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Determination of the nutritional and seed properties of some wild edible plants consumed as vegetable in the Middle Black Sea Region of Turkey

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ABSTRACT

This study was carried out to determine the some nutritional and seed properties of three wild edible plants, namely, *Malva neglecta* (common mallow), *Polygonum cognatum* (knotweed) and *Trachystemon orientalis* (Abraham-Isaac-Jacob), consumed as vegetable in the Middle Black Sea Region of Turkey. In this study, the plants were collected from five different localities in four different provinces (Amasya, Ordu, Samsun and Tokat) of the region. As a result, the nutritional and seed properties of wild edible plants varied considerably depending on the species and locality. Nutritional analysis showed that the wild edible plants contained important levels of protein (15.71 to 19.96%), potassium (1219.19–1867.47 mg/100 g), phosphorus (56.89–195.86 mg/100 g), calcium (282.96–688.32 mg/100 g) and magnesium (112.54–165.79 mg/100 g). The length, width, thickness, geometric mean diameter, sphericity, surface area, volume, 1000 seed weight and bulk density of wild edible plant seeds varied from 1.71 to 3.11 mm, 1.37 to 1.83 mm, 1.00 to 1.61 mm, 1.41 to 2.06 mm, 0.60 to 0.85, 6.27 to 13.29 mm^2, 1.20 to 3.17 mm^3, 1.40 to 3.41 g and 532.3 to 680.9 kg/m^3, respectively. The germination rate and mean germination time of seeds changed from 36.33 to 64.67% and 7.00 to 12.67 day, respectively. The results clearly revealed that these wild plants had important nutritional properties. Thus, these wild plant species could serve as good and cheap food sources in human diet. Additionally, the findings of this study may provide useful information on nutritional composition and seed properties of these wild plants for researchers.

1. Introduction

Plants have been commonly used as food sources by people since ancient times. There has been an increasing interest in wild edible plants in recent years all over the world (Aberoumand and Deokule, 2009), because these plants are good sources of proteins, minerals, vitamins, dietary fibers, carbohydrates, essential fatty acids, antioxidants, phenolic compounds and secondary metabolites (Imran et al., 2007; Khan et al., 2016). According the Food and Agricultural Organization, about one billion people particularly in developing countries depend on wild edible plants for their diets (Bharucha and Pretty, 2010).

Turkey is one of the richest countries of the world in terms of plant diversity due to its geographical structure and climate conditions. The Turkish flora contains over 10,000 plant species and many of them are endemic (Guner et al., 2000). Many wild edible plants are traditionally used in the human nutrition and consumed as vegetable in Turkey (Yildirim et al., 2001; Sekeroglu et al., 2006; Akgunlu, 2012). The Black Sea Region located in the north of Turkey has also a great diversity of wild edible plants because the region is situated at the junction of Irano-Turanian and Euro-Siberian phytogeographic regions. Some of wild edible plants commonly consumed as vegetable in the region are *Malva neglecta* (common mallow), *Polygonum cognatum* (knotweed) and *Trachystemon orientalis* (Abraham-Isaac-Jacob). These wild plants emerge especially in the early spring and are sold at the local markets in the region. They contribute significantly to human nutrition particularly in the rural areas of this region. In addition to, they are the important sources of income for poor people.

Determination of the nutritional properties of wild edible plants is highly important in assessing their nutritional significance. Many studies carried out on wild edible plants have revealed that the nutritional composition of these plants could be comparable to or even sometimes superior to the cultivated vegetables (Yildirim et al., 2001; Turan et al., 2003; Sekeroglu et al., 2006; Kibar and Temel, 2016).

Seed quality is generally determined by a number of physical and chemical properties of seeds (Batistella et al., 2002). In recent years, scientists have made great efforts in evaluating physical properties of seeds and have pointed out their practical utility in machine and

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structural design (Amin et al., 2004). The knowledge of physical properties of seeds such as size, volume, shape, surface area, sphericity, bulk density, true density, porosity, 1000 seed weight, geometric mean diameter, terminal velocity, angle of repose, static and dynamic coefficients of friction is required for the design of planting, harvesting, handling, drying, cleaning, conveying, storing and processing equipment (Coşkuner and Karababa, 2007). The morphological and optical features of seeds are useful in quality inspection, identification, classification, discrimination and differentiation between cultivars (Majumdar and Jayas, 2000).

However, the studies conducted on the nutritional (Turan et al., 2003; Civelek and Balkaya, 2013; Ceylan and Yücel, 2015; Koca et al., 2015) and seed properties (Önen et al., 2014) of *M. neglecta*, *P. cognatum* and *T. orientalis* commonly used as vegetable and play a significant role in the human nutrition are limited. Hence, the objective of this study was to determine the some nutritional (dry matter, pH, ash, protein, K, P, Ca and Mg content) and seed properties (length, width, thickness, seed shape index, geometric mean diameter, sphericity, surface area, seed volume, 1000 seed weight, bulk density, seed color, germination rate and mean germination time) of three wild edible plants, namely *M. neglecta*, *P. cognatum* and *T. orientalis* collected from four different provinces in the Middle Black Sea Region of Turkey.

2. Materials and methods

2.1. Plant materials

Some botanical properties of three wild edible plants used in the present study and ethnobotanical information about them are briefly explained below. The pictures related to wild edible plants and their seeds examined in the study is given in Fig. 1.

M. neglecta Wallr. is an annual herbaceous plant of the family Malvaceae. The plant is about 60 cm long. The leaves are orbicular and very shallow lobed and occur on long petioles along the stem. Flowers are pale pink, pale violet or white in leaf axils. In Turkey, its local names are "Ebegümeci, Ebemgümeci, Gömeç and Toluk". This plant is usually widespread in all regions of Turkey. It grows naturally in the croplands, fields, roadsides and gardens up to 2000 m above mean sea level. The leaves of the plant are consumed as vegetable. It is also used as a medicinal plant by people (Yücel and Tülükoğlu, 2000).

P. cognatum Meissn. is a perennial herbaceous plant belongs to the family Polygonaceae. The plant is 15–30 cm long and has a slender prostrate stem. Leaves are oblong-elliptic and often slightly mucronate. Flowers are pinkish and occur in bundles in the leaf axils. It is locally known as "Madımak, Kuşekmeği, Madımalak, Kayışkıran" in Turkey. This plant has a wide distribution area in Turkey and it is one of the widely consumed traditional wild edible plants particularly in the Central Anatolia Region (Onen et al., 2011). It grows between 720 and 3000 m above mean sea level. It is commonly found in both agricultural and non-agricultural areas such as field edges, roadsides, pastures, slopes, cliffs and industrial areas. The leaves and young shoots of plant are consumed as vegetable. It is also used for medicinal purposes (Yıldırım et al., 2003). The production of plant with seeds is quite difficult because of the seed dormancy. Recently, the cultivation of *P. cognatum* has been begun in Central Anatolia Region of Turkey to compensate the increasing demand (Onen et al., 2011).

T. orientalis (L.) G. Don. is a rhizomatous perennial herb of the family Boraginaceae. It has a height of 30–40 cm and blue-violet flowers and large leaves. It is locally called as "Kaldırayak, Hodan, Ispıt, Kaldırık, Kaldirik, Kalduruk, Balıkotu, Acı Hodan and Doğu Hodanı" in Turkey. This species is generally distributed in the Black Sea Region of Turkey (Akçin et al., 2004). It grows widely in shady riverbanks, humid habitats and *Fagus* forests between 50 and 1000 m above mean sea level. The flowering branches, rhizomes, leaves and petioles of plant are consumed as vegetable. In addition to, stem and petioles of the plant are generally consumed as pickle (Yıldırımlı, 1994). This plant has also medicinal properties (Köse et al., 2010). The rhizomes of *T. orientalis* are used as reproductive organs although it is a flowering species. This species can't produce enough seed because it generally occurs in habitats with low light intensity.

