winter temperatures may reach to -30°C and even below.

Fig. 1. Naturally grown *Berberis sphaerocarpa* shrub of Jeti-Oguz

Fig. 2. *Berberis sphaerocarpa* shrubs near the pinewood forest

Fig. 3. Different spherical-fruited barberry genotypes in front Jeti-Oguz rocks

Beside winter colds, berberis species are quite resistant to high temperatures and air pollution; they require ample amounts of light [Dzhangaliev et al 2002]. Berberis species have around 500 cultivars and they are common under natural conditions in Europe, Asia, North-eastern Africa and South America [Ahrendt 1961]. There are some cultured cultivars of barberry and they are commonly used as food stuff, drug and decorative plant.

Despite all these characteristics, international resources about berberis are quite limited. There are some earlier researches about biochemical characteristics of the fruits [Verekovski and Shapiro 1985, 1986], molecular studies on *B. iliensis* M. Pop. and *B. sphaerocarpa* Kar. Et Kir. species [Pozharskiy and Chekalin 2015], preservation and rational use of natural hybrids of these species [Chekalin et al 2013]. Apart from these studies, the most detailed information about morphology of *Berberis* species was provided by Dzhangaliev et al [2002] about the naturally grown species in Kyrgyzstan.

According to Dzhangaliev et al [2002] providing general information about these species, there are 9 berberis species as of *B. bykoviana* (Bykovskiy barberry), *B. iliensis* (Iliyskei barberry), *B. integerrima* (Integrifolious barberry), *B. karkaralensis* (Karkara barberry), *B. kaschgaria* (Kashgar barberry), *B. nummularia* (Monetary barberry), *B. oblonga* (Oblong barberry), *B. sibirica* (Siberian barberry) and *B. sphaerocarpa* (Spherical-fruited barberry) naturally grown in Kyrgyzstan.

Immature fruits of berberis species contain 'berberine' which is used as styptic in drugs. The immature fruits are also used in jams, jellies, marmalades and pastries. They sometimes used in vines, liquors, nalivkas, syrup and extracts. Leaves, fruits and roots are used by local people in treatment of urinary system diseases, chronic hepatitis, to expel gall stones, or as diaphoretic and styptic [Dzhangaliev et al. 2002]. Local people are producing and selling herbal drugs in Jeti-Oguz village and *B. sphaerocarpa* fruits are both dried and used in jams in the region. The jam is used to treat coughing in quite cold winter months and dried fruits are consumed as herbal tea and believed to be food for diabetes, blood pressure, stomach ulcers, hemoglobin, liver, hepatitis, kidney and gastritis. It was also indicated that the tea brewed from the roots was a blood pressure regulator and good for kidney and liver, the tea brewed from the leaves was good for postnatal bleedings.

In this study, fruits and general plant characteristics of wild *B. sphaerocarpa* genotypes, which were able to survive under harsh ecological conditions of Kyrgyzstan flora for centuries, were investigated in that much detail for the first time in the world.

MATERIALS AND METHODS

Plant material. Barberry genotypes widely grown under natural conditions of 2141 m altitude plains between Jeti-Oguz rocks and pinewoods around the Jeti-Oguz village close to Issyk-Kul Lake in North Eastern Kyrgyzstan (figs 4, 5). Ripened violet-black fruits (figs 6, 7) of 26 wild spherical-fruited barberry genotypes were used as plant material of the present study.

Phenological observations. Only the fruit ripening dates were determined as phenological characteristic.

Morphological observations. A total of 30 fruits from each genotype of spherical-fruited barberry genotypes were analyzed pomologically to determine fruit characteristics. Fruit length and width (mm), length/width index, pedicle length (mm) were investigated using digital caliper, fruit weight (g) determined by precision scale, total soluble solids content (TSS) (%) was measured with hand refractometer, fruit shape, plant forms and thorns were also assessed observationally.

Statistical analysis. Means and standard deviations for pomological characteristics were determined by using Microsoft Office Excel software.

