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Variation of Antioxidant Activity and Total Phenolic Content of Tea (*Camellia sinensis* L. O. Kuntze) Genotypes

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ABSTRACT
This study was carried out to determine tea (*Camellia sinensis* L. O. Kuntze) genotypes with high antioxidant activity and also high total phenolic content (TPC) in Rize/Turkey conditions in 2017. In the research, the seeds collected from tea plantations located at different five locations of Rize were used. Plants were grown under controlled conditions in pots in greenhouse at first and then transferred to field conditions. Harvest of fresh leaves was realized for 3.5 leaves (three leaves and bud) in August. Ferric-Reducing Antioxidant Power (FRAP) and total phenol content of young leaves of selected 103 genotypes were determined. As a result, FRAP values varied between 638.4 and 1093.0 mg $FeSO_4$ g-1 dw while total phenol content varied from 210.9 to 450.6 mg GAE g-1 dw depending on the genotypes. FRAP values belonging each genotype group representing locations were very close to each other. On the other hand, 87 of a total of 103 genotypes had high antioxidant values. The fact that the genotypes showed a high level of antioxidant activity and total phenol content reveals the presence of evaluable tea genotypes to be used in tea breeding in Rize.

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ÖZET
Bu çalışma toplam fenolik içeriği (TPC) ve antioksidan aktivitesi yüksek çay (*Camellia sinensis* (L.) O. Kuntze) genotiplerinin belirlenmesi amacıyla Rize/Türkiye koşullarında 2017 yılında yürütülmüştür. Araştırmada, Rize'nin farklı lokasyonlarında yer alan çay plantasyonlarından toplanmış tohumlar kullanılmıştır. Saksılarda kontrollü koşullarda yetiştirilen bitkiler daha sonra açık hava koşullarına taşınmıştır. Genç yaprakların hasadı, Ağustos ayı içinde 3.5 yaprak üzerinden yapılmıştır. Liyofilizatörde kurutulan toplam 103 genotipe ait taze yaprakların antioksidan değerleri ve toplam fenol içerikleri tespit edilmiştir. Sonuç olarak, incelenen genotipler içinde elde edilen ortalama FRAP değerleri 638.4-1093.0 mg $FeSO_4$ g^{-1} kuru ağırlık; toplam fenol içeriği ise 210.9-450.6 mg GAE g^{-1} kuru ağırlık arasında değişim göstermiştir. Lokasyonları temsil eden her bir genotip grubuna ait ortalama FRAP değerleri birbirine çok yakın çıkmıştır. Diğer taraftan, toplam 103 genotip içinden 87 tanesi yüksek antioksidan değerlere sahip olmuştur. Genotiplerin yüksek düzeyde antioksidan aktivite ve toplam fenol içeriği göstermesi, Rize'de çay yetiştiriciliğinde kullanılabilecek değerli çay genotiplerinin varlığını ortaya koymaktadır.

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INTRODUCTION
Tea is a valuable plant of the family *Theaceae* (Weisburger, 1997) and three different types of tea grown widely in the world. *Camellia sinensis* var.

L.O. Kuntze is a species of tea grown in Turkey (Taylor, 2003). The young leaves of this species, particularly suitable for green tea production and contain useful antioxidant components (Tariq and Reyaz, 2013; Nibir et al., 2017). Natural antioxidants are important components that strengthen the defense system in body and have beneficial effects on health (Öğüt, 2014). Therefore, nutritional values and benefits of fruits are closely followed by consumers (Scalzo et al., 2005). This tendency of consumers has led to the fact that breeding studies are concentrating on increasing efficiency of the products which are consumed intensively on health nowadays. The amounts of bioactive components, total phenolic content and antioxidant effects of the harvested products vary according to plant species. Sirisa-Ard et al. (2017) reported that total phenolic content of fermented Miang varried between 147.48±0.006 and 438.51±0.018 mg GAE g^{-1} dw while the antioxidant activity values (TEAC) of that varried between 5,578.34±0.019 mg g^{-1} dw and 18,315.21±0.022 mg g^{-1} dw. Especially green tea is known as a source of beneficial antioxidants (Graham, 1992). Since green tea is obtained by processing fresh leaves without fermenting, the closest results to the content of this tea type can undoubtedly be obtained by analysis of fresh tea leaves. It is reported that antioxidant activity in green tea is similar to that of white tea because of the high levels of EGCG (Epigallocatechin Gallate) and ECG (Epicatechin Gallate), which are the strongest antioxidants in young tea leaves (Karori et al., 2007). There are many studies showing that the high amounts of antioxidant components in tea leaves are anticancergenic (Wang and Bachrach, 2002; Hayakawa et al., 2016; Vishnoi et al., 2018; Mir et al., 2019). In the production of tea products with high antioxidant capacity, cultivation of genotypes with high potential of polyphenols in appropriate ecologies and under suitable conditions can be significantly effective.