2.2. Collection of plant materials, determination of nutritional and seed properties

Three wild edible plant species (*M. neglecta*, *P. cognatum* and *T. orientalis*) used as experimental material in this study were collected

Malva neglecta *Polygonum cognatum* *Trachystemon orientalis*

Fig. 1. The wild edible plants and their seeds examined in the study.

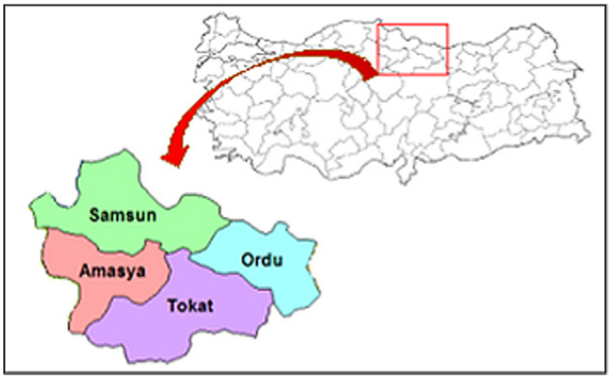

Fig. 2. Location map of the study area.

from their native populations in four different provinces (Amasya, Ordu, Samsun and Tokat) in the Middle Black Sea Region of Turkey (Fig. 2), in April–May 2011 at optimum growth stage of the plants for consumption. The taxonomic identifications of the plants were made according to Davis et al. (1988). The localities collected of wild edible plants are given in Table 1.

To determine nutritional properties, the plants collected from different localities were separated primarily as the edible and the discarded parts. Then, the plant samples were weighed, placed in paper envelope and dried in an oven at 65 °C until constant weight was obtained. Prior to analysis, the dried plant samples were ground to fine powder by using an electric grinder. The ground samples were then packed in new plastic bags and stored at 4 °C in a refrigerator until use for nutritional analysis. The dried and ground samples were used for the chemical analyses, except for dry matter. Dry matter was determined in fresh samples. The dry matter, pH, ash and crude protein content of the samples were determined by using the methods recommended by the Association of Official Analytical Chemists (AOAC, 1990). All values except for pH were expressed as percentage. For mineral analysis, the plant samples were prepared by wet digestion method using H_2SO_4 and H_2O_2 (Kacar and Inal, 2008). Mineral element (K, P, Ca and Mg) contents of each sample solution were determined by inductively coupled plasma-optical emission spectrometry (ICP-OES; Thermo Scientific, Cambridge, U.K.). Mineral contents of the plant samples were calculated as mg/100 g dry weight. All analyses were performed in triplicate.

In order to get the seeds from the plants, they were removed together with soil using a shovel and placed in the pots. Afterwards, the plants were brought to the experimental field of Black Sea Agricultural Research Institute, located in Samsun. The experimental site is situated at 41°13′ N latitude, 36°29′ E longitude and at an altitude of 6 m above mean sea level. Each plant sample was planted into the experimental field and labeled. After the seeds were mature, they were harvested from these plants. The seed samples were put into paper bags for transport to the laboratory. The seeds were dried in shade and cleaned manually to remove all foreign materials, immature and damaged seeds. Then, the properties related to the seeds were determined.

The initial moisture content of the seeds was determined by oven drying at 105 °C for 24 h using samples of 50 g with three replications (Gupta and Das, 2000). The initial moisture content of *M. neglecta*, *P. cognatum* and *T. orientalis* seeds were found to be 8.95, 8.23 and 7.59% dry basis (d.b.), respectively.

Three principal dimensions of seeds, namely, length (L), width (W) and thickness (T) were measured using a digital caliper with an accuracy of 0.01 mm in 100 randomly selected seeds.

The seed shape index was calculated using size dimensions such as seed length, width and thickness (Özgüven and Vursavuş, 2005).

The geometric mean diameter of the seeds was calculated from the three axial dimensions by using the following relationship (Eq. (1); Mohsenin, 1986):

$$D_g = (L \times W \times T)^{1/3} \quad (1)$$

The sphericity of seeds was calculated using the following formula given according to Eq. (2) by Mohsenin (1986):

$$\varphi = \frac{D_g}{L} \quad (2)$$

The surface area of seeds was found using following equation as described according to Eq. (3) by Jain and Bal (1997):

$$S = \pi \times D_g^2 \quad (3)$$

The seed volume was obtained using the following formula as reported according to Eq. (4) by Jain and Bal (1997) and Kibar et al. (2014).

$$V = \frac{\pi \times (W \times T)L^2}{6 \times \left(2L - \sqrt{W \times T}\right)} \quad (4)$$

1000 seed weight was determined according to ISTA (2007).

To determine bulk density, a cylindrical container of 1000 ml in volume was filled to 5 cm above the top with seeds. The seeds were then allowed to settle into the container, the excess seeds were removed by sweeping the surface of the container and then filled container was weighed using an electronic balance. Bulk density was determined using the following Eq. (5) (Kibar et al., 2010):

$$\rho_b = \frac{m_2 - m_1}{V_b} \quad (5)$$

The color of seeds was measured using a colorimeter (Minolta CR 400, Osaka, Japan) and recorded in $L^*a^*b^*$ color system (Hunt, 1995). The $L^*a^*b^*$ color system consists of a lightness component (L^*) and two chromatic components: the a^* value indicates from green ($-a$) to red ($+a$) while the b^* value indicates from blue ($-b$) to yellow ($+b$) colors (Mavi, 2010).

The germination tests were carried out at 25 °C in the climate cabinet on 100 seeds according to ISTA (2007) and it was continued for 30 days. Germination rate (%) and mean germination time (day) were determined according to Bewley and Black (1994) using the following Eqs. (6) and (7):

$$GR = \frac{\Sigma n_i}{N} \times 100 \quad (6)$$

$$MGT = \frac{\Sigma (t_i \times n_i)}{\Sigma n_i} \quad (7)$$

2.3. Statistical analysis

Mean values and standard deviations were calculated, and the data were expressed as mean ± standard deviation. The results related to nutritional properties were subjected to analysis of variance (ANOVA) using SPSS statistical software. Differences among means were evaluated by Duncan's multiple range test.

3. Results and discussion

The dry matter, pH, ash, protein, potassium (K), phosphorus (P), calcium (Ca) and magnesium (Mg) contents of three wild edible plants in different localities are given in Table 2. The analyses of variance showed that there were significant differences ($P < 0.01$) in terms of

Table 1
The localities collected of wild edible plants.

