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DETERMINATION OF THE QUALITY CHARACTERISTICS OF NATURALLY GROWING HAWTHORN IN SUŞEHRI

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ABSTRACT

The study was conducted in 2017 in the district of Sivas. In the study, 20 genotypes, which are considered to be different from each other, taking into account the fruit characteristics such as color and size and shape, were determined from the hawthorns that were naturally grown in the flora of Suşheri. At harvest time, the fruit, which would be adequate for pomological and biochemical measurements and analyzes, was harvested. According to the results of the measurements and analyzes in the study, fruit weight was found to vary between 0.68 g and 6.35 g, fruit width was between 10.52 and 29.48 mm and fruit length was between 11.40 and 20.67 mm. The highest firmness values were recorded with the genotype (G) 20 genotype, while the G4 had the lowest values in terms of the firmness values of the fruit flesh. While there are no significant differences between the pH values of the genotypes, the differences between the genotypes in terms of SSC, TA and vitamin C contents are quite significant. It has been found that there are significant differences between the genotypes in terms of total phenolic, total flavonoid and antioxidant activity. The total phenolic content ranged from 218.8 (G17) to 605.8 (G5 and G8) mg GAE kg^{-1} f.w., while the lowest total flavonoid content was 21.58 (G 17) and the highest total flavonoid content was 67.75 (G9) mg GAE kg^{-1} f.w. When the antioxidant activity was evaluated, the DPPH values were 1.08 (G17) – 15.43 (14) mmol TE kg^{-1} f.w., the FRAP values were 15.43 (G16) – 47.23 (G8) mmol TE kg^{-1} f.w. respectively.

Key words: hawthorn, bioactive compound, *Crataegus*, biochemical properties

INTRODUCTION

Hawthorn, which belong to the *Crataegus* genus of the *Rosaceae* family, has 1000 species and it has been cultured for 1700 years. Due to its antioxidant, antimicrobial, antiproliferative and mutagenic properties, hawthorn has been used in traditional medicine for many years and is consumed by humans [Liu et al. 2016]. The consumption of the hawthorn, which have started to attract attention with its positive effects on cardiovascular diseases in recent years, is increasing day by day. However, in Turkey, hawthorn species and varieties have not been registered, so its production has been limited to the trees growing spontaneously in nature. This situation has created a perception that hawthorn is not a fruit species, which is made cultivation, and it is a fruit species by collected in nature [Gündoğdu et al. 2014]. In the disappearance of this perception, it is very significant to register the varieties and species and to determine the species and varieties which will be suggested to be grown. Hawthorn, which can grow nearly every region of Turkey, has got a lot of species and the inadequacy of undertakings to determine their characteristics may result in the destruction of very valuable hawthorn species and varieties. Therefore, it is fairly significant to examine by

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using the selection method to the hawthorn region in Turkey. The foreign pollination in a lot of fruit species is widespread, so there is a wide genotype diversity in the species propagated by seed. Hawthorn is one of these species. The genetic diversity of Turkey is fairly significant for selection of the fruit species and provide to successfully selection works in a short time. By considering this important advantage, "The Spot Selection" studies should be carried out in order to determine the significant hawthorn species and varieties which are hidden in nature and waiting for the day when they will be revealed. Şen, who thought some types could be overlooked in the selection works carried out in large areas, applied to "The Spot Sellection" in walnut for the first time in Turkey and has directed to the selection studies to narrower areas.

"The Spot Selection" is still being implemented successfully in many fruit species in Turkey [Akça 2001]. In Turkey, a few studies [Ozcan et al. 2005, Balta et al. 2006, Yavıc et al. 2016, Bektas et al. 2017] in hawthorn have been carried out with this selection method. However, in Turkey, there is a large hawthorn population, which have not been investigated.

The aim of the study is to determine the fruit quality characteristics by using the selection method in natural hawthorn population in Susehri, which is located in Kelkit valley and has a significant with a great potential for hawthorn due to its climate and soil conditions.

MATERIAL AND METHOD

The study was carried out in the district of Susehri in Sivas in 2017. In the study, 20 genotypes, which are considered to be different from considering the fruit characteristics such as color and size and shape, were determined from the hawthorn trees growing naturally in the flora of Susehri. At harvest time, 2 kg fruit from a each tree was harvested for pomological and biochemical measurements and analyzes. Fruit was immediately transported at 10 ±1.0°C and 80 ±5.0 for 2 h by frigorific vehicles to postharvest physiology laboratory of Horticulture Department of Ordu University, Ordu, Turkey.