Liu et al. (2008) reported that the highest FRAP value among the 68 plant materials in China was Chinese White Olive with 15.853 mmol FeII g^{-1} dw. In another study, antioxidant values in parts of 33 medicinal and edible plants grown in China varied between 2.1 µmol $FeSO_4$ g^{-1} dw and 4790.1 µmol $FeSO_4$ g^{-1} dw (Jiang et al., 2011). The highest FRAP value was obtained from floral buds of Flos Caryophylli and followed by leaves of *Camellia sinensis* L. with 2433.9 µmol $FeSO_4$ g^{-1} dw.

In recent years, focused on studies to increase the specific bioactive components of various plants. As a matter of fact, Capocasa et al. (2008) have shown that nutrient characteristics and quality of strawberries can be increased by crossing. Likewise, antioxidant properties of varieties are taken into consideration in potato (Stushnoff et al., 2008), Peach and Nectarine (Cantin et al., 2009) in breeding programs while bioactive components in many medical and aromatic plants are overemphasized.

Rich in flavonol glycosides, which are related to antioxidant potential, are reported to be used effectively in breeding programs (Jeganathan et al., 2016). Green tea and black tea are rich in antioxidants (Shannon et al., 2018) and are widely consumed in almost all populations (Van et al., 1997). Therefore, it can be seen as a great chance to make the most of tea consumed extensively in the world.

Tea plant is highly allogamous nature due to self-sterility. This makes progeny from seed possible to produce a wide variation in productivity and other characters and to be used this variation (Waheed et al., 2001). As a matter of fact, there are many improved cultivars either by crossing (Benihikari, Okuhikari, Okumidori, Tsuyuhikari, Saemidori ect.) or via selection (Yabukita, Yutakamidori, Utakamidori, Benihomare ect.) from tea plantations in the world (Yagi et al., 2010).

This study was conducted to determine antioxidant activity and total phenolic content of young leaves of the genotypes multiplicated from seeds collected from different locations in Rize/Turkey and to reveal present variation which is important for breeders.

MATERIAL and METHODS

In this study, seeds (5 seeds per each plant and total of 515 seeds) were collected in total of 103 different plants from tea fields located on five different places in Rize province where has the most tea plantation in Turkey. Locations (L) from where the tea seeds were collected are given in Table 1.

Table 1. Genotype groups belonging to tea seeds collected according to different locations (L)

Çizelge 1. Farklı lokasyonlara göre toplanan çay tohumlarına ait genotip gruplar

Genotype group	Location	Number of material
L1	Location-1	41
L2	Location-2	20
L3	Location-3	17
L4	Location-4	15
L5	Location-5	10
	Total	103

L1 and L3 are adjacent to each other as well as L2 and L4. On the other hand, average distance from L5 to L1-L3 is 7.1 km, and distance to L2-L4 is 32.3 km (Figure 1).

The seeds taken from each plant were sown in the same pot in March 2017 and grown in greenhouse conditions. One of the best growing seedlings was left in every pot and others removed from pods. Thus,

80% of total 515 tea plants were initially eliminated in the seedling stage.

The plants were kept in the greenhouse until they were strengthened and then taken out of the greenhouse. Plants growing in pots when reached sufficient growth were harvested once by hand in August. Overall, 3.5 leaves (three leaf and bud) were harvested from each plant. The harvested fresh leaves were kept in lyophilizer until dry, and antioxidant activities and total phenolic content of leaf samples were determined after methanol extraction.