Species	Locality	Collection date	Latitude (North)	Longitude (East)	Altitude (m)
M. neglecta	Amasya, Göynücek, Karayakup	17.05.2011	40°22′597″	35°28′319″	700
	Amasya, Merzifon, Kayadüzü	17.05.2011	40°53′314″	35°35′473″	677
	Amasya, Ezinepazar	17.05.2011	40°33′221″	36°03′162″	782
	Amasya, Suluova, Akören	17.05.2011	40°48′160″	35°45′580″	830
	Amasya, Taşova, Güvendik	17.05.2011	40°44′175″	36°19′020″	578
	Ordu, Akkuş, Esentepe	09.05.2011	40°52′547″	37°03′581″	1122
	Ordu, Orhaniye	10.05.2011	41°00′216″	37°51′169″	368
	Ordu, Perşembe, Okçulu	10.05.2011	41°05′520″	37°38′496″	130
	Ordu, Ulubey, Güzelyurt	10.05.2011	40°52′349″	37°48′143″	290
	Ordu, Ünye, Sahilköy	09.05.2011	41°07′224″	37°11′246"	115
	Samsun, Bafra, Osmanbeyli	13.04.2011	41°31′439″	35°58′482″	82
	Samsun, Çarşamba, Dalbahçe	12.04.2011	41°13′072″	36°48′520″	18
	Samsun, Havza, Ereli	19.04.2011	41°00′652″	35°42′432″	684
	Samsun, Ladik, Çadırkaya	15.04.2011	40°59′407″	35°50′449″	744
	Samsun, Vezirköprü, Pazarcı	21.04.2011	41°04′172″	35°30′249	686
	Tokat, Erbaa, Çalkara	27.04.2011	40°44′028″	36°25′570″	237
	Tokat, Büyükbağlar	26.04.2011	40°17′849″	36°21′704″	645
	Tokat, Niksar, Boğazbaşı	27.04.2011	40°31′316″	36°53′392″	381
	Tokat, Reşadiye, Güvendik	27.04.2011	40°26′252″	37°19′402″	816
	Tokat, Turhal, Şenyurt	26.04.2011	40°19′725″	36°12′124″	560
P. cognatum	Amasya, Göynücek, Şeyhler	17.05.2011	40°25′399″	35°34′486″	485
	Amasya, Merzifon, Çavundur	17.05.2011	40°53′044″	35°33′158″	633
	Amasya, Kaleköy	17.05.2011	40°36′288″	35°56′450″	730
	Amasya, Suluova, Eraslan	17.05.2011	40°42′570″	35°36′586″	506
	Amasya, Taşova, Ballıdere	17.05.2011	40°41′128″	36°15′528″	506
	Ordu, Akkuş, Gökçebayır	09.05.2011	40°42′541″	37°01′294"	921
	Ordu, Akkuş, Yolbaşı	09.05.2011	40°42′330″	37°00′054″	1049
	Ordu, Akkuş, Gedikli	09.05.2011	40°45′207″	36°57′120″	1139
	Ordu, Ünye, Tekkiraz	09.05.2011	40°59′138″	37°09′359″	521
	Ordu, Ünye, Ortaköy	09.05.2011	40°53′088″	37°09′166″	649
	Samsun, Havza, Yenice	19.04.2011	40°59′345″	35°45′269″	668
	Samsun, Havza, Başpelit	19.04.2011	41°01′862″	35°45′167″	734
	Samsun, Ladik, Ahmetsaray	15.04.2011	40°59′480″	35°52′325″	765
	Samsun, Vezirköprü, Ersandık	21.04.2011	41°02′370″	35°30′542″	787
	Samsun, Vezirköprü, Çakırtaş	21.04.2011	41°08′187″	35°29′312″	362
	Tokat, Erbaa, Koçak	27.04.2011	40°38′294″	36°30′201″	451
	Tokat, Kemalpaşa	26.04.2011	40°21′476″	36°30′312″	700
	Tokat, Niksar, Kaşıkçı	27.04.2011	40°40′524″	37°01′126″	1182
	Tokat, Reşadiye, Bozçalı	27.04.2011	40°32′140″	37°17′376″	1322
	Tokat, Turhal, Sütlüce	26.04.2011	40°25′480″	36°06′905″	537
T. orientalis	Amasya, Merzifon, Bayat	17.05.2011	40°55′334″	35°36′466″	864
	Amasya, Merzifon, Osmanoğlu	17.05.2011	40°56′096″	35°35′240″	851
	Amasya, Taşova, Kozluca	17.05.2011	40°50′378″	36°09′436″	732
	Amasya, Taşova, Yayladibi	17.05.2011	40°51′089″	36°11′325″	801
	Amasya, Taşova, Korubaşı	17.05.2011	40°56′480″	36°12′075″	987
	Ordu, Akkuş, Yenikonak	09.05.2011	40°51′117″	37°06′326″	942
	Ordu, Kumbaşı	10.05.2011	41°00′498″	37°51′336″	63
	Ordu, Perşembe, Medreseönü	10.05.2011	41°04′445″	37°37′415″	28
	Ordu, Ulubey, Akoluk	10.05.2011	40°49′480″	37°42′039″	511
	Ordu, Ünye, Kuşçulu	09.05.2011	41°03′166″	37°17′356″	270
	Samsun, Bafra, Köseli	13.04.2011	41°28′617″	35°57′922″	99
	Samsun, Çarşamba, Karaağaç	12.04.2011	41°12′200″	36°47.555″	20
	Samsun, Havza, Çamyatağı	19.04.2011	41°07′226″	35°50′385″	938
	Samsun, Ladik, Aşağı Gölyazı	15.04.2011	40°54′666″	35°57′188″	916
	Samsun, Vezirköprü, Devalan	21.04.2011	41°15′258″	35°39′576″	936
	Tokat, Erbaa, Gökal	27.04.2011	40°49′530″	36°39′450"	679
	Tokat, Erbaa, Ortaköy	27.04.2011	40°52′059″	36°36′405″	648
	Tokat, Niksar, Özdemir	27.04.2011	40°40′211″	36°59′487″	1256
	Tokat, Niksar, Geritköyü	27.04.2011	40°39′260″	36°57′367″	1123
	Tokat, Reşadiye, Bereketli	27.04.2011	40°30′480″	37°17′186″	1285

all nutritional properties examined among plant species with the exception of pH.

The dry matter content of plants varied from 10.45 to 17.41% depending on the plant species and locality. *P. cognatum* collected from Amasya and Samsun had the highest dry matter content, while the lowest value was observed in *T. orientalis* collected from Tokat. Among plant species, *P. cognatum* had higher dry matter content than the other species. Similarly, Samsun and Amasya had the highest dry matter content among different localities (Table 2). The dry matter content was found to be in agreement with the earlier studies in different wild edible plants grown in Turkey (Yildirim et al., 2001; Sekeroglu et al., 2006; Kibar and Temel, 2016).

The pH values of the investigated plant species in different localities were similar and pH values ranged from 5.27 to 6.57. Three plant species had also slightly acidic pH (Table 2). Our findings related to pH values were similar to the results of other researchers for wild edible plants (Yildirim et al., 2001; Turan et al., 2003).

The highest ash content was observed in *T. orientalis* collected from Ordu (18.73%) and Samsun (18.17%). However, *M. neglecta* collected from Ordu (11.3%) possessed the lowest ash content. Among wild edible

Table 2
Some nutritional properties of wild edible plants.

