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Full Length Research Paper

Arbutus unedo L. (Strawberry tree) selection in Turkey Samanli mountain locations

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***Arbutus unedo* L. enjoys a growing interest in the world as a result of common uses in the industrial, pharmaceutical and chemical fields. The bulk material comes from the natural populations because of the lack of selection and culture of this fruit. Natural populations are severely damaged due to deforestation, over-collecting and new construction on the coasts, so that the future of the species is in a danger. In this work, the pomological and chemical characteristics of 37 *A. unedo* L. types were evaluated in Samanli mountain locations between the years 2008 to 2010. The present research is very important because no studies had been made about *A. unedo* L. in this region before this one. The data were evaluated using the weighed-ranked method, with the highest score occurring for type UL1 (285 total scores). The fruit weights, soluble solid contents and titratable acid values ranged from 1.13 to 6.46 g; from 16.50 to 31.68% and from 0.48 to 1.24%, respectively. According to the results, fruit firmness of the types was between 0.79 and 4.32 N. In addition, a taste group rated the qualitative characteristics of the fruit. Based on the result of this evaluation, five types were selected as being superior. The taste and appearance of these types are very good while their stoniness is low or medium. Fruit number per cluster ranged from 2.68 to 3.54 for these superior types.**

Key words: Selection, pomology, chemical properties, weighed-ranked method, natural populations.

INTRODUCTION

Arbutus unedo L., the strawberry tree (Ericaceae family), is a fruit species native to the Mediterranean, growing in Anatolia, Greece, Lebanon, Ireland and Southern Europe (Torres et al., 2002; Karadeniz and Sisman, 2004; Aydinözü, 2008). It is wide-spread in scrub areas of the Marmara, Aegean, Mediterranean and Black Sea regions of Turkey (Yarilgac and Islam, 2007) and there are many types having different characterizations. It grows at altitudes ranging from 400 to 1200 m on silicious or carbonated dry soil (Ozcan and Hacisefferoğullari, 2007). *A. unedo L. i*s an evergreen plant with small globose tubercled fruits and long stems. It matures in autumn with a color ranging from red to deep crimson when ripe. The tree bears mature fruits and flowers at the same time. The species is diploid (2n = 2x = 26), reproduces sexually via seeds and is capable of vegetative spreading through root suckers. Development is very slow; it takes 25 years to reach a height of 9 m. It grows in the form of single-trunk tree in light-arid lands, while developing in the form of a bush in more dry land. This plant requires protection in the earlier stages of growth, then becoming very tolerant to harsh conditions such as air pollution, high winds, sea salt and cold air (Hileman et al., 2001; Szczesna and Rybak-Chemielewska, 2004; Takrouni and Boussaid, 2010).

The consumption of locally grown wild edible plants has been important for most human cultures, especially in the Mediterranean region, making an important contribution to the health of local communities (Heinrich et al., 2006). The *Arbutus* berries are rarely eaten as fresh fruit but have some importance in local agricultural economies, which use them for the production of highly appreciated alcoholic beverages such as wines, liquors and brandies. Other food applications such as preserves, jams, jellies, and marmalade can also be obtained from strawberry tree fruit. It is also possible to incorporate the berries into yogurts and use them, like other fruits, as confectionaries for pie and pastry fillings and cereal products (Seidemann, 1995; Pawlowska et al., 2006). The fruits are also well-known in folk medicine as antiseptics, diuretics and laxatives, while the leaves of the plant are

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Table 1. The scores of the characteristics and their relative values