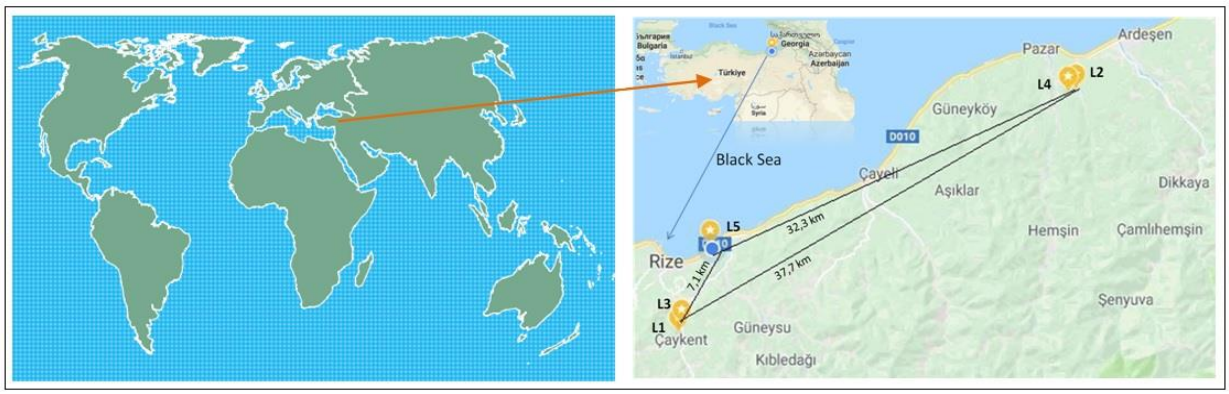

Figure 1. Locations containing genotype groups
Şekil 1. Genotip grupları içeren lokasyonlar

Extraction of Samples

The fresh tea leaves were dried in a lyophilizer with Labconco brand and powdered in a porcelain mortar. Then, 0.1 g of each powdered sample was extracted in 10 ml methanol (80%) at 40 ^{0}C using an orbital shaking for 1 hour. The sample-solvent mixture was centrifuged at 4000 rpm minute^{-1} for 20 minutes. The supernatants were separated from the mixture and analyzed for the determination of antioxidant activity and total phenol content.

Ferric-Reducing Antioxidant Power (FRAP)

The method of Benzie and Strain (1996) was used by modifying in the analysis of the samples. Buffer solution prepared by mixing 200 ml of acetate buffer (pH 3.6), 20 ml of 2,4,6-tripyridyl-s-triazine (TPTZ) solution and 20 ml of ferric chloride ($FeCl_3.6H_2O$) solution in a ratio of 10:1:1 as FRAP (Iron reduction antioxidant capacity) reagent. HCl was used to dissolve these chemicals while the buffer solution was preparing. Overaall, 20 µl sample (supernant) was added to a total of 1980 µl FRAP reagent and value was read using UV Spectrophotometer (Shimadzu UV-1800 brand) at 593 nm wavelength. A standard curve was obtained from known Fe (II) ($FeSO_4$) concentrations (5 µl, 10 µl, 15 µl and 20 µl). FRAP values of the samples were determined according to standard curve. The results were expressed as mg of iron (II) sulfate ($FeSO_4$) equivalents per gram dried weight (dw) of the sample.

Total of Phenolic Content (TPC)

Total phenolic content of samples was determined using the Folin-Ciocalteau method (Waterhouse, 2002). 20 µl of the supernant and 100 µl of Folin-Ciocalteau reagent were added to 1580 µl of distilled water. Subsequently, 300 µl of Na_2CO_3 (Sodium carbonate solution) was added into the mixture. The final solution was incubated at 50 ^{0}C for 15 minute and values of absorbance were measured at 765 nm using the Spectrophotometer. Values of gallic acid of the samples were determined according to standard curve. The results were expressed as mg of gallic acid equivalents (GAE) per gram dried weight (dw) of the samples.

Statistical Analysis

Values for each genotype group (L1, L2, L3, L4 and L5) were analyzed separately as completely randomized design with 3 replications using JMP statistical program. The means were separated by the Tukey HSD (Honestly Significant Difference) test.