Properties	Species	Locality				Mean
		Amasya	Ordu	Samsun	Tokat	
Dry matter (%)	*M. neglecta*	16.04 ± 0.93abc**	12.75 ± 1.01de	16.53 ± 0.72ab	14.36 ± 0.91 cd	14.92b**
	P. cognatum	17.41 ± 1.20a	16.56 ± 1.15ab	17.22 ± 1.14a	15.09 ± 1.13bc	16.57a
	T. orientalis	12.21 ± 1.06ef	13.19 ± 0.71de	12.43 ± 1.26de	10.45 ± 1.24f	12.07c
	Mean	15.22a**	14.17ab	15.39a	13.30b	
pH	*M. neglecta*	5.69 ± 0.43ns	6.21 ± 0.67	5.27 ± 0.64	6.55 ± 0.61	5.93ns
	P. cognatum	6.57 ± 0.79	5.76 ± 0.58	6.32 ± 0.77	6.27 ± 0.44	6.23
	T. orientalis	6.03 ± 0.63	6.18 ± 0.59	5.51 ± 0.58	5.28 ± 0.55	5.75
	Mean	6.10ns	6.05	5.70	6.03	
Ash (%)	*M. neglecta*	12.26 ± 0.62de**	11.13 ± 0.68f	13.53 ± 0.56c	11.28 ± 0.55ef	12.05c**
	P. cognatum	15.28 ± 0.74b	14.12 ± 0.49c	13.09 ± 0.42 cd	15.71 ± 0.57b	14.55b
	T. orientalis	16.05 ± 0.56b	18.73 ± 0.57a	18.17 ± 0.37a	15.89 ± 0.80b	17.21a
	Mean	14.53ns	14.66	14.93	14.29	
Protein (%)	*M. neglecta*	17.31 ± 0.71 cd**	15.71 ± 0.43f	17.83 ± 0.57bc	16.75 ± 0.58de	16.90b**
	P. cognatum	17.92 ± 0.55bc	16.03 ± 0.35ef	17.11 ± 0.49 cd	18.58 ± 0.48b	17.41b
	T. orientalis	17.95 ± 0.38bc	19.96 ± 0.55a	19.71 ± 0.37a	17.86 ± 0.49bc	18.87a
	Mean	17.73ns	17.23	18.22	17.73	
K (mg/100 g)	*M. neglecta*	1615.5 ± 142.61bcd**	1415.7 ± 77.53ef	1608.8 ± 101.37bcd	1525.60 ± 107.18de	1541.38b**
	P. cognatum	1345.24 ± 110.73 fg	1219.19 ± 82.86 g	1326.56 ± 92.83 fg	1546.33 ± 101.36cde	1359.34c
	T. orientalis	1715.78 ± 99.18abc	1867.47 ± 110.88a	1769.64 ± 98.89ab	1541.59 ± 68.10cde	1723.63a
	Mean	1558.84ns	1500.79	1568.32	1537.83	
P (mg/100 g)	*M. neglecta*	57.28 ± 6.18d**	56.89 ± 5.96d	58.49 ± 3.89d	58.74 ± 6.82d	57.85c**
	P. cognatum	90.24 ± 6.51c	89.27 ± 8.52c	88.12 ± 7.60c	90.57 ± 10.20c	89.55b
	T. orientalis	165.95 ± 13.79b	195.86 ± 22.45a	176.77 ± 8.26b	165.02 ± 9.35b	175.90a
	Mean	104.49ns	114.01	107.79	104.77	
Ca (mg/100 g)	*M. neglecta*	688.32 ± 71.10a**	641.02 ± 63.12ab	605.33 ± 64.79bc	518.21 ± 48.11d	613.22a**
	P. cognatum	288.57 ± 36.33f	282.96 ± 21.33f	288.51 ± 25.82f	297.72 ± 28.26f	289.43c
	T. orientalis	545.31 ± 20.69 cd	613.25 ± 41.87bc	602.39 ± 29.80bc	437.13 ± 32.60e	548.69b
	Mean	507.40a**	511.29a	498.74a	417.69b	
Mg (mg/100 g)	*M. neglecta*	162.09 ± 5.78a**	163.57 ± 5.07a	165.79 ± 7.98a	163.95 ± 9.66a	163.85a**
	P. cognatum	124.58 ± 11.51b	120.11 ± 9.65b	122.18 ± 11.89b	123.13 ± 10.86b	122.50b
	T. orientalis	112.54 ± 12.57b	123.85 ± 12.37b	124.75 ± 9.88b	112.54 ± 11.75b	118.42b
	Mean	133.07ns	135.84	137.58	133.21	

The data are mean values ± standard deviation of three replicates. The values for dry matter are expressed on fresh weight basis and the values for ash, protein, K, P, Ca and Mg are expressed on dry weight basis.
Means followed by different letters are significantly different.
** Significant at $P < 0.01$, ns: non significant.

plants, *T. orientalis* had the highest ash content (Table 2). The ash content of the plants is thought as an indicator of their total mineral contents because ash contains all the important nutritional ingredients especially minerals. The ash content obtained in the plants is in accordance with the findings of previous researchers (Turan et al., 2003; Sekeroglu et al., 2006; Civelek and Balkaya, 2013; Kibar and Temel, 2016).

The protein content of wild edible plants collected from different localities was in the range from 15.71 to 19.96%. The highest protein content was found in *T. orientalis* collected from Ordu and Samsun, whereas the lowest protein content was observed in *M. neglecta* collected from Ordu. The protein content of *T. orientalis* was higher than *M. neglecta* and *P. cognatum* (Table 2). The presence of higher protein content in the plants increases their nutritional value. In general, protein contents of the plants vary according to factors such as plant species, climate and soil properties. Protein deficiency contributes to low body mass, growth retardation in children and developmental deficiency during pregnancy. The use of wild edible plants with high protein content in diet may contribute to overcome the protein gap. The values obtained for protein content in the present study were higher than the values reported by Yildirim et al. (2001), Turan et al. (2003) and Sekeroglu et al. (2006) and lower than the values reported by Civelek and Balkaya (2013) for some wild edible plants. However, our results were compatible with the values of Kibar and Temel (2016).

The potassium content of the plants varied significantly depending on the species and locality. All of the analyzed plants had considerable amounts of potassium. Maximum potassium content was determined to be 1867.47 mg/100 g in *T. orientalis* collected from Ordu, while minimum potassium content was found in *P. cognatum* collected from Ordu (1219.19 mg/100 g). Among plant species, *T. orientalis* (1723.63 mg/100 g) had the highest potassium content (Table 2). In previous studies, the potassium content was within the range of 272–5579.1 mg/100 g for many other wild edible plants (Turan et al., 2003; Akgunlu, 2012; Civelek and Balkaya, 2013; Kibar and Temel, 2016).

The phosphorus content of the plants showed great range of variation from 56.89 to 195.86 mg/100 g. The richest source of this mineral was *T. orientalis* collected from Ordu. On the other hand, phosphorus content was the lowest in *M. neglecta* collected from Amasya, Ordu, Samsun and Tokat. The phosphorus amount of *T. orientalis* (175.90 mg/100 g) was about two to three times that of *M. neglecta* (57.85 mg/100 g) and *P. cognatum* (89.55 mg/100 g) (Table 2). The phosphorus levels of some wild edible plants grown in Turkey were found in the ranges of 2.07–60.74 mg/100 g (Turan et al., 2003), 349.2–691.3 mg/100 g (Akgunlu, 2012), 380–490 mg/100 g (Civelek and Balkaya, 2013), and 239.57–636.77 mg/100 g (Kibar and Temel, 2016).

As seen in Table 2, the calcium values of the plants ranged from 282.96 to 688.32 mg/100 g. All of the investigated wild edible plants contained significant amounts of calcium. Among different localities, Amasya, Ordu and Samsun had higher calcium content than Tokat. *M. neglecta* possessed the highest calcium content among plant species. In previous studies related to some wild edible plants, the calcium concentrations were found in a wide range from 27.0 to 7775.2 mg/100 g (Turan et al., 2003; Akgunlu, 2012; Civelek and Balkaya, 2013; Kibar and Temel, 2016).