Physical characteristics

Fruit size and flesh/seed ratio. Fruit and seed weights were determined using a digital scale (±0.01 g) (Radwag PS 4500/C/1, Poland). Fruit width and fruit length were determined by measuring with a digital caliper with 0.01 mm precision. Flesh/seed ratio (%); 20 fruits and 20 seed weight were weighed with a sensitive scale of 0.001 g. Flesh/seed ratio was calculated with the formula:

$$\text{Flesh/seed ratio} = (\text{Fruit weight} - \text{seed weight})/\text{fruit weight} \times 100.$$

Fruit firmness. Texture analyzer, TA-TX Plus (Stable Microsystems, Godalming, UK), fitted with a 2.0 mm penetrometer probe, a 50 N load cell, operating at a penetration speed of 10 mm s^{-1} and a penetration depth of 3 mm, was used to measure flesh firmness (N mm^{-1}). The maximum force needed for penetrating the fruit 3 mm deep was 5 N. For texture measurements, 10 fruits were used in each replication.

Color characteristics. Color characteristics (L*, chroma and hue angle) were measured at opposite sides of each fruit with a colorimeter (Konica-Minolta, model CR–400, Japan). For color measurement, 10 fruits were used in each replication. Chromatic analyses were conducted in accordance with the CIE (Commission Internationale de l'Eclairage) system. Values of L*, a* and b* were used to define a three-dimensional color space. The chroma value was calculated with the formula C* = (a*2 + b*2)1/2, and the hue angle with $h° = \tan^{-1}$ b*/a*.13.

Chemical characteristics

SSC, titratable acidity and vitamin C. For SSC, titratable acidity and vitamin C measurements, 90 fruits were selected from each replicate and fruit were divided into 3 groups each of with 30 fruits. Stones of each fruit were removed and fruit juice was extracted with an electrical fruit juice extractor (HR1855/70, Philips, Turkey). A digital refractometer (PAL-1, McCormick Fruit Tech., Yakima, Wash., USA) was used to determine SSC (% Brix). For titratable acidity, 10 ml extract was diluted with 10 ml distilled water, and then titrating to pH 8.2 using 0.1 mol l^{-1} sodium hydroxide was expressed in malic acid equivalent (g kg^{-1}).

For vitamin C content, 0.5 ml of extract was taken and resultant volume was completed to 5 ml with the addition of 0.5% oxalic acid. Ascorbic acid test strip (Catalog no: 116981, Merck, Germany) was taken from reclose tube, dipped into the solution for

2 seconds and reflectometer set (Merck RQflex plus 10) was started. The test strip was then shaken off to remove excess liquid over it, waited for 8 seconds and reading was performed until the end of 15th second. The results were expressed as g kg^{-1}.

Bioactive compounds

For bioactive compounds, 10 fruits were selected from each replication. Then these fruits were sliced with a sharp no serrated knife, and placed into tubes and stored at –20°C for biochemical analyses. Samples were thawed at room temperature (≈21°C) and homogenized in a food-grade blender. The resultant slurry was centrifuged (12 000 rpm) at 4°C for 30 min to separate the juice from the pulp. The freshly obtained juice was diluted with distilled water, divided into multiple sample aliquots and refrozen at –20°C until used in total phenolics, total flavonoid and antioxidant assay procedures (DPPH and FRAP).

Total phenolics. A portion of 300 µl from each sample was diluted with 4.3 ml distilled water and 100 µl Folin-Ciocalteu reagents were added. After an interval of 3 min, 20% Na_2CO_3 was added to 300 µl portions and the mixture was vortexed and incubated for 30 min. Absorbances were then read on a UV-Vis spectrophotometer (Shimadzu, Kyoto, Japan) at 760 nm. Gallic acid was used as the standard. The results were expressed as milligram (mg) of gallic acid equivalents (GAE) per kg of fresh weight (f.w.) (mg GAE kg^{-1} f.w.) [Beyhan et al. 2010].

Total flavonoid. The total flavonoid contents of fruit samples were determined according to the calorimetric method [Chang et al. 2002]. Briefly, each extract (0.1 g) was dissolved in 1 ml of the appropriate solvent. This solution (0.1 ml) was mixed with 10% $AlCl_3 \cdot 6H_2O$ and 0.1 ml of 1 M potassium acetate (CH_3COOK). The absorbance of the reaction mixture was measured at 415 nm. Quercetin was chosen as a standard. The results were expressed as mg quercetin equivalents (QE) kg^{-1} f.w.

DPPH free radical scavenging activity. The hydrogen atom or electron donation abilities of some pure compounds were measured by the bleaching of a purple colored methanol solution of DPPH. The free radical scavenging activities of methanol extract of fresh fruit were measured by 1,1-diphenyl-2-picryl-hydrazil (DPPH·) using the method of Blois [1958] wherein the bleaching rate of a stable free radical, DPPH· was monitored at a characteristic wavelength in the presence of the sample. An amount of 0.5 ml of 0.1 mM ethanol solution of DPPH was added to 3.0 ml of all the extract samples or standard antioxidant solution (50–500 µg ml^{-1}) in water. The mixture was shaken vigorously and kept standing at room temperature for 30 min. Then the absorbance of the mixture was measured at 517 nm. The results were expressed as mmol trolox equivalents (TE) kg^{-1} f.w. [Demirtas et al. 2013].