RESULTS and DISCUSSION

In the study, fresh leaves of genotypes obtained from seeds collected from different locations were compared in terms of antioxidant activity and total phenolic content (Table 2 and Table 3). The antioxidant values were between 638.4 and 1093.0 mg $FeSO_4$ g^{-1} dw while the total phenolic content varied from 210.9 to 450.6 mg GAE g^{-1} dw depending on the genotypes (Figure 2, 3, 4).

On the other hand, when considering the average of each genotype group, this variation ranged from 900.4 to 950.3 mg $FeSO_4$ g^{-1} dw in terms of average antioxidant activity and from 285.1 to 321.2 mg GAE g^{-1} dw for total phenolic content.

In the research, there was a significant ($P<0.01$) positive correlation ($r=0.342$) between antioxidant activity and total phenolic content (Figure 5). Similar

to these results, many investigators reported that there was a significant correlation between these traits (Anesini et al., 2008; Liu et al., 2008; Rusak et al., 2008; Jayasekera et al., 2011; Jiang et al., 2011). Therefore, the content of phenolic compounds could be used as an important indicator of its antioxidant capacity. The antioxidant values in 27 of 103 genotypes grown in Rize exceeded 1000 mg $FeSO_4$ g^{-1} dw. The lowest FRAP value among the genotypes which was statistically in the group "a" belonged to genotype number 88 with 857.2 mg $FeSO_4$ g^{-1} dw. Total number of genotypes with FRAP values above this value was 87. This result shows that 84.5% of the genotypes used are primarily antioxidant-rich and only 15.5% of the existing genotypes should be eliminated.

Tea Research Foundation, in Africa, reported that number of the material was reduced from 5000 genotypes to 350 genotypes by plant selection on rooting ability and nursery performance in the first years of the breeding program for new cultivars (Apostolides et al., 2006). In this breeding program, it is seen that a large number of genotypes were eliminated at the beginning and 7% of total number of genotypes was selected as important material. But in present study, a total of 515 genotypes collected from different locations were reduced to 103 genotypes in terms of seedling vigour at first. A large parts of this genotypes (87 genotypes), which was 16.9% of the initial number, showed high antioxidant activity.

The genotypes within each group were considered separately and the numerical ratios of those in terms of rich in antioxidant activity were calculated. 93.3% of the genotypes in the L4 genotype group had high antioxidant activity. This rate was followed by L5 with 90.0%, L1 with 85.4%, L2 with 80.0% and L3 genotype group with 76.5% respectively. These differences among the genotype groups are entirely due to genetic factors.

In a research on antioxidant activites of different green teas, FRAP values were found to vary between 0.554-2.876 mmol FeII g^{-1} (Hajimahmoodi et al., 2008). Rusak et al. (2008) determined FRAP values generally between 4.02-17.9 mmol L^{-1} Fe2+ in white tea and 2.45-19.0 mmol L^{-1} Fe2+ in green tea depending on the methods. Ercisli et al. (2008) reported that total phenolic content of fresh tea leaves of Derepazari-7 tea clone growing in Rize conditions varied with harvest periods (July>May=September) and that the highest value was obtained in the July 15 harvest. Erturk et al. (2010) showed that the values obtained from 2.5 leaves (consisting of fresh tea shoots) were changed according to tea clones and the highest value was found at the 3rd harvest period (September) in Pazar 20 clone with a mean of 291.8 mg GAE g^{-1} dw. In another study conducted in Rize, Yazici and Goksu (2017) found that FRAP values of fresh tea leaves varied between 5.00±0.90 and 5.93±0.45 mmol $FeSO_4$ g^{-1} dw, and total phenolic content varied between 112.88±4.19 and 131.64±4.52 mg GAE g^{-1} dw.

In a study conducted by Nor Qhairul Izzreen and Mohd Fadzelly (2013) in Malaysia, antioxidant activity and total phenolic content in green tea and black tea produced by processing tea leaves according to the maturity level (shoots, young and mature leaves) were compared. In the study, the highest FRAP value was achieved in green tea (from shoots) with 14.83±0.21 µmol $Fe_2SO_4.7H_2O$ ml^{-1}. In the same study, the values obtained for TPC ranged from 56.63 (green tea from shoots) to 80.27 mg GAE g^{-1} dw (black tea from mature). Oh et al. (2013) reported that total phenolic content in green tea was 144.52±5.36 mg GAE g^{-1} dw.