Fig. 4. Jeti-Oguz district of North Eastern Kyrgyzstan

(Source: http://www.huffingtonpost.com/2010/04/07/kyrgyzstan-map-population_n_528963.html)

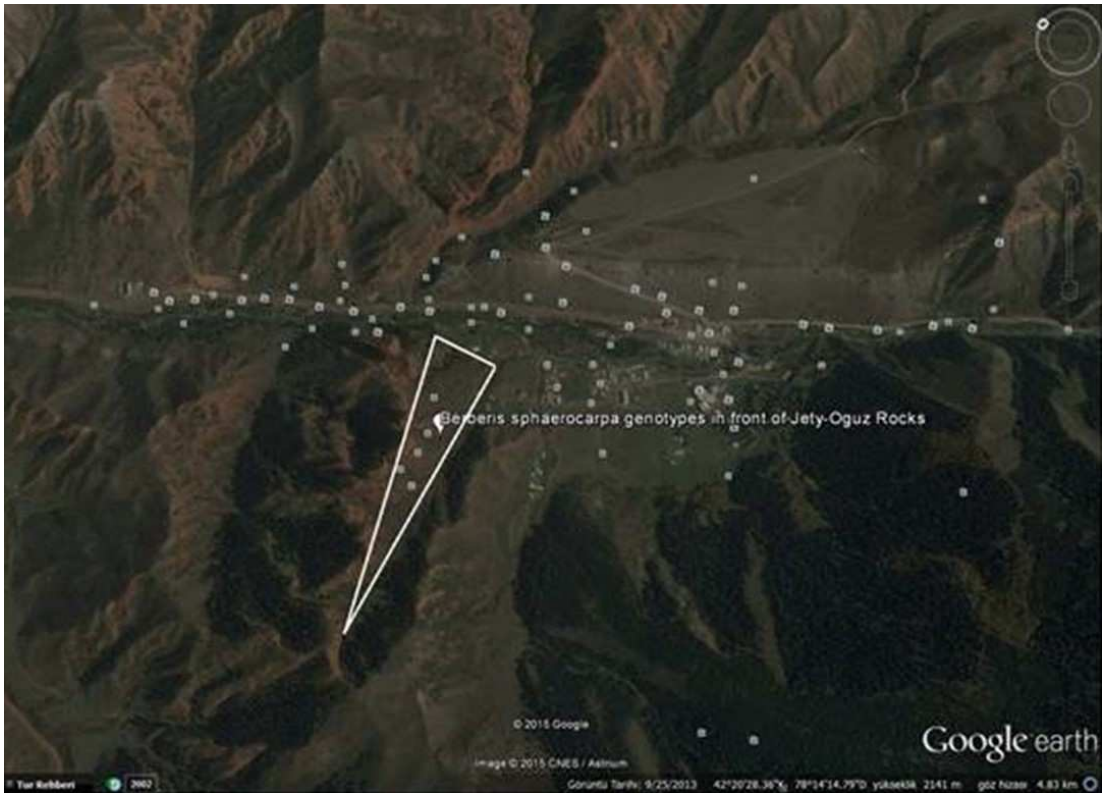

Fig. 5. *Berberis sphaerocarpa* genotypes' distribution area in this study

Fig. 6. *Berberis sphaerocarpa* shrub with fruits

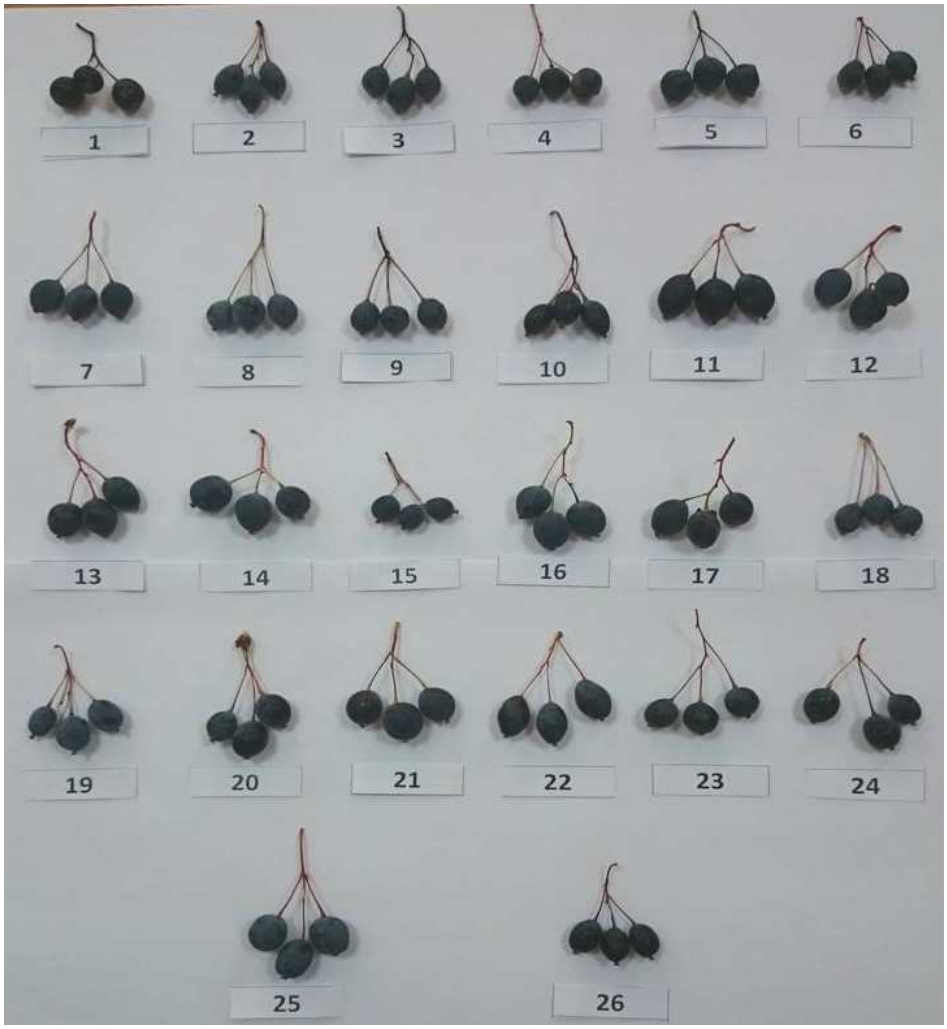

Fig. 7. Ripened *Berberis sphaerocarpa* barberries

RESULTS AND DISCUSSION

To the best of our knowledge there is no report related to fruit characteristics of *B. sphaerocarpa.* However, researches regarding to the information about morphological studies for several other *Berberis* species were reported.

Ripening dates and fruit characteristics of the genotypes are provided in Table 1. The most distinctive characteristic of Spherical-fruited barberry (*B. sphaerocarpa*) fruits was their color since they were all in violet-black color at ripening.

Ripening dates of fruits revealed that all genotypes ripened in September. Although genotypes were sampled from quite narrow space and from almost identical altitudes, a significant variation was observed in their ripening times. While the genotype 01-JO-005 had the earliest ripening (09.09.2015), the latest ripening times were observed in 01-JO-026 numbered genotype (25.09.2015) and 01-JO-026 numbered genotype (26.09.2015). The other genotypes ripened between the dates 11.09.2015 (01-JO--004, 01-JO-021, 01-JO-022 and 01-JO-024) and 22.09.2015 (01-JO-003 and 01-JO-007).