Characteristics	Relative values %)	Class of the characteristics and their scores		
Fruit weight (FW) (g)	20	Large:3 (6.46-4.68)	Medium:2 (4.67-2.91)	Small:1 (2.90-1.13)
Soluble solids contents (SSC) (%)	15	High: 3 (31.68-26.62)	Medium:2 (26.61-21.56)	Low:1 (21.55-16.50)
Titratable acid (TA) (%)	5	High:3 (1.24-0.99)	Medium:2 (0.98-0.73)	Low: 1 (0.72-0.48)
Fruit firmness(FF) (N)	10	High:3 (4.32-3.14)	Medium:2 (3.13-1.96)	Low:1 (1.95-0.79)
Fruit taste (FT)	15	Tasty:3 (3.00-2.41)	Medium:2 (2.40-1.81)	Tasteless:1 (1.80-1.22)
Juiciness(J)	5	High:3 (3.00-2.33)	Medium:2 (2.32-1.67)	Low: 1 (1.66-1.00)
Stoniness(S)	15	High:1 (3.00-2.33)	Medium:2 (2.32-1.67)	Low: 3 (1.66-1.00)
Appearence(A)	15	High:3 (3.00-2.33)	Medium:2 (2.32-1.67)	Low: 1 (1.66-1.00)
Total scores	100			

used a for diuretic, urinary antiseptic, antidiarrheal, astringent, depurative and antihypertensive purposes (Bnouham et al., 2002). *A. unedo* is an ornamental bush; its beauty lies in the mixture of its foliage, green and of notable brightness, with its white flowers and red fruits decorating the bush throughout the year.

Breeding programs to obtain *A. unedo* cultivars with high fruit quality have rarely been attempted (Songlin et al., 1995; Cai-Huang, 1997; Celikel et al., 2008), while the phenological and pomological characteristics among local populations of *A. unedo* L. have been assessed (Karadeniz et al., 1996; Mulas and Deidda, 1998; Seker et al., 2004). All populations, mainly near roads and coastlines, have been severely damaged due to deforestation and over-collecting for road-building studies during recent decades.

Habitat fragmentation and the decrease of the population's size augment genetic drift and elevate genetic differentiation among populations (Takrouni and Boussaid, 2010). According to the searched literature, there is a need to select good quality fruits for this species. Fruit size and fruit quality have to be investigated in order to increase the commercial potential of new types. The aim of the present study is to determine some pomological and chemical properties of strawberry tree types to aid in selection of types favorable for cultivation. As a result of this study, an alternative fruit crop will be obtained for growers and abundant high-quality curative fruits will be supplied to consumers.

MATERIALS AND METHODS

This study was carried out in the eastern part of the Marmara region in Samanli Mountain locations during the years 2008 to 2010 for three growing seasons. The material for the study consisted of wild *A. unedo* trees. 37 types were determined after surveying the wild growing populations in different localities of the Samanli Mountains and investigated for large fruit, variability of fruit characteristics and healthy mature plants. Each tree was considered as a type.

In all types (37 types), pomological and chemical characteristics were investigated for three years. The selection criteria used in order to choose superior types were: fruit weight, soluble solid firmness, fruit taste, stoniness and juiciness of fruit, and appearance of fruit (Table 1). Cherry laurel types were rated from good to bad for their fruit characteristics by the modified weighed-ranked method (Michelson et al., 1958; Ayfer et al., 1977). The relative value for each characteristic was calculated from these ratings (scores) (Table 2).

Fruit characteristics

The fruit characteristics of the types, for example fruit weight, width and length, color of fruit, fruit number per cluster and length of cluster, were determined for 40 fruit and cluster samples picked randomly from each type. The weight of the fruit was determined using a 0.01 g-sensitive balance. The measurement of both the length and width (diameter) and length of fruit cluster was made using a 0.01 mm-sensitive digital caliper compass. Color determinations were made with a colorimeter (Minolta CR-300, Minolta, Osaka, Japan); the color of the fruit was objectively measured at three points. Coordinate L* indicates color lightness (0 = black and 100 = white), while the a* and b* scales range between -60 and +60, where the maximum colors are red (+a*) and yellow (+b) and minimum are green (-a) and blue (-b). The hue angle (h) was calculated as $h = \tan^{-1}(b^*/a^*)$. An increase in the value expresses a color change in the strawberry tree fruits from red to orange. The calculated chrome value $C^* = \sqrt{(a^{*2}+b^{*2})}$ expresses the saturation of colors, with high-saturated colors being vivid and low-saturated colors dull (Voss, 1992; Hoppula and Karhu, 2006). The qualitative fruit characteristics (fruit taste, stoniness and juiciness of fruit, and appearance of fruit) were rated by a taste group of ten people, who rated the fruits on a scale of 1 to 3.