There are differences in the units of FRAP values calculated in some studies carried out before. When a comparison is made by unit conversions, the values obtained in the present study are between the values determined by Rusak et al. (2008) and above reported by Hajimahmoodi et al., (2008) and Yazici and Goksu (2017). Similarly, the data obtained in the present study with respect to the total phenolic content are above the values stated by Ercisli et al. (2008), Erturk et al. (2010), Nor Qhairul Izzreen and Mohd Fadzelly (2013), Oh et al. (2013) and Yazici and Goksu (2017). In another study conducted in Malaysia, total phenolic content of Iran-100 tea clone was limited to 8.44±1.03 mg gallic acid equivalents (Gonbad et al., 2015). This value is too below the values obtained in present study.

Differences in the values obtained from different studies for antioxidant activity and total phenolic content may be due to the phenolic composition and quality of tea, and several other factors including pre-harvest and post-harvest conditions (Tounekti et al., 2013). These important factors also include genetic differences (Erturk et al., 2010), different environmental conditions (Hajiboland et al., 2011; Kaur et al., 2014), harvest season (Jayasekea et al., 2011), pruning age (Savsatli et al., 2018), harvest standards and frequency (Kaur et al., 2014), analysis methods (Rusak et al., 2008), manufacturing process (Carloni et al., 2013, Benzie and Szeto, 1999), type of tea (Karori et al., 2007; Tounekti et al., 2013).

CONCLUSION

Tea genotypes multiplicated from seeds collected from different locations of Rize produced leaves were rich in antioxidant activity and total phenolic content. The fact that the genotypes investigated in the study showed naturally high levels of antioxidant activity and total phenolic content. These results clearly prove that it is possible that these genotypes reached to high quality for tea breeding.

Table 2. Ferric-reducing antioxidant power (FRAP) (mg $FeSO_4$ g^{-1} dw) in genotypes belonging to different locations (L)
Çizelge 2. Farklı lokasyonlara (L) ait genotiplerin demir indirgenme antioksidan kapasitesi (FRAP) (mg $FeSO_4$ g^{-1} dw)