Among 26 genotypes investigated in this study, the greatest fruit widths (equatorial fruit diameter) were observe in genotypes 01-JO-014 (10.82 mm), 01-JO-021 (10.74 mm), 01-JO-008 (10.28 mm), 01-JO-025 (10.08 mm) and 01-JO-023 (10.02 mm); the lowest values were respectively seen in genotypes 01-JO-002 (7.49 mm), 01-JO-006 (7.58 mm), 01-JO-009 (7.97 mm) and 01-JO-003 (7.98 mm). Arena and Curvetto [2008] found equatorial fruit diameter of another *Berberis* species *Berberis buxifolia* fruits as 8.97 mm. On the other hand Ahmed et al [2013] reported fruit weight of *Berberis aristata* as 2.65–4.34 mm. In general other *Berberis* species had the lower fruit widths than *Berberis sphaerocarpa.*

With regard to fruit length (polar fruit diameter) of genotypes, the greatest values were observed in genotypes 01-JO-022 (13.96 mm), 01-JO-011 (13.72 mm) and 01-JO-013 (13.16 mm) and the lowest value was seen in 01-JO-004 numbered genotype with 8.98 mm. The others had fruit length values in between them. In previous studies this parameters reported as 8.56 mm for *Berberis buxifolia* [Arena and Curvetto 2008] and 7.12–9.75 mm for *Berberis aristata* fruits Ahmed et al [2013] which mainly lower than our results.