Soluble solid content was measured by Hand Held Brix refractometer, at 20°C for all types. Titratable acidity was measured by neutralization of the fruit's juice to pH 8.2 with 0.1 N NaOH, while total acidity was given as % malic acid (Mitcham et al., 1996). Texture measurement was made in two different places in the equatorial region of the fruits with a handle fruit hardness tester with 5 mm plunger, as g and converted to N. pH of the fruit's juice was determined directly using a pH meter with a sensitivity of 0.001.

Flower and leaf characteristics

The flower characteristics, such as cluster length and flower number per cluster, were determined for 40 clusters for selected types. Leaf width, length and leaf stalk length were measured with a 0.01 mm-sensitive digital caliper compass for 40 leaves.

RESULTS AND DISCUSSION

According to the average values for three growing

Table 2. Selection criteria with their scores and total scores

Types	Weight (g)	S	SSC (%)	S	Acidity (%)	S	Firmness (N)	S	Taste	Juiciness (s)	Stoniness (s)	Appearance (s)	Total scores
KI1	4.45	2	30.65	3	1.03	3	1.75	1	3	3	2	2	230
KI2	5.43	3	29.88	3	0.92	2	2.09	2	3	2	2	3	265
KI3	4.10	2	24.03	2	0.48	1	1.54	1	2	3	1	1	160
KM1	2.51	1	22.50	2	0.84	2	1.59	1	3	3	2	2	190
KM2	3.12	2	24.03	2	0.95	2	3.13	2	2	2	1	2	185
KM3	5.66	3	25.83	2	0.73	2	4.15	3	2	2	1	3	230
KM4	1.13	1	20.33	1	0.75	2	2.39	2	1	2	2	1	135
KM5	1.95	1	31.35	3	1.08	3	1.13	1	2	3	1	3	195
KM6	3.68	2	23.78	2	1.16	3	2.09	2	2	2	2	2	205
BH1	3.90	2	23.75	2	1.01	3	1.84	1	2	2	1	1	165
BH2	4.01	2	31.25	3	0.99	3	1.42	1	3	3	2	2	230
NM1	2.67	1	31.00	3	1.04	3	2.21	2	1	1	2	1	165
NM2	3.67	2	26.88	3	0.84	2	2.03	2	3	3	3	3	265
NM3	4.92	3	27.03	3	1.24	3	1.49	1	3	3	1	2	235
NM4	4.02	2	24.03	2	0.77	2	2.16	2	2	2	2	2	200
UL1	6.46	3	27.08	3	0.91	2	2.47	2	3	3	3	3	285
UL2	2.06	1	22.75	2	0.73	2	1.95	1	1	1	2	1	135
ER1	5.89	3	26.00	2	0.99	3	1.99	2	3	3	3	3	275
SU1	2.32	1	30.95	3	0.88	2	4.32	3	1	1	3	1	185
SU2	4.70	3	17.88	1	1.12	3	2.35	2	2	2	3	3	240
SU3	2.63	1	26.85	3	0.85	2	3.18	3	3	2	3	2	235
DT1	5.06	3	22.90	2	0.75	2	2.39	2	3	3	2	3	255
DT2	3.97	2	18.45	1	0.65	1	3.54	3	2	3	2	2	195
DT3	2.02	1	23.85	2	0.94	2	3.73	3	2	2	2	1	175
YV1	4.97	3	31.68	3	0.87	2	1.32	1	3	2	1	1	210
YV2	2.71	1	22.40	2	0.75	2	2.63	2	3	2	1	3	195
YV3	5.42	3	30.03	3	0.98	2	2.60	2	3	3	2	3	270
YV4	3.48	2	26.82	3	0.98	2	2.67	2	3	3	2	3	250
BL1	2.94	2	19.25	1	0.86	2	0.92	1	1	1	2	1	140
BL2	3.20	2	21.50	1	0.94	2	1.87	1	2	1	3	1	170
NS1	3.45	2	24.75	2	0.98	2	1.32	1	1	1	2	1	155
SS1	3.86	2	20.03	1	0.79	2	2.43	2	2	3	1	3	190
MS1	2.51	1	16.50	1	0.94	2	2.03	2	1	2	2	1	135
MH1	1.40	1	18.67	1	0.95	2	0.79	1	1	1	3	1	135
SP1	3.35	2	19.53	1	1.04	3	2.11	2	2	1	2	2	185
SP2	4.01	2	21.95	2	1.02	3	2.94	2	3	3	3	3	255
SP3	3.08	2	26.13	2	0.97	2	2.57	2	3	3	1	2	205