L1				L2		L3		L4		L5	
No	FRAP Sx	No	FRAP Sx	No	FRAP Sx	No	FRAP Sx	No	FRAP Sx	No	FRAP Sx
1.	1042.7 ±3.5 a-d	22.	906.9 ±106.9 a-f	42.	1015.7 ±11.7 a-c	62.	812.7 ±30.1 c-e	79.	999.9 ±80.8 a	94.	908.8 ±46.2 a-c
2.	910.6 ±11.3 a-f	23.	881.7 ±57.2 a-f	43.	871.8 ±17.3 b-e	63.	932.5 ±22.9 a-c	80.	894.0 ±35.6 ab	95.	974.8 ±4.0 ab
3.	1030.3 ±2.7 a-d	24.	1063.3 ±24.5 a-c	44.	1067.3 ±4.8 a-b	64.	869.1 ±15.2 b-d	81.	866.5 ±10.6 ab	96.	974.9 ±29.4 ab
4.	815.6 ±8.0 d-f	25.	933.9 ±42.2 a-f	45.	1047.3 ±8.8 ab	65.	745.8 ±26.2 d-f	82.	964.0 ±13.0 ab	97.	954.2 ±12.0 ac
5.	912.7 ±8.4 a-f	26.	934.9 ±24.1 a-f	46.	1019.4 ±20.1 a-c	66.	1046.7 ±15.0 a	83.	912.2 ±9.2 ab	98.	828.2 ±15.0 c
6.	859.9 ±4.4 a-f	27.	1001.2 ±16.2 a-d	47.	929.9 ±46.8 a-e	67.	908.0 ±30.7 a-c	84.	937.3 ±46.7 ab	99.	922.6 ±1.8 a-c
7.	719.3 ±8.0 f	28.	1043.5 ±13.3 a-d	48.	855.7 ±35.2 c-e	68.	685.9 ±46.2 ef	85.	970.6 ±51.8 ab	100.	971.0 ±32.6 ab
8.	1007.8 ±13.2 a-d	29.	938.5 ±6.3 a-f	49.	894.5 ±12.0 a-e	69.	990.6 ±32.3 ab	86.	974.9 ±75.2 a	101.	1038.6 ±24.2 a
9.	1028.4 ±8.8 a-d	30.	1047.6 ±15.4 a-d	50.	951.6 ±23.8 a-e	70.	978.5 ±27.3 ab	87.	958.9 ±57.3 ab	102.	1022.4 ±37.8 ab
10.	878.6 ±6.4 a-f	31.	962.3 ±19.3 a-e	51.	904.8 ±12.4 a-e	71.	924.1 ±52.1 a-c	88.	857.2 ±28.6 ab	103.	907.4 ±17.3 bc
11.	1078.1 ±5.8 ab	32.	873.1 ±24.5 a-f	52.	960.7 ±54.6 a-d	72.	998.8 ±18.0 ab	89.	986.7 ±25.7 a		
12.	950.5 ±8.0 a-f	33.	841.8 ±9.3 b-f	53.	752.9 ±72.2 e	73.	952.9 ±9.0 a-c	90.	1089.6 ±14.3 a		
13.	925.5 ±10.5 a-f	34.	979.2 ±22.6 a-d	54.	883.9 ±34.4 a-e	74.	935.7 ±50.9 a-c	91.	956.7 ±61.9 ab		
14.	723.0 ±1.9 e-f	35.	1080.5 ±28.6 ab	55.	796.5 ±59.6 d-e	75.	955.6 ±2.1 a-c	92.	730.8 ±49.0 b		
15.	1004.5 ±12.5 a-d	36.	977.4 ±27.1 a-d	56.	1067.3 ±25.2 ab	76.	638.4 ±23.8 f	93.	977.4 ±43.5 a		
16.	898.5 ±3.7 a-f	37.	1091.7 ±7.5 a	57.	745.0 ±88.4 e	77.	1034.9 ±16.3 a				
17.	825.4 ±5.9 c-f	38.	970.8 ±29.9 a-d	58.	906.1 ±16.9 a-e	78.	897.3 ±16.1 a-d				
18.	832.7 ±5.0 c-f	39.	961.2 ±28.6 a-e	59.	1029.7 ±23.3 a-c						
19.	891.5 ±5.7 a-f	40.	1092.8 ±30.6 a	60.	1085.8 ±32.3 a						
20.	1093.0 ±10.2 a	41.	904.4 ±38.5 a-f	61.	905.6 ±38.0 a-e						
21.	1044.8 ±17.6 a-d										
% CV=7.6 Fcal=5.3**				% CV=7.2 Fcal=7.0**		%CV=5.6 F_{cal}=16.4**		% CV=8.5 F_{cal}=3.1**		% CV=4.7 F_{cal}=5.6**	

**Level of significance: Means with the same letter are not statistically significant (P<0.01). CV: Coefficient of Variation. F_{cal}: Calculated F Value.
Sx: Standard Error

Table 3. Total phenolic content (TPC) (mg GAE g^{-1} dw) in genotypes belonging to different locations (L)
Çizelge 3. Farklı lokasyonlara (L) ait genotiplerin toplam fenolik içeriği (TPC) (mg GAE g^{-1} dw)