The range of magnesium content in the plant species analyzed was 112.54–165.79 mg/100 g. With regard to magnesium content, the highest values were observed in *M. neglecta* collected from Amasya, Ordu, Samsun and Tokat. Among plant species, *M. neglecta*

(163.85 mg/100 g) possessed relatively high amounts of magnesium. However, the lowest values for magnesium were determined in *P. cognatum* and *T. orientalis* collected from Amasya, Ordu, Samsun and Tokat (Table 2). Magnesium contents of various wild edible plants varied from 30.33 to 864.3 mg/100 g (Turan et al., 2003; Akgunlu, 2012; Civelek and Balkaya, 2013; Kibar and Temel, 2016).

Mineral elements such as potassium, phosphorus, calcium and magnesium have numerous important functions in the human body. The nutritional contents of wild plants studied were much higher than some cultivated vegetables (Roe et al., 2013). The differences in the mineral contents of these plants may be due to genetic factors, growing conditions, geographical variations, different analytical methods and growth stage of the plant during collection.

Dimensional properties and the values of seed shape index of wild edible plant seeds are presented in Table 3. Dimensional properties of seeds markedly differed among the plant species. The length, width and thickness of wild edible plant seeds ranged from 1.71 to 3.11 mm, 1.37 to 1.83 mm and 1.00 to 1.61 mm, respectively. From Table 3, it can be seen that the values of length, width and thickness in *P. cognatum* seeds were considerably higher than that of *M. neglecta* and *T. orientalis*. With regard to the length, width and thickness of seeds, the highest values were observed in *P. cognatum* seeds collected from Tokat, *M. neglecta* seeds collected from Samsun and *P. cognatum* seeds collected from Samsun, respectively. However, the lowest seed length, width and thickness were determined in *M. neglecta* seeds collected from Ordu, *T. orientalis* seeds collected from Amasya and *M. neglecta* seeds collected from Ordu, respectively. These results indicates that seed size is strongly affected by not only genetic factors but also environmental variations. L/W, L/T, L/Dg and L/φ ratios in seeds were found in the ranges of 1.03–2.05, 1.57–2.25, 1.18–1.67 and 2.08–4.80, respectively. The values belonging to L/W, L/T, L/Dg and L/φ ratios in *T. orientalis* seeds were found to be higher than those of *M. neglecta* and *P. cognatum*. *T. orientalis* seeds collected from Tokat had the highest L/W, L/T, L/Dg and L/φ ratios. The lowest L/T and L/Dg ratios were recorded in *M. neglecta* seeds collected from Amasya and Samsun while L/W and L/φ ratios were the lowest in *M. neglecta* seeds collected from Ordu (Table 3). Our results related to seed length, width and L/W ratio were in agreement with the findings of Civelek and Balkaya (2011) for some wild plants used as vegetable in Bafra plain. In addition, the dimensional properties and shape index values of *P. cognatum* seeds were within the same range that those reported by Önen et al. (2014) for *P. cognatum* seeds. Similarly, the values obtained related to the seed length and seed width *P. cognatum* in this study are consistent with the results of Özkurt (2008) for *P. cognatum* seeds. Seed size is considered as an important indicator of seed quality. Seed morphological properties of the wild plants are considered to be the first step in ascertaining genetic variability of the population (Rao et al., 2008). Also, the importance of seed dimensional properties in determining aperture sizes and other parameters in machine design have been highlighted by Omobuwajo et al. (1999).

Some physical, color and germination properties of wild edible plant seeds in the study are shown in Table 4.

The geometric mean diameter varied from 1.41 to 1.60 mm for *M. neglecta* seeds, 1.69 to 1.84 mm for *T. orientalis* seeds and 1.85 to 2.06 mm for *P. cognatum* seeds. Among the plant species, the highest geometric mean diameter was obtained in *P. cognatum*. The geometric mean diameter values in *M. neglecta* seeds were lower than the seed length and width, and higher than seed thickness. On the other hand, the geometric mean diameter values in *P. cognatum* and *T. orientalis* seeds were lower than the seed length, and higher than seed width and thickness (Table 4). These results were similar to those reported by Tunde-Akintunde and Akintunde (2004) for sesame, Çalışır et al. (2005) for rapeseed and Önen et al. (2014) for *P. cognatum*. The geometric mean diameter of seed is positively related to its length, width and thickness. The geometric mean diameter can be used for the theoretical determination of seed volume and sphericity.

The sphericity values of seeds were observed in the range of 0.60–0.63 for *T. orientalis*, 0.66–0.73 for *P. cognatum* and 0.83–0.85 for *M. neglecta*. Maximum sphericity value was determined in *M. neglecta* seeds collected from Amasya, while *T. orientalis* seeds collected from Tokat had minimum sphericity value. The sphericity of *T. orientalis* and *P. cognatum* seeds was much lower compared to *M. neglecta*. Thus, *M. neglecta* seeds are closer to the shape of sphere than *T. orientalis* and *P. cognatum* seeds. It indicates that the shape of *T. orientalis* and *P. cognatum* seeds makes it difficult to roll on surface (Table 4). The closer the sphericity to 1.0, the higher the tendency to roll about any of the three axes. On the other hand, most flat seeds slide easier than spherical seeds. The sphericity are closely related to the diameter of seed. The sphericity values of wild plant seeds examined in this study fall within the range of 0.32–1.00 reported by Mohsenin (1986) for most agricultural crops. Similar results were reported by Altuntaş et al. (2005) for fenugreek, Ixtaina et al. (2008) for chia and Önen et al. (2014) for *P. cognatum*. This property is very important in the design of hoppers.

The surface area values of seeds differed considerably among plant species and the surface area of a single seed for *M. neglecta*, *T. orientalis* and *P. cognatum* changed from 6.27 to 8.08 mm^2, 8.92 to 10.63 mm^2 and 10.78 to 13.29 mm^2, respectively. The highest surface area was recorded in *P. cognatum* seeds collected from Samsun and the lowest surface area was determined in *M. neglecta* seeds collected from Ordu. From these results, *P. cognatum* seeds possessed higher surface area than *M. neglecta* and *T. orientalis* seeds (Table 4). The obtained values for surface area in this study are in accordance with those presented for sesame (Tunde-Akintunde and Akintunde, 2004) and *P. cognatum* (Önen et al., 2014). However, our results were higher than that of chia (Ixtaina et al., 2008) and lower than that of fenugreek

Table 3
Dimensional properties and the values of seed shape index of wild edible plant seeds.