*Average three years (2008-2010); s: scores.

seasons, 2008 to 2010, pomological and chemical properties of *A. unedo* types are presented in Table 2. Fruit weights of types varied from 1.13 g (KM4) to 6.46 g (UL1). Previous studies showed that the fruit weight of the *A. unedo* types varied from 0.96 to 13.63 g (Seker et al., 2004; Yarilgac and Islam, 2007; Celikel et al., 2008). In our region, fruit weight is lower than that of Karadeniz region, because fruit weight and quality are affected by genotypes and depend on the climatic conditions of the region. The total soluble solid content of the types studied in this research varied from 16.50% (MS1) to 31.68% (YV1), while titratable acidity content varied from 0.48% (KI3) to 1.24% (NM3). These results were similar with previous studies, which had determined that SSC contents of *A. unedo* varied from 14 to 32% (Karadeniz et al., 1996; Yarilgac and Islam, 2007; Celikel et al., 2008). Acidity of the types selected as promising ranged from 0.75 to 1.24% (Table 2). Celikel et al. (2008) reported that acidity varied from 0.80 to 1.59% in *A. unedo* genotypes while it varied from 0.80 to 1.59% according to the results of Karadeniz et al. (1996). In our region, the acidity of *A. unedo* fruits is at a moderate level, except for

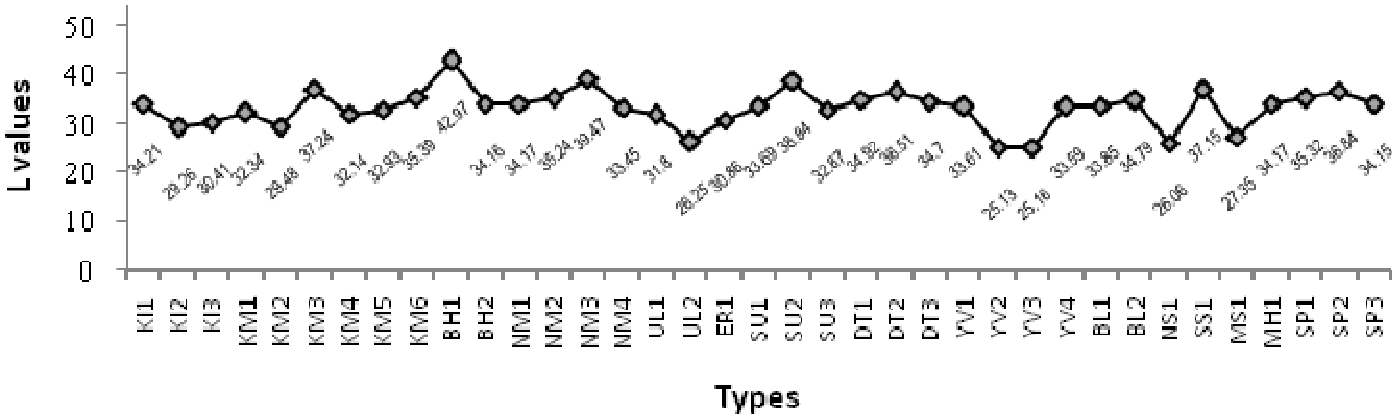

Figure 1. L values of types.