L1				L2				L3				L4				L5			
No	TPC	Sx		No	TPC	Sx		No	TPC	Sx		No	TPC	Sx		No	TPC	Sx	
1.	292.2 ±3.5	i-p		22.	371.9 ±4.8	c-e		42.	295.5 ±8.6	a-c		62.	253.8 ±11.3	e		79.	306.9 ±2.1	ab		94.	257.5 ±6.1	de	
2.	290.6 ±11.3	j-p		23.	312.2 ±8.0	f-n		43.	288.7 ±8.4	b-d		63.	284.2 ±2.4	b-e		80.	274.5 ±4.8	c-f		95.	286.0 ±4.3	cd	
3.	270.7 ±2.7	l-p		24.	343.6 ±5.3	c-i		44.	276.1 ±4.8	cd		64.	286.6 11.0	b-e		81.	303.1 ±9.7	a-c		96.	307.7 ±2.9	bc	
4.	259.6 ±8.0	o-p		25.	298.6 ±2.9	h-p		45.	310.6 ±2.3	ab		65.	292.6 ±5.9	b-e		82.	255.7 ±9.9	f		97.	280.2 ±6.2	c-e	
5.	391.7 ±8.4	bc		26.	274.9 ±9.1	k-p		46.	312.9 ±6.2	ab		66.	314.5 ±6.9	a-c		83.	292.8 ±6.4	a-d		98.	243.5 ±3.4	e	
6.	324.0 ±4.4	e-k		27.	319.5 ±16.5	f-l		47.	295.1 ±5.4	a-c		67.	301.5 ±3.1	a-d		84.	305.4 ±1.2	ab		99.	272.0 ±9.4	c-e	
7.	272.0 ±8.0	l-p		28.	343.6 ±13.5	c-i		48.	235.9 ±3.4	ef		68.	283.3 ±14.0	b-e		85.	310.4 ±2.5	ab		100.	260.6 ±6.1	de	
8.	383.3 ±13.2	cd		29.	345.9 ±10.5	c-h		49.	289.1 ±4.4	b-d		69.	277.8 ±13.7	b-e		86.	317.8 ±5.3	a		101.	337.2 ±5.9	b	
9.	324.4 ±8.8	e-k		30.	346.1 ±5.1	c-h		50.	316.0 ±2.4	ab		70.	342.0 ±10.6	a		87.	286.8 ±6.1	b-e		102.	396.1 ±10.6	a	
10.	318.2 ±6.4	f-m		31.	298.2 ±7.7	h-p		51.	302.1 ±3.9	a-c		71.	268.9 ±9.0	de		88.	305.8 ±4.8	ab		103.	306.5 ±14.7	bc	
11.	435.1 ±5.8	ab		32.	262.7 ±14.1	n-p		52.	295.3 ±4.0	a-c		72.	271.4 ±12.1	c-e		89.	272.6 ±3.1	d-f					
12.	306.0 ±8.0	g-o		33.	288.9 ±11.4	j-p		53.	261.0 ±7.5	de		73.	322.6 ±6.2	ab		90.	260.0 ±9.5	ef					
13.	333.5 ±10.5	d-j		34.	304.0 1±3.9	g-o		54.	279.2 ±5.0	cd		74.	298.8 ±6.2	a-e		91.	296.5 ±2.6	a-d					
14.	248.7 ±1.9	p		35.	295.9 ±4.3	h-p		55.	215.6 ±5.5	f		75.	319.1 ±3.3	ab		92.	272.6 ±4.8	d-f					
15.	380.6 ±12.5	cd		36.	313.7 ±1.8	f-n		56.	278.8 ±8.4	cd		76.	300.3 ±8.4	a-d		93.	266.6 ±3.4	d-f					
16.	353.5 ±3.7	c-g		37.	291.6 ±5.8	j-p		57.	304.4 ±5.0	a-c		77.	318.8 ±4.2	ab									
17.	350.8 ±5.9	c-g		38.	271.0 ±5.8	l-p		58.	296.1 ±5.4	a-c		78.	311.6 ±4.7	a-d									
18.	360.1 ±5.0	c-f		39.	295.9 ±8.4	h-p		59.	315.5 ±1.8	ab													
19.	332.3 ±5.7	d-j		40.	283.5 ±6.1	j-p		60.	323.4 ±8.1	a													
20.	450.6 ±10.2	a		41.	267.9 ±14.4	m-p		61.	210.9 ±6.8	f													
21.	363.4 ±17.6	c-f																					
% CV=4.9 F_{cal}= 26.3**				% CV=3.5 F_{cal}= 30.8**				% CV=5.0 F_{cal}=7.0**				% CV=3.5 F_{cal}=12.1**				% CV=4.6 F_{cal}=33.8**			

**Level of significance: Means with the same letter are not statistically significant (P<0.01). CV: Coefficient of Variation. F_{cal}: Calculated F Value.
Sx: Standard Error