Species	Locality	Length (mm)	Width (mm)	Thickness (mm)	Seed shape index			
					L/W	L/T	L/Dg	L/φ
M. neglecta	Amasya	1.77 ± 0.06	1.70 ± 0.06	1.13 ± 0.05	1.04 ± 0.06	1.57 ± 0.10	1.18 ± 0.05	2.09 ± 0.14
	Ordu	1.71 ± 0.08	1.66 ± 0.08	1.00 ± 0.05	1.03 ± 0.10	1.72 ± 0.16	1.21 ± 0.08	2.08 ± 0.24
	Samsun	1.90 ± 0.08	1.83 ± 0.09	1.19 ± 0.06	1.04 ± 0.03	1.57 ± 0.13	1.18 ± 0.03	2.25 ± 0.14
	Tokat	1.76 ± 0.04	1.71 ± 0.06	1.05 ± 0.06	1.03 ± 0.02	1.68 ± 0.10	1.20 ± 0.03	2.11 ± 0.08
P. cognatum	Amasya	3.00 ± 0.04	1.74 ± 0.04	1.55 ± 0.03	1.72 ± 0.03	1.94 ± 0.05	1.49 ± 0.02	4.48 ± 0.11
	Ordu	2.54 ± 0.05	1.76 ± 0.04	1.43 ± 0.04	1.44 ± 0.05	1.78 ± 0.08	1.37 ± 0.04	3.48 ± 0.16
	Samsun	3.02 ± 0.03	1.79 ± 0.04	1.61 ± 0.04	1.69 ± 0.06	1.88 ± 0.03	1.47 ± 0.01	4.43 ± 0.08
	Tokat	3.11 ± 0.05	1.78 ± 0.04	1.55 ± 0.04	1.75 ± 0.02	2.01 ± 0.09	1.52 ± 0.02	4.73 ± 0.12
T. orientalis	Amasya	2.81 ± 0.03	1.37 ± 0.04	1.25 ± 0.05	2.05 ± 0.03	2.25 ± 0.10	1.67 ± 0.02	4.69 ± 0.08
	Ordu	2.94 ± 0.08	1.54 ± 0.05	1.38 ± 0.04	1.91 ± 0.05	2.13 ± 0.10	1.60 ± 0.04	4.70 ± 0.24
	Samsun	2.89 ± 0.08	1.50 ± 0.05	1.40 ± 0.06	1.93 ± 0.11	2.07 ± 0.13	1.59 ± 0.06	4.59 ± 0.30
	Tokat	2.88 ± 0.04	1.41 ± 0.05	1.28 ± 0.04	2.05 ± 0.10	2.25 ± 0.09	1.67 ± 0.05	4.80 ± 0.20
Number of observation		100	100	100	100	100	100	100

L/W: Length/Width, L/T: Length/Thickness, L/Dg: Length/Geometric mean diameter, L/φ: Length/Sphericity.

Table 4
Some physical, color and germination properties of wild edible plant seeds.

Species	Locality	Geometric mean diameter (mm)	Sphericity	Surface area (mm^2)	Seed volume (mm^3)	1000 seed weight (g)	Bulk density (kg/m^3)	L^*	a^*	b^*	Germination rate (%)	Mean germination time (day)
M. neglecta	Amasya	1.50 ± 0.04	0.85 ± 0.04	7.09 ± 0.37	1.47 ± 0.15	2.14 ± 0.06	574.3 ± 2.06	27.67 ± 0.09	3.91 ± 0.08	9.83 ± 0.09	40.00 ± 2.65	10.33 ± 0.58
	Ordu	1.41 ± 0.02	0.83 ± 0.05	6.27 ± 0.22	1.20 ± 0.12	2.00 ± 0.07	590.8 ± 1.26	24.55 ± 0.09	2.81 ± 0.04	6.19 ± 0.05	36.33 ± 0.58	11.67 ± 0.58
	Samsun	1.60 ± 0.03	0.84 ± 0.02	8.08 ± 0.34	1.77 ± 0.07	2.62 ± 0.07	584.3 ± 0.96	26.06 ± 0.13	3.09 ± 0.07	7.78 ± 0.11	42.33 ± 1.53	10.00 ± 1.00
	Tokat	1.47 ± 0.05	0.83 ± 0.02	6.77 ± 0.47	1.34 ± 0.16	2.02 ± 0.05	557.5 ± 2.08	27.11 ± 0.11	3.22 ± 0.09	7.83 ± 0.07	38.00 ± 1.00	12.67 ± 0.58
P. cognatum	Amasya	2.01 ± 0.03	0.67 ± 0.01	12.66 ± 0.38	2.92 ± 0.15	3.41 ± 0.03	680.9 ± 1.30	18.02 ± 0.07	3.43 ± 0.06	4.58 ± 0.05	0.00	0.00
	Ordu	1.85 ± 0.02	0.73 ± 0.02	10.78 ± 0.24	2.43 ± 0.12	2.44 ± 0.03	671.8 ± 2.22	21.89 ± 0.07	1.84 ± 0.04	6.10 ± 0.05	0.00	0.00
	Samsun	2.06 ± 0.00	0.68 ± 0.01	13.29 ± 0.06	3.17 ± 0.02	2.82 ± 0.03	653.3 ± 1.71	19.99 ± 0.07	5.18 ± 0.05	7.43 ± 0.05	0.00	0.00
	Tokat	2.05 ± 0.01	0.66 ± 0.01	13.13 ± 0.17	3.06 ± 0.04	3.37 ± 0.03	667.5 ± 1.29	21.13 ± 0.05	2.85 ± 0.04	6.37 ± 0.04	0.00	0.00
T. orientalis	Amasya	1.69 ± 0.02	0.60 ± 0.01	8.92 ± 0.22	1.64 ± 0.07	1.51 ± 0.04	532.3 ± 2.50	20.97 ± 0.08	4.50 ± 0.04	7.69 ± 0.05	54.00 ± 1.00	9.67 ± 0.58
	Ordu	1.84 ± 0.02	0.63 ± 0.01	10.63 ± 0.21	2.17 ± 0.05	1.86 ± 0.05	545.5 ± 2.65	21.84 ± 0.05	3.41 ± 0.04	6.95 ± 0.03	51.67 ± 1.53	8.33 ± 0.58
	Samsun	1.82 ± 0.04	0.63 ± 0.03	10.43 ± 0.44	2.12 ± 0.17	2.24 ± 0.06	571.1 ± 1.64	20.57 ± 0.11	3.97 ± 0.11	7.42 ± 0.08	64.67 ± 1.15	7.00 ± 1.00
	Tokat	1.73 ± 0.02	0.60 ± 0.02	9.40 ± 0.27	1.78 ± 0.11	1.40 ± 0.04	563.0 ± 2.50	21.23 ± 0.05	2.53 ± 0.05	6.39 ± 0.03	57.00 ± 1.00	10.00 ± 1.00
Number of observation		100	100	100	100	100	10	10	10	10	100	100

(Altuntaş et al., 2005). Surface area in irregular shaped seeds plays an important role in determining the projected area of the seeds.

The volume of single seed was found to range from 1.20 (*M. neglecta* seeds collected from Ordu) to 3.17 mm^3 (*P. cognatum* seeds collected from Samsun). The seed volume of *P. cognatum* was almost twice that of *M. neglecta* and *T. orientalis*. This may be due to the fact that length, width and thickness of *P. cognatum* seeds were higher compared to *M. neglecta* and *T. orientalis* seeds. These results are within the same range to that of chia (Ixtaina et al., 2008) and *P. cognatum* (Önen et al., 2014), but these values were lower than that of fenugreek (Altuntaş et al., 2005) and coriander (Coşkuner and Karababa, 2007). Eke et al. (2007) reported that the size, surface area and volume of seeds have to be considered in bulk handling and processing operations especially in heat and mass transfer.

1000 seed weight was found to between 1.40 (*T. orientalis* seeds collected from Tokat) and 3.41 g (*P. cognatum* seeds collected from Amasya). It was determined that 1000 seed weight in *P. cognatum* was higher than that of *M. neglecta* and *T. orientalis*. This is probably owing to higher values related to length, width and thickness in *P. cognatum* seeds when compared to other two species (Table 4). Similar trends have been reported for *M. neglecta* (Civelek and Balkaya, 2011) and *P. cognatum* (Önen et al., 2014). This parameter is useful in the theoretical estimation of seed volume, cleaning using aerodynamic forces and selecting storage and handling containers (Kibar et al., 2014).