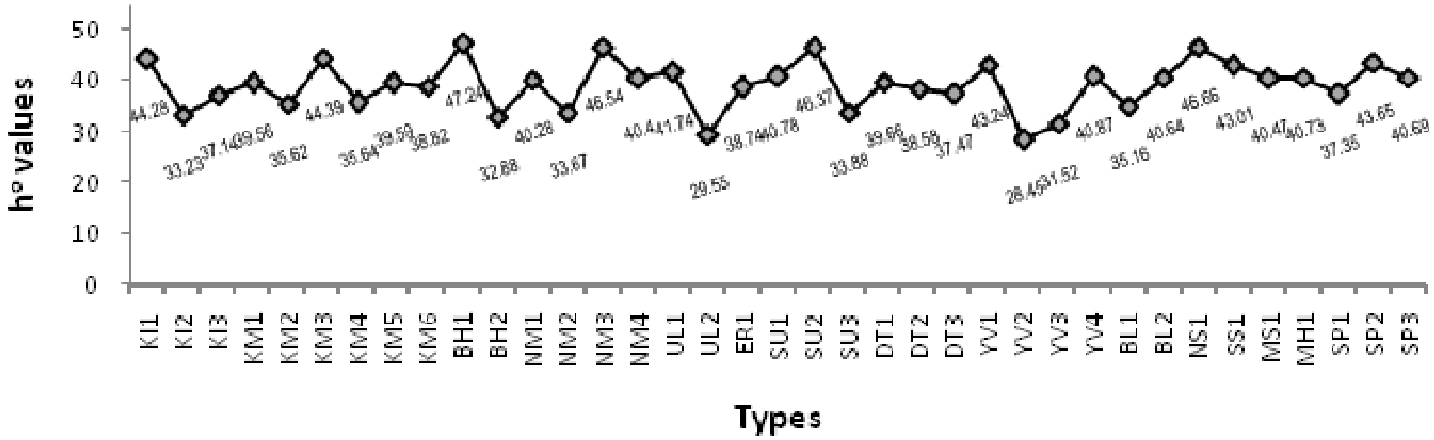

Figure 2. h° values of types.

KI3, which has a very low acidity value. Fruit firmness was determined as being between 0.79 N (MH1) and 4.32 N (SU1). No analytical data were found in previous studies regarding fresh firmness for the *A. unedo*.

In this study a high level of taste and juiciness were desired factors for the selection of fruits. Sixteen of the types had good taste and juiciness that scored high points. Stoniness also affected the attractiveness of fruits, with the taste group evaluating it as a very negative criterion. Nine of the types had low stoniness (scoring 3) according to the taste group results. Appearance of fruit was recorded as good for thirteen of the types investigated. Fruit skin color of *A. unedo* types is given in Figures 1, 2, 3 and 4. The highest L value was observed for type BH1 (42.97) and the lowest for YV2 (25.13). The h value of the types varied from 28.45 (YV2) to 47.24 (BH1), while the c value ranged from 33.72 (NS1) to 59.06 (KM6). a* and b* values ranged from 23.00 to 47.25 and from 22.50 to 41.40, respectively. According to positive values of a and b, *A. unedo* types included reddish orange to deep crimson red fruit colors.

After determination of the characteristics, scores for each *A. unedo* type were evaluated and are given in Figure 5. While the highest weighed ranked score (285) was recorded for type UL1, the lowest (135) was recorded for UL2, KM4, MS1 and MH1. MH1 is the least preferable type in this study for most of selection criteria (Table 2).