The FRAP assay. For the FRAP (ferric ions (Fe^{+3}) reducing antioxidant power assay), portions of 120 µl were taken from the samples, 0.2 M of phosphate buffer (PO_4^{-3}) (pH 6.6) was added to obtain a volume of 1.25 ml and then 1.25 ml of 1% potassium ferricyanide ($K_3Fe(CN)_6$) solution was added. After vortexing, they were incubated at 50°C. Afterwards, 1.25 ml of 10% TCA (trichloroacetic acid) and 0.25 ml of 0.1% $FeCl_3$ were added to the samples. The absorbances of the resultant solution were read on an UV-Vis spectrometer at 700 nm. The results were expressed as mmol TE kg^{-1} f.w. [Benzie and Strain 1996].

Statistical analysis

The normality of the data was confirmed by the Kolmogorov-Smirnov test and the homogeneity of variances by the Levene's test. ($P > 0.05$). Therefore, the pearson correlation test was performed. Data were analyzed by two-way ANOVA with SAS Version 9.1 (SAS Institute Inc., Cary, NC, USA) software. When the F test was significant, means were compared with Tukey's range test. The level of significance was set as 5%.

RESULTS AND DISCUSSION

Physical characteristics

Fruit size and fruit flesh ratio: fruit size and fruit flesh ratio are significant quality characteristics that affect consumer preferences in hawthorn. In the study that we carried out in Kelkit valley, where has a large hawthorn potential was determined fruit quality characteristics in 20 genotypes, which are considered to be different. İt was determined that the size of the fruit in these genotypes showed a very large change. The fact that, while the smallest fruit was 0.68 g (G: 11), the fruit

weight of G 13 with the largest fruit was 6.35 g. In the majority of genotypes, while the number of seeds was between 4 and 6, it was determined that the fruits of the hawthorn species, which are known as "Öküzgötü" in the region, were relatively smaller and they have 1 or 2 seeds. The fruit flesh ratio was found to be between 72.53 and 86.31% (Tab. 1).

In the studies carried out in the different regions in Turkey, in the study conducted in hawthorn in the Hakkari (Şemdinli) region by Yavıç et al. [2016], they have determined that the fruit mass is between 2.16 and 4.89, and the fruit flesh ratio is between 77.84 and 85.99%. Ozcan et al [2005] have reported that average fruit mass of hawthorns in the Konya-Dergent region is 3.03 g. Again in the study conducted by Balta et al. [2015] in the Çorum region, it was determined that fruit mass varies between 1.54 and 4.72 g. Karadeniz and Kalkişim [1996] have reported that the mass in the hawthorn grown in Van (Edremit and Gevaş) is between 0.81 and 2.14 g. Yanar et al. [2011], in their study in the region of Malatya fruit mass was determined as 0.65–4.19 g. Again, in a study conducted in Malatya – Akçadağ and Hekiman region [Bektas et al. 2017], it was reported that the mass of fruit in hawthorn ranged from 0.98 to 6.25 g. When compared to the results of the study, it can be said that hawthorns grown naturally in Kelkit basin have larger fruits.

When compared to many fruit species (grapes, cherries, strawberries, etc.), it will be seen that the hawthorn fruit has a longer shelf life after harvest and has more firmness fruits.

No studies have been carried out on post-harvest. Therefore, the fruit firmness has not been the subject of curiosity. Harvest storage from the hawthorn is seen as a species to be utilized by collecting in nature in certain days of the year. In our study, the fruit firmness was determined to be between 17.50 N and 68.80 N. When the Table 1 is examined carefully, it can be said that relatively large fruits have higher fruit firmness values.

Attractive color is one of the most important quality attributes of processing food and strongly affects their consumer acceptance and preference. The color of the ripe fruit of hawthorn ranges from yellow, through green to red and on to dark purple [Brown 1995]. In some studies, fruit color is generally determined visually. Yanar et al. [2011] reported that the color of the hawthorn in the Malatya region was yellow, green, light green, orange, light orange, red and dark red, whereas Bektaş et al. [2017] have determined that the color of the hawthorn in the Malatya region (Akçadağ and Hakiman) is yellow, red and orange. Within the scope of our study, the genotypes, which is red, green, yellow and orange, were used. However, in the study, the fruit color was determined by measuring L*, a*, b*, chroma and hue angle values. When Table 2 is reviewed, it will be seen that there are significant differences between the genotypes in terms of color values. In our study, it has been determined that the L*, a*, b*, chroma and hue color values in the genotypes ranged from 28.10 (G14) – 75.03 (G11); 10.28 (G4) – 43.04 (G3); 14.89 (G14) – 65.62 (G6); 39.45 (G14), 66.52 (G6) and (22.07 (G14) – 100.67 (G4) respectively. Balta et al. [2015] reported that L* value was 43.80–71.80; a* value was 0.46–35.22, and b* value was 23.32–42.03. Compared to the results of this study, it will be seen that in our study, the change in L*, a* and b* color values is higher.