Considering the fruit weights of the genotypes, the greatest values were measured in genotypes 01-JO-025 (0.61 g), 01-JO-016 (0.54 g), 01-JO-021 (0.53 g) and 01-JO-017 (0.50 g). The lowest fruit weights were respectively observed in genotypes 01-JO-006 (0.23 g), 01-JO-002 (0.28 g) and 01-JO-003 (0.2 g). When the fruit weights were assessed together with fruit sizes, it was observed that larger fruits had higher fruit weights. Such a case was also found to be related to water and nutrient concentrations in fruits. Although not encountered with any study about the fruit weight of *Berberis sphaerocarpa* until now, some studies were reported on other *Berberis* species. Arena and Vater [2003], sampled the *Berberis buxifolia* in terms of their different sides and determined the fruit weight in the range between 0.23 and 0.27 g. On the other hand, Arena and Curvetto [2008] estimated the fruit weight as 0.352 and 0.323 g for *Berberis buxifolia* after 112 and 126 days of flowering, respectively. Ahmed et al [2013] determined the fruit weight of *Berberis aristata* in the range between 0.115 and 0.122 g. It can be concluded that although the studies were conducted in different ecological situations, fruits of *Berberis sphaerocarpa* were considerably bigger compared with those of *Berberis buxifolia* and *Berberis aristata.*

With regard to inflorescence, spherical-fruited barberry fruits had 5–9 yellow flowers per raceme. Different pedicle lengths were observed in fruits. While longest pedicle was observed in 01-JO-023 numbered genotype with 18.12 mm, the shortest pedicle was observed in 01-JO-015 numbered genotype with 9.63 mm (fig. 7).

Black fruits had sour and astringent flavor. Total soluble solids (TSS) measurements revealed that genotypes had quite closer values to each other. Measurements indicated that 13 genotypes (01-JO-004, 01-JO-023, 01-JO-24, 01-JO-026, 01-JO-009, 01-JO-022, 01-JO-001, 01-JO-003, 01-JO-007, 01-JO-021, 01-JO-025, 01-JO-010 and 01-JO-018) had TSS values between 18–19%. The lowest value was observed in 01-JO-014 numbered genotype with 16.67%. The least variation among 26 genotypes was observed in TSS values. In a study, TSS was ranged between 22.77, 24.88% respectively for 112 and 16 days after full flower of *Berberis buxifolia* [Arena and Curvetto 2008]. Ozgen et al [2012] notified that TSS of *Berberis vulgaris* fruits as 19.27–21.80%. Ahmed et al [2013] reported in another study TSS ratio of *Berberis aristata* as 23.60–27.63%. According to results these three *Berberis* species (*B. buxifolia*, *B. vulgaris* and *B. aristata* had the higher TSS ratio than *B. sphaerocarpa.*

Despite quite widespread natural growing areas of spherical-fruited barberries, fruit samples were taken in this study from a narrow site. However, variations were observed in investigated parameters of the genotypes collected from limited area. Such a case was also remarkable in morphological characteristics of the genotypes. Fruit shapes of the genotypes can constitute the most remarkable case. In 26 genotypes, fruits were spherical, long, oblate spherical and long spherical in shape and a wide variation was observed in fruit shapes of the genotypes. A significant variation was also observed in leaves of the genotypes sampled from mountainous high altitudes. However, these observations were not provided herein.

