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Determination of Some Pomological and Chemical Properties of Some Blueberry Varieties Cultivated in the Northern Marmara Region

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Abstract

Blueberries are very beneficial for human health in recent years due to the high levels of antioxidants and many other components they contain. This study compared Duke, Darrow, Patriot, Bluecrop blueberry varieties grown as standard in the Northern Marmara Region. The first harvest was made at maturity (June 25, 2024). Fruit weight (g), fruit width and length (mm), L*, a*, b* color values, SSC (%), TEA (%), pH amounts, Ascorbic acid, total phenolic substances, antioxidant amounts were determined. In blueberry varieties, fruit weight was determined between 1.29 g and 1.79 g, fruit width was determined between 13.52 mm- 15.33 mm, and fruit length was determined between 10.21 mm-11.49 mm. L* value was found between 27.23-32.25, a* value between 2.27-2.84, b* value between (-3.98)- (-6.29). SSC amounts were found between 7.73%-11.17%, TA amounts between 1.26%-2.97%, and pH values between 4.01-4.47. Ascorbic acid amounts were found between 1.14-1.38, total phenolic was found between 0.183-035, and antioxidant amounts were found between 2.97-3.25.

Key words

Blueberry, fruit pomology, Marmara, SSC, TA, Ph, Ascorbic acid, Antioxidant

Introduction

There are three different types of blueberries cultivated in the world. Of these, the high-growing (*Vaccinium corymbosum*) blueberries of northern and southern origin in the blueberry group, which are in the form of shrubs, can reach 1-3 m in height and hundreds of varieties have been obtained as a result of breeding studies. The low-growing blueberry group includes the Vaccinium angustifolium species, which grows as a surface cover plant in high-altitude plateaus, especially in Canada, and the Vaccinium myrtillus species, which grows in plateaus in the Black Sea Region. Some Vaccinium species, which are found in the highlands of the Eastern Black Sea Region and naturally grow in open areas and under forests, are known by very different names by the local people. Another blueberry of economic importance is the rabbit's eye blueberry (*Vaccinium ashei*). Rabbit's eye blueberries grow between 1.5 and 5.0 m tall and have better tolerance to heat than other species (Çelik, 2004).

The countries with the highest blueberry production worldwide are the USA, Canada, Poland, Germany, France, Mexico, the Netherlands, Spain, and Sweden, respectively. In our country, 170 tons were produced from 485 decares of land in 2013, while 375 tons were obtained from 990 decares in 2018. As of the end of 2019, 443 tons of blueberry fruit were produced in 1,055 decares of land in Turkey (Asil, 2019).

In studies conducted on the benefits of blueberries on human health and nutrition, it was determined that one cup of blueberries weighs 145 grams and contains 21 grams of carbohydrates, 1 gram of protein, 0.5 grams of fat, 19 milligrams of vitamin C, 145 IU of vitamin A and 85 calories, and it was also determined that 100 grams of edible blueberries are 83% water, 0.7% protein, 0.5% fat, 15% carbohydrates, 1.5% fiber and provide 62 calories (Ronald, 1998).

This fruit, which is beneficial for health, is one of the cultivated fruits with the highest antioxidant content.

Blueberries are also rich in vitamins A and C, minerals, phenolic compounds and fiber (Giongo et al., 2013; Scalzo et al., 2013). At the same time, it can prevent visual impairments such as night blindness and dazzle, clean the blood, and lower blood sugar and cholesterol. Leaf and fruit teas are good for urinary tract infections. Blueberries can also relieve stomach problems, heal mouth sores, and have disinfectant properties for inflammations (Antonio et al., 2009; Çelik and Islam, 2014).

Blueberries can be consumed fresh, frozen, cooked, canned, dried. They can also be used with fruits, milk and dairy products, in pastries, as a spice, in jams, marmalades and jellies, in cakes and cereals (Lim, 2012).

This study was carried out in a 5-year-old blueberry orchard in Göçbeyli village of Pendik district of Istanbul. The physical and chemical properties of Bluecorp, Duke, Darrow, Patriot varieties were investigated in the study.

Material and Methods

This study was conducted in 2024 in a commercial blueberry orchard owned by a private company in Göçbeyli village of Pendik district of Istanbul. The orchard was established in 2006 and the plants are 8 years old. Patriot, Bluecrop, Darrow and Duke blueberry varieties were investigated in the trial and fully ripe fruits collected at the first harvest (June 24, 2024) were used. Patriot used in the trial is early, has large and delicious fruits. It is one of the most resistant varieties to cold weather. Bluecrop Fruits are medium-sized. Fruit color is bright blue and the fruit taste is aromatic. Darrow variety Fruits are large, light blue, hard and crisp. The flavor is excellent, sweet but very slightly tart. The shelf life of the fruits is long. It produces huge fruits. It has pretty durable fruits. Duke variety has light blue and fruits. It has a sharp sweet flavor (Çelik, 2012).