Chemical characteristics

The biochemical properties of the fruits such as soluble solid content, pH, acidity and vitamin C affect the fruit quality and hence consumer preferences. SSC and acidity levels, which are used as a criterion in determining the maturity level of fruits, are most ideal for consumption during maturity. In our study, it has been recorded that the ratio of the SSC of hawthorn in growing naturally in Suşehri is between 14.80 and 21.8%, while acidity was found to be between 0.38 and 1.58%. In the study, it was determined that the lowest pH value was 4.10 (G 11) and the highest was 5.22 (G 8) (Tab. 3). Compared to similar studies, it can be said that the hawthorns grown naturally in Suşehri are richer in terms of SSC and the acidity is lower. As a matter of fact, Gündoğdu et al. [2014] found that the SSC ratio in the hawthorn region of Erzincan ranged from 2.35 to 20.00%, and the acidity was between 0.22 and 2.40%, Yanar et al. [2011] SSC ratio of hawthorn in Malatya region are at most 16%, Ozcan et al. [2005] in his study in Konya, the ratio of acidity and pH value of hawthorn was found to be 1.98 and 3.38% respectively. Li et al. [2015] have reported that, the ratio of SSC in hawthorn in China varied from 3.9 to 11.65%, and the acidity ranged from 1.18

Table. 1. The physical characteristics of the genotypes

Genotype number	Fruit mass (g)	Seed mass (g)	Fruit flesh ratio (%)	Fruit width (mm)	Fruit length (mm)	Firmness (N)
1	2.25 fghij	0.41 fgh	81.78 ab	18.87 cd	14.74 cdef	18.60 j
2	2.00 g–j	0.27 gh	86.31 a	29.48 a	13.62 ef	26.89 h
3	2.92 d–h	0.52 efg	82.19 ab	19.44 cd	15.22 bcdef	20.38 hij
4	1.66 hıj	0.35 gh	78.91 bcd	14.33 fgh	14.27 f	17.50 j
5	1.58 hij	0.33 gh	79.11 bcd	14.61 efg	14.12 def	37.62 g
6	3.99 b–f	1.04 abc	73.57 efg	22.35 bc	17.83 abcd	51.73 c
7	2.75 e–h	0.74 de	73.09 fg	18.56 cde	14.89 bcdef	19.00 ij
8	0.71 j	0.19 h	73.23 efg	10.52 h	12.24 f	18.42 j
9	3.31 cdefgh	0.71 de	77.81 bcdef	19.90 cd	17.13 abcde	60.55 b
10	5.23 ab	1.06 abc	79.52 bcd	22.28 bc	17.99 a–d	73.55 a
11	6.35 a	1.25 a	80.31 bc	25.12 b	20.67 a	68.44 a
12	5.06 abc	1.07 abc	78.06 bcde	25.21 b	18.77 ab	55.53 bc
13	0.68 j	0.17 h	75.00 defg	17.19 def	14.22 cdef	38.57 fg
14	0.92 ij	0.21 h	76.20 cdefg	10.72 gh	11.40 f	26.10 h
15	3.76 bcdefg	0.92 bcd	75.53 cdefg	21.19 bcd	16.92 abcde	48.74 cde
16	3.13 defgh	0.65 def	79.30 bcd	19.26 cd	17.42 abce	44.90 def
17	3.48 bcdefg	0.81 cd	76.72 cdefg	20.78 cd	17.04 abcde	42.11 efg
18	4.69 abcd	1.08 abc	76.59 cdefg	22.20 bc	18.20 abc	51.47 cd
19	2.73 efghi	0.75 de	72.53 g	17.94 def	16.42 bcde	25.46 hi
20	4.09 bcde	1.09 ab	73.39 efg	20.67 cd	17.72 abcd	68.80 a

Means in columns with the same letter do not differ according to Tukey's test at $p < 0.05$