Five types, namely KI2, NM2, UL1, ER1, and YV3, were selected (Tables 2, 3 and Figure 5) and evaluated to be propagated for orchard performance studies. Some morphological, phenological and chemical characteristics of these types are shown in Table 3. The fruit shape was mostly spherical-oblate, flattened, and the width of the fruit was greater than their length. Only one of the selected types had ellipsoid fruits (YV3). Fruit firmness of the selected types varied from 1.99 N to 2.60 N (Table 2). Fruit taste of the superior types is very good and stoniness is a medium level, except for type KI2 (low level). The five types selected showed high c* values for skin color and all of them had very vivid colors (Figure 3). Roughness is low or medium, and the appearance of the fruits is very good for all of these types.

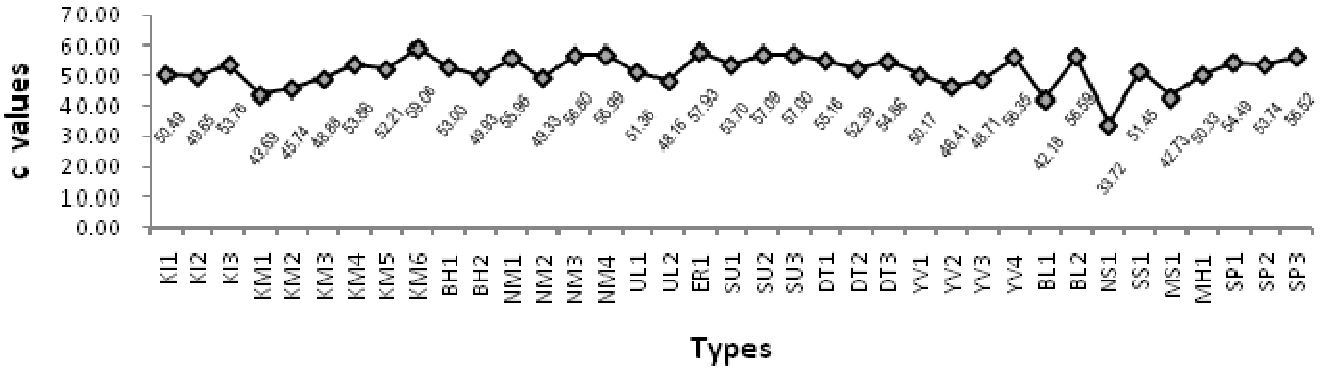

Figure 3. c values of types.

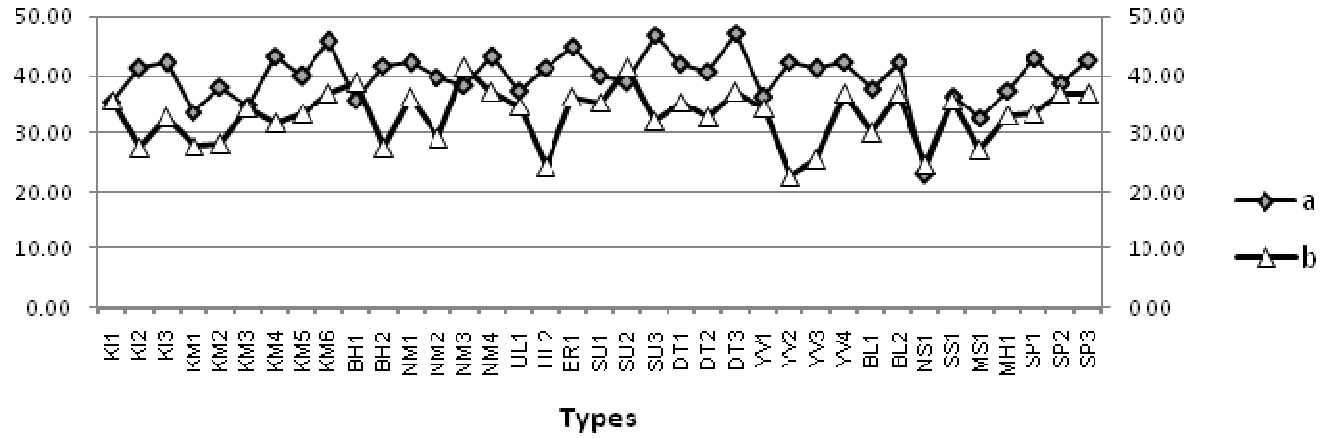

Figure 4. a and b values of types.