Table 1. Fruit characteristics of wild *Berberis sphaerocarpa* Kar. et Kir. genotypes in Jeti-Oguz district – North Eastern Kyrgyzstan. (Plant form of all genotypes were shrub and all of them were thorny, so these traits were not provided in the table)

Genotypes	Width (mm)	Length (mm)	Weight (g)	Pedicle length (mm)	WSDM (%)	Width/ length index	Shape	Harvesting date
	mean ±SD (min–max)							
01-JO-001	9.02 ±0.58 8.23–10.08	11.22 ±0.72 9.99–12.01	0.41 ±0.05 0.35–0.50	14.59 ±1.85 12.30–17.06	18.53 ±0.64 19.0–17.8	0.80 ±0.02	spherical	16.09.2015
01-JO-002	7.49 ±0.41 6.85–8.16	11.88 ±0.46 11.08–12.54	0.28 ±0.02 0.26–0.33	13.47 ±2.81 8.96–19.36	17.33 ±1.60 15.8–19.0	0.63 ±0.01	long	21.09.2015
01-JO-003	7.98 ±0.58 7.11–9.22	10.95 ±0.91 9.59–12.93	0.29 ±0.04 0.23–0.37	13.48 ±2.80 9.24–16.72	18.53 ±0.64 17.8–19.0	0.73 ±0.01	long	22.09.2015
01-JO-004	9.96 ±0.35 9.55–10.48	8.98 ±0.66 7.88–9.83	0.40 ±0.05 0.28–0.44	16.34 ±2.24 11.47–19.23	18.0 ±0.60 17.4–18.6	1.11 ±0.15	oblate spherical	11.09.2015
01-JO-005	9.50 ±0.96 8.28–11.42	10.98 ±0.33 10.45–11.45	0.44 ±0.09 0.34–0.60	14.64 ±2.76 10.68–18.98	17.27 ±0.50 16.8–17.8	0.86 ±0.06	spherical	09.09.2015
01-JO-006	7.58 ±0.43 7.08–8.54	10.95 ±0.64 10.35–12.39	0.23 ±0.04 0.16–0.29	14.32 ±1.50 13.00–17.44	17.27 ±0.99 16.6–18.4	0.69 ±0.01	long	19.09.2015
01-JO-007	8.86 ±0.53 8.03–9.66	11.95 ±0.54 11.38–13.05	0.48 ±0.05 0.39–0.54	15.69 ±1.23 13.98–17.85	18.60 ±0.60 18.0–19.2	0.74 ±0.02	oblate spherical	22.09.2015
01-JO-008	10.28 ±0.74 8.82–11.38	10.76 ±0.53 10.08–11.42	0.47 ±0.08 0.34–0.57	17.41 ±2.09 14.92–21.00	17.47 ±1.14 16.2–18.4	0.95 ±0.04	spherical	15.09.2015
01-JO-009	7.97 ±0.56 7.09–8.91	10.79 ±0.90 9.42–12.51	0.31 ±0.05 0.24–0.37	14.78 ±1.73 12.81–17.30	18.27 ±0.70 17.6–19	0.74 ±0.02	long	17.09.2015
01-JO-010	8.53 ±0.59 7.53–9.31	11.86 ±0.79 10.38–12.59	0.30 ±0.05 0.23–0.36	14.06 ±1.95 11.19–17.86	18.73 ±0.70 18.0–19.4	0.72 ±0.02	long	18.09.2015
01-JO-011	9.36 ±0.87 8.16–10.88	13.72 ±0.95 12.43–15.57	0.46 ±0.06 0.39–0.57	13.53 ±2.47 10.64–18.64	17.33 ±0.46 16.8–17.6	0.68 ±0.02	long	12.09.2015
01-JO-012	9.19 ±0.46 8.46–9.82	11.00 ±0.70 10.00–12.36	0.35 ±0.06 0.27–0.47	11.52 ±1.59 8.59–13.59	17.40 ±0.53 16.8–17.8	0.84 ±0.02	oblate spherical	18.09.2015
01-JO-013	9.02 ±0.74 8.15–10.18	13.16 ±2.30 11.09–18.88	0.45 ±0.04 0.37–0.50	15.25 ±2.74 11.05–18.73	17.53 ±0.50 16.8–18.2	0.69 ±0.06	long	18.09.2015
01-JO-014	10.82 ±1.05 9.56–12.16	12.01 ±0.69 11.01–13.34	0.46 ±0.12 0.33–0.65	10.96 ±1.95 7.94–14.84	16.67 ±0.81 15.8–17.4	0.90 ±0.05	spherical	25.09.2015
01-JO-015	8.49 ±0.55 7.86–9.54	9.49 ±0.48 8.83–10.03	0.33 ±0.04 0.26–0.39	9.63 ±1.93 6.52–13.32	17.27 ±0.42 16.8–17.6	0.89 ±0.02	spherical	21.09.2015
01-JO-016	10.55 ±0.62 9.47–11.15	12.11 ±0.66 11.79–12.76	0.54 ±0.07 0.47–0.63	14.36 ±3.46 10.25–19.71	17.40 ±0.80 16.6–18.2	0.87 ±0.04	spherical	17.09.2015

Table 1 cont.