Table. 2. The color characteristics of the genotypes

Genotype number	L*	a*	b*	C*	Hue angle
1	56.61 ef	27.15 c	46.15 fgh	56.21 cde	59.83 fg
2	59.33 de	25.75 cd	48.14 efg	61.03 abcd	61.28 fg
3	45.90 hi	43.04 a	37.58 ij	57.24 cde	41.15 j
4	74.07 ab	–10.28 i	54.93 cde	56.05 cde	100.67 a
5	53.39 efgh	27.32 c	46.72 fg	59.59 abcde	56.37 fgh
6	70.78 abc	9.59 f	65.62 a	66.52 a	81.70 cd
7	52.00 efgh	37.03 ab	44.65 fhgi	58.13 bcde	50.25 hi
8	48.06 ghi	28.45 c	38.44 hij	53.00 e	49.10 hi
9	66.79 bcd	15.85 e	57.79 bcd	61.63 abcd	74.35 de
10	70.58 abc	–1.06 h	61.12 abc	61.98 abcd	90.72 b
11	75.03 a	2.20 gh	61.87 abc	62.01 abcd	88.17 bc
12	68.44 abc	9.42 f	60.19 abc	62.29 abc	80.98 cd
13	56.29 ef	22.96 cd	46.48 fg	60.02 abcde	62.90 fg
14	28.10 j	36.51 b	14.89 k	39.45 f	22.07 k
15	43.83 i	38.06 ab	36.24 j	52.82 e	43.70 ij
16	64.42 cd	16.07 e	51.58 def	54.45 de	72.58 e
17	54.52 efg	20.19 de	45.46 fgh	57.41 bcde	63.13 f
18	71.13 abc	7.36 fg	64.42 ab	65.10 ab	83.57 bc
19	47.75 ghi	38.90 ab	38.45 hij	54.98 cde	44.90 ij
20	51.52 fghi	24.71 cd	42.46 ghij	56.36 cde	55.19 gh

Means in columns with the same letter do not differ according to Tukey's test at $p < 0.05$

Table. 3. The biochemical characteristics of the genotypes

Genotype number	SSC (%)	pH	TEA (%)	Vitamin C (mg 100 g^{-1} f.w.)
1	17.20 bcd	4.76 bc	0.72 de	92 cd
2	18.00 bc	4.71 bcd	0.42 fg	63 efg
3	16.80 cde	4.60 cdef	0.54 efg	104 bc
4	21.20 a	4.93 abc	0.46 fg	18 j
5	18.40 b	4.99 ab	0.45 fg	119 ab
6	17.20 bcd	4.31 efg	0.96 bc	49 ghi
7	17.20 bcd	4.63 cde	0.48 fg	69 ef
8	20.80 a	5.22 a	0.38 g	134 a
9	17.20 bcd	4.24 g	1.10 bc	60 efgh
10	17.60 bcd	4.26 fg	1.14 b	55 fghi
11	14.80 f	4.10 g	1.58 a	48 ghi
12	20.40 a	4.24 g	1.01 bc	44 hi
13	16.40 de	4.80 bc	0.45 fg	71 ef
14	14.80 f	5.21 a	0.54 efg	109 bc
15	18.40 b	4.39 defg	1.02 bc	47 ghi
16	15.60 ef	4.27 fg	1.09 bc	60 efgh
17	16.80 cde	4.64 cde	0.50 fg	40 i
18	16.80 cde	4.23 g	1.04 bc	60 efgh
19	16.80 cde	4.40 defg	0.61 ef	74 de
20	14.80 f	4.34 efg	0.91 cd	47 ghi

Means in columns with the same letter do not differ according to Tukey's test at $p < 0.05$

Table. 4. Bioactive compounds content of the genotypes

Genotype number	TPs (mg GAE kg^{-1} f.w.)	TFs (mg GAE kg^{-1} f.w.)	DPPH (mmol TE kg^{-1} f.w.)	FRAP (mmol TE kg^{-1} f.w.)
1	358.3 fgh	28.46 cdef	2.95 cdefg	17.86 fg
2	473.2 cd	31.60 cdef	5.89 c	26.73 bc
3	479.1 cd	55.47 ab	5.17 cde	29.65 b
4	324.9 gh	35.24 cde	2.10 defg	29.48 b
5	605.8 b	53.51 b	12.79 ab	45.85 a
6	387.7 efg	28.36 cdef	2.95 cdefg	19.01 efg
7	449.6 cde	39.95 c	4.45 cdefg	24.58 bcde
8	605.8 b	59.11 ab	11.97 ab	47.23 a
9	491.8 c	67.75 a	5.77 cd	28.93 b
10	335.7 gh	34.25 cde	1.48 fg	17.14 g
11	304.2 h	30.32 cdef	1.95 efg	24.47 bcde
12	360.2 fgh	34.74 cde	1.95 efg	17.47 g
13	414.2 def	27.67 cdef	4.43 cdefg	23.97 bcdef
14	711.9 a	54.69 b	15.43 a	45.74 a
15	380.8 fg	29.44 cdef	2.63 cdefg	19.12 efg
16	319.9 gh	26.00 def	1.93 efg	15.43 g
17	218.8 i	21.58 f	1.08 g	19.95 defg
18	422.1 def	24.53 ef	2.61 cdefg	20.56 cdefg
19	458.4 cd	38.18 cd	4.94 cdef	25.57 bcd
20	601.9 b	65.49 ab	11.52 b	41.61 a