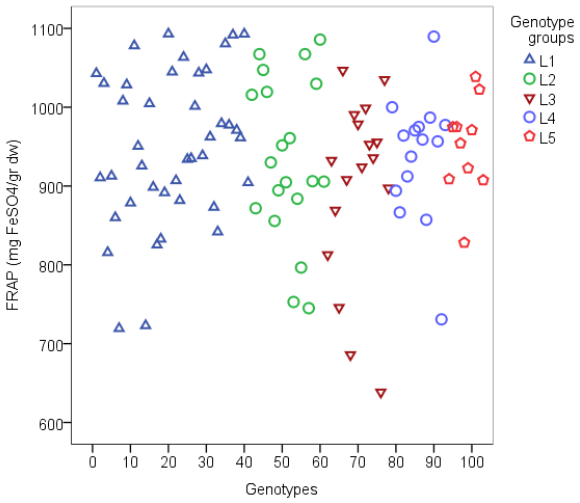

Figure 2. FRAP values of genotypes
Şekil 2. Genotiplere ait FRAP değerleri

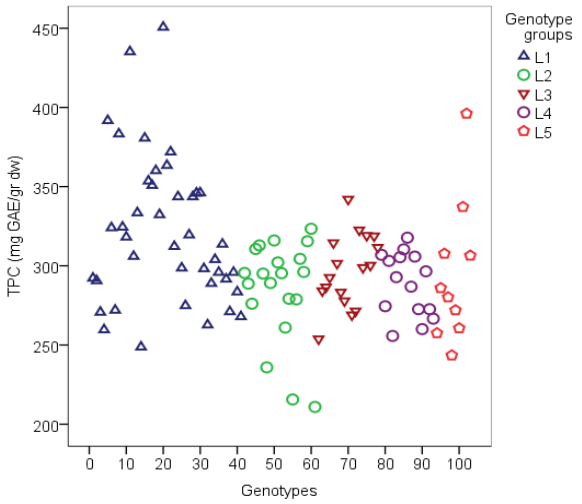

Figure 3. TPC values of genotypes
Şekil 3. Genotiplere ait TPC değerleri

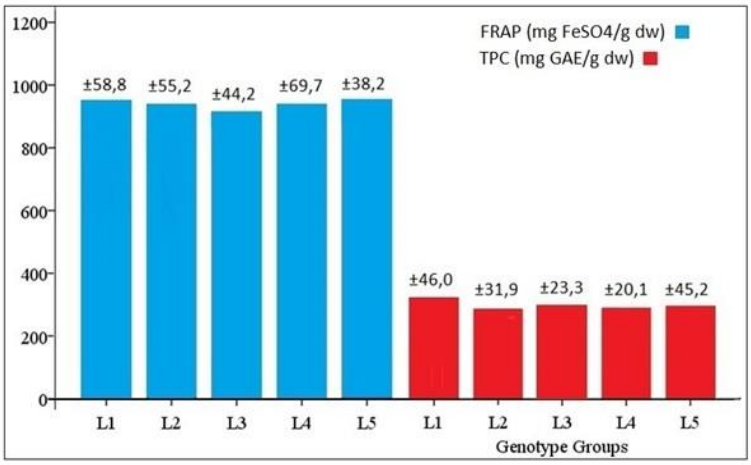

Figure 4. FRAP and TPC values of tea genotype groups
Şekil 4. Genotiplere ait FRAP ve TPC değerleri

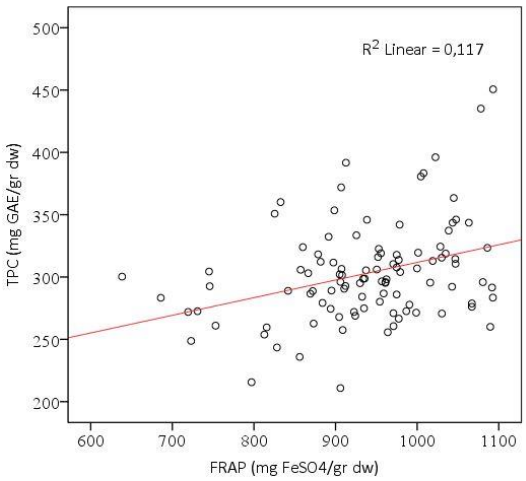

Figure 5. Relationship between FRAP and TPC
Şekil 5. FRAP and TPC arasındaki ilişki

Considering the importance of consumption of tea rich in antioxidant on human health. It could be appropriate for breeders to focus on improving genotypes showing higher antioxidant activity than approximate value of 1000 mg $FeSO_4$ g^{-1} dw.

Contribution of Authors

The authors declare that they have contributed equally to the article.

Conflict of Interest

Article authors declare that there are no conflicts of interest among them.

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