01-JO-017	9.35 ±1.02 7.53–10.54	12.47 ±0.73 11.12–13.53	0.50 ±0.09 0.38–0.68	11.02 ±0.70 7.98–13.24	17.00 ±0.53 16.6–17.6	0.75 ±0.04	long	21.09.2015
01-JO-018	8.50 ±0.39 7.61–9.07	10.13 ±0.67 9.05–11.00	0.33 ±0.08 0.21–0.45	16.92 ±4.32 10.44–22.90	18.73 ±0.50 18.2–19.2	0.84 ±0.03	spherical	12.09.2015
01-JO-019	8.82 ±0.77 7.19–9.59	11.45 ±0.66 10.55–12.36	0.41 ±0.07 0.30–0.54	12.75 ±1.55 11.67–16.38	17.80 ±0.92 17.0–18.8	0.77 ±0.04	oblate spherical	19.09.2015
01-JO-020	9.81 ±0.41 9.30–10.57	11.93 ±0.75 10.65–12.77	0.46 ±0.06 0.37–0.58	17.68 ±1.25 15.41–19.12	17.93 ±0.50 17.4–18.4	0.82 ±0.02	spherical	14.09.2015
01-JO-021	10.74 ±0.93 9.18–12.17	11.34 ±0.78 10.40–12.55	0.53 ±0.09 0.41–0.73	15.94 ±1.64 14.24–18.84	18.60 ±0.60 18.0–19.2	0.95 ±0.03	spherical	11.09.2015
01-JO-022	9.55 ±0.63 8.86–10.83	13.96 ±0.73 12.78–15.25	0.44 ±0.07 0.33–0.56	13.28 ±2.10 10.18–16.63	18.45 ±0.14 18.4–18.6	0.68 ±0.02	long	11.09.2015
01-JO-023	10.02 ±0.93 8.55–11.20	9.87 ±0.56 9.06–10.37	0.40 ±0.04 0.33–0.45	18.12 ±3.42 13.02–24.51	18.07 ±1.01 17.0–19.0	1.01 ±0.05	spherical	16.09.2015
01-JO-024	9.51 ±0.66 8.74–10.92	11.46 ±0.92 9.91–12.60	0.47 ±0.08 0.31–0.59	16.08 ±1.97 13.58–19.16	18.07 ±0.61 17.4–18.6	0.83 ±0.03	spherical	11.09.2015
01-JO-025	10.08 ±0.91 8.72–11.21	12.96 ±0.87 11.36–13.94	0.61 ±0.14 0.43–0.83	17.30 ±3.88 11.87- 22.27	18.67 ±0.42 18.2–19.0	0.78 ±0.03	oblate spherical	18.09.2015
01-JO-026	8.94 ±0.35 8.42–9.45	11.09 ±0.63 10.22–11.80	0.37 ±0.02 0.34–0.40	10.88 ±2.44 7.85–16.39	18.07 ±0.42 17.6–18.4	0.81 ±0.02	oblate spherical	26.09.2015

It was reported by Dzhangaliev et al [2002] that these species commonly grown in shrub forms over mountain slopes, river and stream beds and galleries coming from the mountains. All genotypes of the present study were also in shrub forms (figs 1, 2, 3) and had a thorny structure (tab. 1). *Berberis* species, called as "Karamuk" in Turkish and "Karagat" in Kirghiz, are sustaining their existence in wild forms especially over the mountainous areas with high altitudes and harsh climates in natural flora of Kyrgyzstan.

CONCLUSIONS

Central Asia with natural beauties and unique flora hosts several wild species not placed in literature, yet. Spherical-fruited barberries are among these species and they were investigated in detail in this study and brought into the literature. The species which were not included in literature much have been used widely by local people in treatment of various diseases. The species also have a significant place for human life in Kyrgyzstan just because of their several health benefits.

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