Means in columns with the same letter do not differ according to Tukey's test at $p < 0.05$

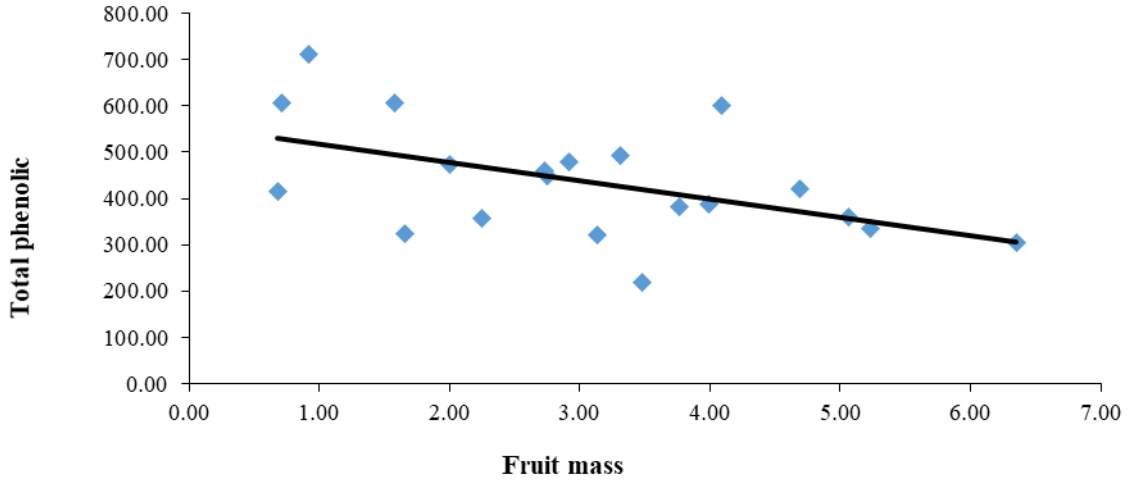

Fig. 1. The correlation between the fruit mass and total phenolic

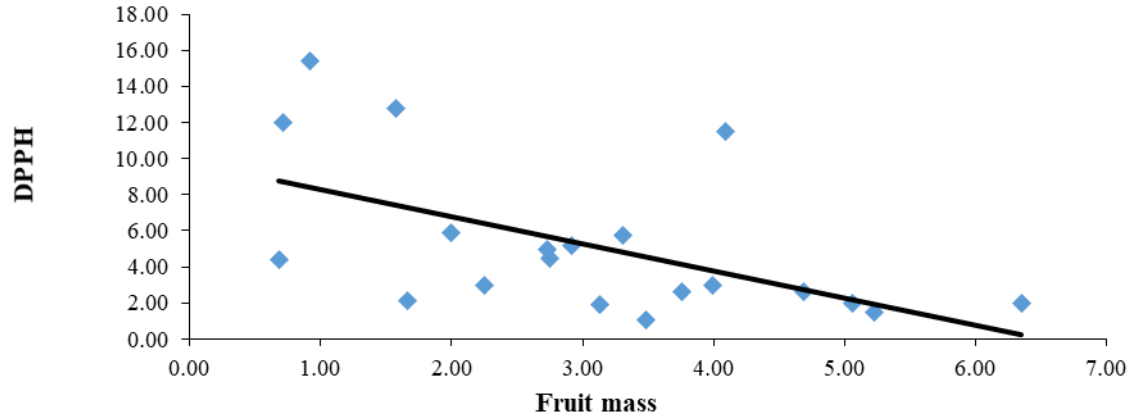

Fig. 2. The correlation between the fruit mass and antioxidant acticity (DPPH)

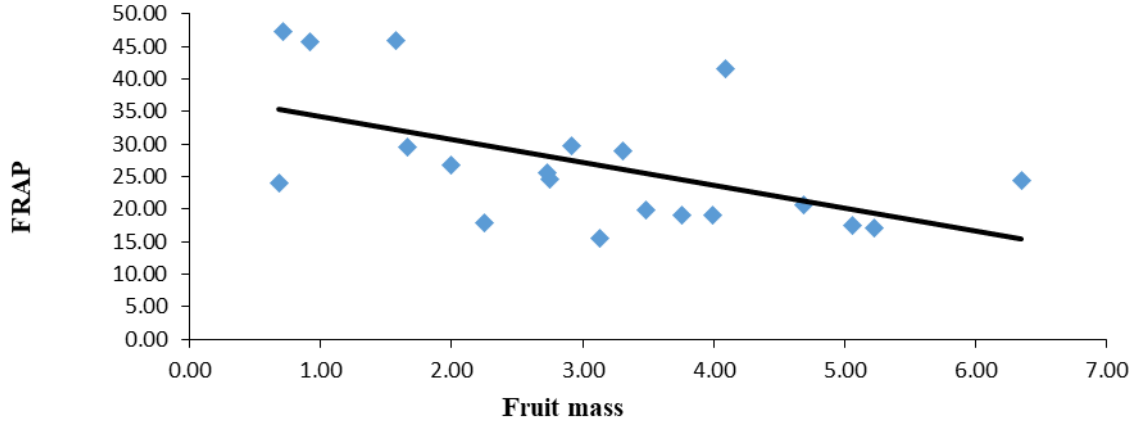

Fig. 3. The correlation between the fruit mass and antioxidant acticity (FRAP)