Table 4 clearly indicated that the bulk density of the wild edible plant seeds changed considerably depending on locality and species. The values of bulk density for wild plant seeds changed from 532.3 to 680.9 kg/m^3. The highest value for bulk density was determined in *P. cognatum* seeds collected from Amasya and the lowest value was displayed by *T. orientalis* seeds collected from Amasya. *P. cognatum* seeds showed higher bulk density than *T. orientalis* and *M. neglecta* seeds. The results for bulk density were similar to those reported by Tunde-Akintunde and Akintunde (2004) for sesame, Çalışır et al. (2005) for rapeseed and Önen et al. (2014) for *P. cognatum*. On the other hand, these values were lower than that of fenugreek (Altuntaş et al., 2005) and higher than that of coriander (Coşkuner and Karababa, 2007). The bulk density is useful in the development of aeration and drying, processing, packaging systems and the design of silos and storage bins (Nalladurai et al., 2002; Kibar et al., 2014).

The results showed that L^*, a^* and b^* values of wild edible plant seeds varied from 18.02 to 27.67, 1.84 to 5.18 and 4.58 to 9.83, respectively. L^* value is the degree of lightness range from 0 for black and 100 for white, this means the color of *P. cognatum* seeds was darker when compared to other two species and *M. neglecta* seeds had a lighter color. *P. cognatum* seeds collected from Samsun had the highest a^* value, while the lowest a^* value was observed in *P. cognatum* collected from Ordu. The highest b^* value was recorded in *M. neglecta* seeds collected from Amasya and the lowest b^* value was determined in *P. cognatum* seeds collected from Amasya (Table 4).

In the present study, a considerable variation in terms of seed germination was observed among species and localities. The germination rate of seeds varied from 36.33 (*M. neglecta* seeds collected from Ordu) to 64.67% (*T. orientalis* seeds collected from Samsun). Mean germination time ranged from 7.00 to 12.67 day. In *P. cognatum* seeds, no germination was observed, which may be attributed to seed dormancy. In comparison with *M. neglecta* seeds, the higher germination rate and shorter mean germination time were obtained in *T. orientalis* seeds. However, germination rate of *M. neglecta* and *T. orientalis* seeds were less than 65% (Table 4). In a study conducted by Özkurt (2008), to eliminate dormancy and to promote germination in *P. cognatum* seeds sulfuric acid, hot water and mechanical seed scarifications, potassium nitrate, gibberellic acid, chilling applications and washing under running water treatments were used. Scarification in sulfuric acid and mechanically scarification greatly increased germination. Together scarification in sulfuric acid and gibberellic acid application resulted in the highest seed germination (up to 57%) and no germination was observed in control application. Civelek and Balkaya (2011) reported that germination was not observed in *Malva sylvestris* seeds. Seed germination can be considerably influenced by environmental factors, the species and seed characteristics such as thickness of the seed coat, dormancy (Loza-Cornejo et al., 2012). Additionally, degree of germinability of seeds in most plant species vary between and within populations and between and within individuals (Mkonda et al., 2003).

4. Conclusion

Wild edible plants play a significant role in the human nutrition in Turkey. Therefore, it is important to determine nutritional contents and seed properties of wild edible plants. In this study, the some nutritional and seed properties of *M. neglecta*, *P. cognatum* and *T. orientalis* consumed as vegetable in the Middle Black Sea Region of Turkey were investigated. This is the first scientific report on physical properties of *M. neglecta* and *T. orientalis* seeds. The results indicated that three wild edible plants analyzed in this study had good nutritional properties. In addition to, the nutritional and seed properties of these wild plants changed widely depending on the different species and localities collected of these plants. The results of this study will provide valuable theoretical information on the some nutritional and seed properties of *M. neglecta*, *P. cognatum* and *T. orientalis* for researchers. However, further studies should be conducted on the total phenolic contents, antioxidant and antibacterial activities of these wild edible plants, the presence of antinutritional factors in these plants, the effect of moisture content on the physical and mechanical properties of their seeds and different applications to increase germination rate of seeds.

Nomenclature

L	length of seed (mm)
W	width of seed (mm)
T	thickness of seed (mm)
D_g	geometric mean diameter (mm)
φ	sphericity
S	surface area (mm^2)
V	seed volume (mm^3)
m_{1000}	1000 seed weight (g)
ρ_b	bulk density (kg/m^3)
m_1	the free weight of bulk density bucket (kg)
m_2	the weight of bulk density bucket with seeds (kg)
V_b	the volume of bulk density container (m^3)
L^*	lightness component in color system
a^*	from green (−a) to red (+a) colors in color system
b^*	from blue (−b) to yellow (+b) colors in color system
GR	germination rate (%)
MGT	mean germination time (day)
n_i	the number of seeds germinated on the ith day
N	total number of seeds tested
t_i	the number of days counted from the beginning of the test

References

Aberoumand, A., Deokule, S.S., 2009. Studies on nutritional values of some wild edible plants from Iran and India. Pakistan Journal of Nutrition 8, 26–31.

Akçin, Ö.E., Kandemir, N., Akçin, Y., 2004. A morphological and anatomical study on a medicinal and edible plant *Trachystemon orientalis* (L.) G. Don (Boraginaceae) in the Black Sea Region. Turkish Journal of Botany 28, 435–442.

Akgunlu, S.B., 2012. Mineral Content and Microbiological Analysis of Some Wild Edible Vegetables Consumed in Kilis and Gaziantep Provinces. Kilis 7 Aralik University, Graduate School of Natural and Applied Sciences (MSc. Thesis, 59 p. Turkey).

Altuntaş, E., Özgöz, E., Taşer, Ö.F., 2005. Some physical properties of fenugreek (*Trigonella foenum-graceum* L.) seeds. Journal of Food Engineering 71, 37–43.

Amin, M.N., Hossain, M.A., Roy, K.C., 2004. Effects of moisture content on some physical properties of lentil seeds. Journal of Food Engineering 65, 83–87.

AOAC, 1990. Official Method of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, DC.

Batistella, F., Vitto, M.F., De Carvalho, N., 2002. Relationship between physical, morphological and physiological characteristics of seeds developed at different positions of the ear of two maize (*Zea mays* L.) hybrids. Seed Science and Technology 30, 97–106.

Bewley, J.D., Black, M., 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York, p. 445.

Bharucha, Z., Pretty, J., 2010. The roles and values of wild foods in agricultural systems. Philosophical Transactions of the Royal Society, B: Biological Sciences 365, 2913–2926.

Çalışır, S., Marakoğlu, T., Öğüt, H., Öztürk, Ö., 2005. Physical properties of rapeseed (*Brassica napus oleifera* L.). Journal of Food Engineering 69, 61–66.

Ceylan, F., Yücel, E., 2015. Consumption forms and nutrient content values of wild plants consumed as a food in and around Düzce. Afyon Kocatepe University Journal of Sciences and Engineering 15, 1–17.

Civelek, C., Balkaya, A., 2011. Investigation of seed characteristics of some wild species used as vegetable in Bafra plain. Turkey 4th Seed Congress, 14–17 June, Samsun.

Civelek, C., Balkaya, A., 2013. The nutrient content of some wild plant species used as vegetables in Bafra plain located in the Black Sea Region of Turkey. The European Journal of Plant Science and Biotechnology 7, 62–65.