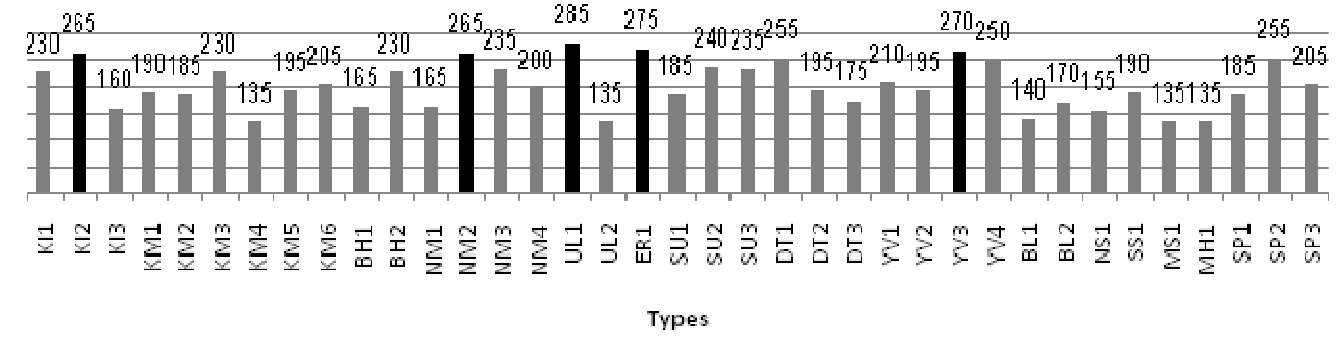

Figure 5. Total weighed-ranked scores for the types.

Flower number per cluster varied from 19.18 (YV3) to 37.63 (UL1) in the selected types, and fruit number per cluster ranged from 2.68 (ER1) to 3.54 (KI2) (Table 3). These results were partly similar with other studies, however two of our selected types had more fruits per cluster (Yarilgac and Islam, 2007).

Conclusion

Turkey has rich plant genetic resources and is a very important center of origin and diversity of fruits. There is a large genetic diversity for *A. unedo* in various part of the country; the tree grows wild but is not yet cultivated. Our

Table 3. Selected *Arbutus unedo* types.

Types	UL1	ER1	YV3	NM2	KI2
Leaf					
Width (cm)	3.23	2.48	2.55	3.21	3.23
Length (cm)	6.77	6.16	6.24	7.51	6.50
Stalk length (cm)	0.88	0.74	0.92	0.95	1.08
Flower					
Cluster length (cm)	3.97	4.03	3.41	4.06	4.33
Flower number/cluster	37.63	26.10	19.18	29.43	22.55
Fruit					
Width (mm)	22.35	23.90	19.66	18.85	19.91
Length (mm)	19.72	19.55	22.30	16.59	17.59
Stalk length (cm)	3.08	2.89	2.63	2.67	3.02
Roughness**	2	2	2	2	3
Cluster length (cm)	4.39	3.58	3.40	4.18	3.04
Fruit number/cluster	3.11	2.68	3.51	3.36	3.54
pH	3.57	3.52	3.60	3.57	3.70

*Average three years (2008-2010); **Roughness: 3: low; 2: moderate; 1: high.

results show large variations in the morphological and chemical properties of wild-growing *A. unedo* types. This point to the need for better investigation on the orchard performance of the selected types. Moreover, all trees investigated during the study were in their natural conditions no cultural practices were applied. Therefore, it is certain that in case of more appropriate cultural conditions it will be possible to obtain more productive trees and better fruit quality which will contribute to the economy. The superior selected *A. unedo* types will be propagated by vegetative propagation methods. Thus, the destruction and uncontrolled collecting of wild growing plants will be prevented and genetic material will be protected.

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