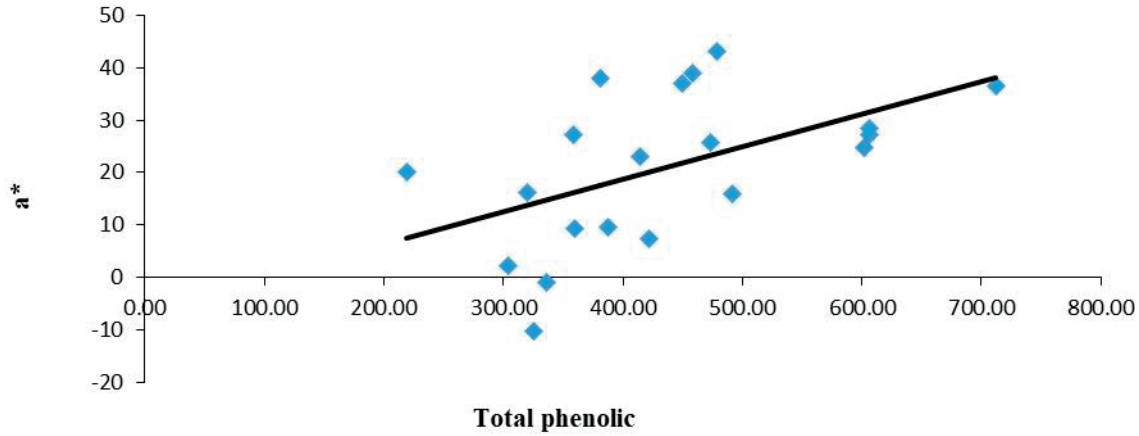

Fig. 4. The correlation between the a* color value and total phenolic

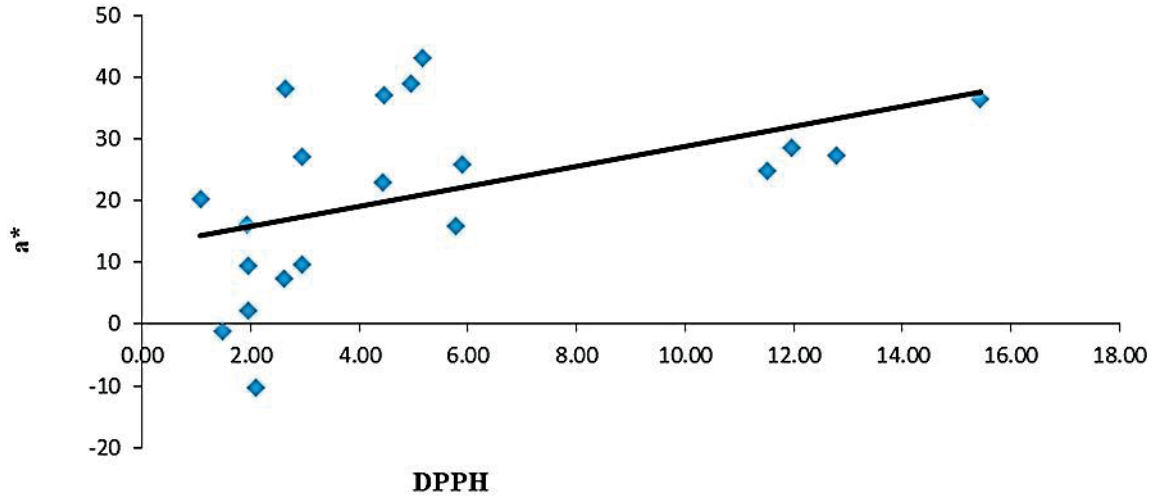

Fig. 5. The correlation between the a* color value and antioxidant acticity (DPPH)

to 4.11%. In our study, vitamin C content in genotypes varies between 18.00 and 134.00 mg 100 g^{-1} (Tab. 3). The similar study results support these significant changes occurring between genotypes. As a matter of fact, Li et al. [2015] reported that vitamin C of the hawthorn ranged from 8.95 to 86.85 mg 100 g^{-1}. However, Gündoğdu et al. [2014] and Yanar et al. [2011] have reported that there were statistically significant differences among species in terms of vitamin C contents. Research has demonstrated that genetic factors, climatic factors, climate and soil structure affect biochemical characteristics of fruits.