Coşkuner, Y., Karababa, E., 2007. Physical properties of coriander seeds (*Coriandrum sativum* L.). Journal of Food Engineering 80, 408–416.

Davis, P.H., Mill, R.R., Tan, K., 1988. Flora of Turkey and the East Aegean Islands. vol. 10. Edinburgh University Press, Edinburgh.

Eke, C.N.U., Asoegwu, S.N., Nwandikom, G.I., 2007. Physical properties of jackbean (*Canavalia ensiformis*). Agricultural Engineering International 9, 1–11.

Guner, A., Ozhatay, N., Ekim, T., Baser, K.H.C., 2000. Flora of Turkey and the Aegean Islands, Suppl. 2, Vol. 11. Edinburgh University Press, Edinburgh.

Gupta, R.K., Das, S.K., 2000. Fracture resistance of sunflower seed and kernel to compressive loading. Journal of Food Engineering 46, 1–8.

Hunt, R.W.G., 1995. Measuring Colour, Second Edition (Ellis Horwood Series in Applied Science and Industrial Technology). Ellis Horwood Limited.

Imran, M., Talpur, F.N., Jan, M.S., Khan, A., Khan, I., 2007. Analysis of nutritional components of some wild edible plants. Journal of the Chemical Society of Pakistan 295, 500–508.

ISTA, 2007. International Rules for Seed Testing. Edition 2007. International Seed Testing Association, Bassersdorf, Switzerland.

Ixtaina, V.Y., Nolasco, S.M., Tomas, M.C., 2008. Physical properties of chia (*Salvia hispanica* L.) seeds. Industrial Crops and Products 28, 286–293.

Jain, R.K., Bal, S., 1997. Properties of pearl millet. Journal of Agricultural Engineering Research 66, 85–91.

Kacar, B., Inal, A., 2008. Plant Analysis. Nobel Publishers, Ankara, Turkey.

Khan, H., Jan, S.A., Javed, M., Shaheen, R., Khan, Z., Ahmad, A., Safi, S.Z., Imran, M., 2016. Nutritional composition, antioxidant and antimicrobial activities of selected wild edible plants. Journal of Food Biochemistry 40, 61–70.

Kibar, B., Temel, S., 2016. Evaluation of mineral composition of some wild edible plants growing in the Eastern Anatolia Region grasslands of Turkey and consumed as vegetable. Journal of Food Processing and Preservation 40, 56–66.

Kibar, H., Öztürk, T., Esen, B., 2010. The effect of moisture content on physical and mechanicalproperties of rice (*Oryza sativa* L.). Spanish Journal of Agricultural Research 8, 741–749.

Kibar, H., Öztürk, T., Temizel, K.E., 2014. Effective engineering properties in the design of storage structures of postharvest dry bean grain. Acta Scientiarum Agronomy 36, 147–158.

Koca, I., Hasbay, I., Bostanci, S., Yilmaz, V.A., Koca, A.F., 2015. Some wild edible plants and their dietary fiber contents. Pakistan Journal of Nutrition 14, 188–194.

Köse, Y.B., Güner, S.T., Malyer, H., Demirci, F., 2010. Elemental Analyses of Medicinal an Food Plant: *Trachystemon orientalis* (L.) G. Don. XIII OPTIMA Meeting, 22–26 March 2010, Antalya.

Loza-Cornejo, S., Terrazas, T., López-Mata, L., 2012. Fruits, seeds and germination in five species of globose Cacteae (Cactaceae). Interciencia 37, 197–203.

Majumdar, S., Jayas, D.S., 2000. Classification of cereal grains using machine vision. II. Colour models. Transactions of ASAE 43, 1677–1680.

Mavi, K., 2010. The relationship between seed coat color and seed quality in watermelon crimson sweet. Horticultural Science 37, 62–69.

Mkonda, A., Lungu, S., Maghembe, J.A., Mafongoya, P.L., 2003. Fruit and seed germination characteristics of *Strychnos cocculoides*, an indigenous fruit tree from natural populations in Zambia. Agroforestry Systems 58, 25–31.

Mohsenin, N.N., 1986. Physical Properties of Plant and Animal Materials-II. Gordon and Breach Sci Publ, New York.

Nalladurai, K., Alagusundaram, K., Gayathri, P., 2002. Airflow resistance of paddy and its byproducts. Biosystems Engineering 83, 67–75.

Omobuwajo, T.O., Akande, E.A., Sanni, L.A., 1999. Selected physical, mechanical and aerodynamic properties of African breadfruit (*Treculla Africana*) seeds. Journal of Food Engineering 40, 241–244.

Onen, H., Parmaksız, I., Gebologlu, N., 2011. Reproduction capacity of *Polygonum cognatum* Meissn. (Knotweed). ASA, CSSA, and SSSA International Annual Meetings, Oct. 16–19, 2011. Global Agronomy, San Antonio, TX, ASA Section.

Önen, H., Altuntaş, E., Özgöz, E., Bayram, M., Özcan, S., 2014. Moisture effect on physical properties of knotweed (*Polygonum cognatum* Meissn.) seeds. Journal of Agricultural Faculty of Gaziosmanpasa University 31, 15–24.

Özgüven, F., Vursavuş, K., 2005. Some physical, mechanical and aerodynamic properties of pine (*Pinus pinea*) nuts. Journal of Food Engineering 68, 191–196.

Özkurt, M., 2008. Determination of Germination Biology of madımak (*Polygonum cognatum* Meissn.) Seeds and Genetic Variation among Clones. Gaziosmanpaşa University, Graduate School of Natural and Applied Sciences (MSc. Thesis, 66 p. Turkey).

Rao, G.R., Korwar, G.R., Shanker, A.K., Ramakrishna, Y.S., 2008. Genetic associations, variability and diversity in seed characters, growth, reproductive phenology and yield in *Jatropha curcas* (L.) accessions. Trees 22, 697–709.

Roe, M., Church, S., Pinchen, H., Finglas, P., 2013. Nutrient analysis of fruit and vegetables. Analytical Report. Institute of Food Research, Norwich Research Park, Colney, Norwich.

Sekeroglu, N., Ozkutlu, F., Deveci, M., Dede, O., Yilmaz, N., 2006. Evaluation of some wild plants aspect of their nutritional values used as vegetable in Eastern Black Sea Region of Turkey. Asian Journal of Plant Sciences 5, 185–189.

Tunde-Akintunde, T.Y., Akintunde, B.O., 2004. Some physical properties of sesame seed. Biosystems Engineering 88, 127–129.

Turan, M., Kordali, S., Zengin, H., Dursun, A., Sezen, Y., 2003. Macro and micro mineral content of some wild edible leaves consumed in Eastern Anatolia. Acta Agriculturæ Scandinavica Section B 53, 129–137.

Yildirim, E., Dursun, A., Turan, M., 2001. Determination of the nutrition contents of the wild plants used as vegetables in upper Çoruh Valley. Turkish Journal of Botany 25, 367–371.

Yıldırım, A., Mavi, A., Kara, A.A., 2003. Antioxidant and antimicrobial activities of *Polygonum cognatum* Meissn extracts. Journal of the Science of Food and Agriculture 83, 64–69.

Yıldırımlı, Ş., 1994. A medicinal and nutritional plant of the Black Sea Region; *Trachystemon orientalis*. The Herb Journal of Systematic Botany 1, 7–12.

Yücel, E., Tülükoğlu, A., 2000. Plants used as folk medicine in and around Gediz (Kütahya). Ecology 9, 12–14.