Bioactive compound content

The positive effects of fruits on human health are directly related to bioactive compounds such as phenolic compounds, flavonoids and antioxidants. The hawthorn, which one of the fruits rich in bioactive

compounds, has been used for the treatment of patients with heart failures [Zapfe Jun 2001, Tauchert 2002, Holubarsch et al. 2008]. Many studies have demonstrated the beneficial effect of extracts of hawthorn fruits on the heart and blood circulation system, including cardiovascular protecting and endothelium-dependent vasorelaxing effects [Kim et al. 2000]. The bioactive compound composition in hawthorn fruits varies among species and cultivars [Gao et al. 1995]. Calıskan et al. [2012] reported that the total phenolic content and antioxidant capacity (DPPH) of hawthorn grown in Hatay were 26.6–57.1 mg GAE g^{-1} d.w. and 21.4–33.2 mmol TE kg^{-1} f.w. respectively, and there were significant differences in terms of antioxidant activity between species. In our study, it was determined that there were significant differences in terms of bioactive compound content between genotypes. In the study, it was recorded that the total phenolic content was 218.8 (G17) and 605.8 (G5 and G8) mg GAE kg^{-1} f.w.; total flavonoid content 21.58 (G17) to 67.75 (G9) mg GAE kg^{-1} f.w., DPPH 1.08 (G17) to 15.43 mmol TE kg^{-1} f.w. and FRAP 15.43 (G16) to 47.23 (G8) mmol TE kg^{-1} f.w. (Tab. 4). The results of the statistical analysis showed that there was a negative correlation between total phenolic content ($r = –0.506$, $p = 0.002$, $N = 20$ – Fig. 1) and anitoxidant activity (DPPH; $r = –0.552$, $p = 0.001$, $N = 20$ and FRAP; $r = –0.536$, $p = 0.001$, $N = 20$ – Fig. 2, 3) with fruit weight. It was determined that total phenolic and antioxidant activity decreased as fruit weight increased. However, there was no correlation between fruit weight and flavonoid content.

It was also found that the color of the fruit had an effect on the bioactive compounds and the bioactive compound content in the red fruits was higher. In the study there was a negative correlation between total phenolic and antioxidant activity (DPPH and FRAP) with L* ($r = –0.633$, $p = 0.003$, $N = 20$; $r = –657$, $p = 0.002$, $N = 20$; $r = –0.531$, $p = 0.001$, $N = 20$); b* ($r = –0.597$, $p = 0.003$, $N = 20$; $r = –0.647$, $p = 0.002$, $N = 20$; $r = –0.558$, $p = 0.001$, $N = 20$), chroma ($r = –0.475$, $p = 0.003$, $N = 20$; $r = –0.558$, $p = 0.001$, $N = 20$; $r = –0.488$, $p = 0.002$, $N = 20$) and hue angle ($r = –0.643$, $p = 0.002$, $N = 20$; $r = –0.638$, $p = 0.002$, $N = 20$; $r = –0.492$, p: $= 0.002$, $N = 20$), but there was a positive correlation between the total phenolic ($r = 0.519$, $p = 0.001$, $N = 20$) and DPPH ($r = 0.473$, $p = 0.003$, $N = 20$) with a* color value (Fig. 4, 5).

As a matter of fact, Calıskan et al. [2012] have determined that the pomological characteristics such as flesh/seed ratio, TSS, fruit skin color of hawthorn fruits have a significant effect antioxidant capacity, DPPH and total phenolic contents and red colored fruits of this species have high bioactive compound content. It is also known that within the same fruit species and the accessions, the smaller fruits tend to have higher TP content and total antioxidant capacity [Atkinson et al. 2006, Polat et al. 2010].

CONCLUSION

As a result, there was significant differences between genotypes in terms of fruit size. It can be said that hawthorns grown naturally in Kelkit Valley have larger fruits. The color of the genotypes in our study were red, green, yellow and orange. The hawthorn grown naturally in Suşehri are richer in terms of SSC and the acidity is lower. There are significant differences in terms of bioactive compound content between genotypes. There is a negative correlation between total phenolic content and anitoxidant activity with fruit weight. Total phenolic and antioxidant activity decreases as fruit weight increases. However, there is no correlation between fruit weight and flavonoid content. The color of the fruit has an effect on the bioactive compounds and the bioactive compound content in the red fruits is higher. There is a negative correlation between total phenolic and antioxidant activity with L*, b*, chroma and hue angle, but there is a positive correlation between the total phenolic with a* color value. At the and of the study, considering fruit size, it can be said that G10, G11 and G13 are significant genotypes. These genotypes should be evaluated in subsequent studies.

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