Pomological Analyses

Fruit (berry) weight (g): Randomly selected fruit samples were weighed and determined on a precision scale.

Fruit width and fruit length (mm): Randomly selected fruit samples were measured with a digital caliper sensitive to 0.01 mm based on the fruit axis.

Soluble solids content (%) (SSC): Measured with a digital refractometer (Model Number REF121, Atago, China).

Acidity (% citric acid): Calculated as % in citric acid using the titration method in fruit juice according to Karaçalı (2002) and the formula [(mL NaOH x 0.1 N x 0.064) x 100].

Fruit juice pH: pH was determined by direct immersion in 10 ml of fruit juice with a handheld pH meter (Hanna HI 8314).

Fruit outer color (L, a, b): Measured with a Minolta brand colorimeter in terms of L*, a* and b*. The L value indicates brightness, the a value indicates color changes from red to green, and the b value indicates color changes from yellow to blue.

Biochemical Analyses

All biochemical analyses were carried out in the laboratories of Eskişehir Osmangazi University, Faculty of Agriculture, Department of Horticulture. Harvested fruits were brought to the laboratory without wasting time. In order to obtain fruit extract, the fruits were first homogenized in a blender. The homogenate obtained was extracted with 70% methyl alcohol in an ultrasonic bath.

Total Phenolic Content Analysis

The total phenolic content of fruits was determined according to Singleton and Rossi (1965). In this method, Folin-Ciocalteu reagent will be used and absorbance will be measured at 760 nm with a spectrophotometer. Pure gallic acid will be used as a standard and the results will be calculated according to the curve and expressed as mg GAE/kg.

Total Anthocyanin Analysis

The total anthocyanin content of fruits was determined using the pH differential method (Giusti et al., 1999). For this purpose, extracts were mixed with pH 1.0 and 4.5 buffers and filtered. By reading absorbances at wavelengths of 700 nm with the highest value, real absorbances (A= (Amax-A700) pH1.0 – (Amax-A700) pH4.5) were determined and total anthocyanin amount was determined as cyanidin-3-glucoside.

DPPH

DPPH free radical scavenging effect was performed according to the method developed by Brand-Williams et al. (1995). Fruit extract (50 µL) was mixed with freshly prepared 2.95 mL 0.1 mM DPPH solution and kept in the dark, and absorbance values were determined at 517 nm in a spectrophotometer at 30-minute intervals. Calibration curves were drawn with Trolox and results were calculated in µmol Trolox/g.

Determination of Vitamin C (L-Ascorbic Acid) Contents

For ascorbic acid analysis, fruit juice samples were pureed and filtered. Samples were homogenized by

centrifugation. 400 µL of oxalic acid (0.4% 0.4%) and 4.5 ml of 2.6-dichlorophenolindophenol solution were added to the samples. Data were read against the blank at a wavelength of 520 nanometers in a spectrophotometer (Arabacı and Sevindik, 2014).

Statistical Analysis

The raw data from the preliminary experiments involving seven distinct treatments were analyzed using analysis of variance (ANOVA) to identify significant differences. Mean separation was performed using Duncan's multiple range test ($P < 0.05$). Subsequently, biochemical parameters from two treatments (HWD-treated and control groups) were compared using an independent-sample t-test at $P < 0.05$. Statistical analysis was conducted using SPSS software (version 17.0, SPSS Inc., Chicago, IL), and results are presented as the mean ±standard error (SE) for the various treatments.

Results

Fruit weight, width, and length of the varieties are presented in Table 1. Pomological characteristics were statistically significantly different among the varieties ($p < 0.05$). Regarding fruit weight, the largest most significant fruits were found in Duke (1.77g), while the smallest fruits were found in Bluecrop (1.25g). Regarding fruit width, the highest value was found in the Duke (15.34mm) variety, and the lowest value was found in the Darrow variety (13.53mm). It was determined that the maximum fruit length was found in Duke variety (11.5mm) and the lowest was found in Bluecrop variety (10.72mm).

Table 1. Values for fruit weight, fruit length and fruit width.

Varieties	Fruit Weight (g)	Fruit Width (mm)	Fruit Lenght (mm)
Duke	1,76 a	15,33 a	11,49 a
Darrow	1,30 c	13,52 b	10,21 b
Patriot	1,54 b	14,06 b	11,24 ab
Bluecrop	1,29 c	13,58 b	10,72 ab

Akbulut et al. (2013) determined the fruit weight as 0.94 g-1.84 g in their studies on ten blueberry varieties. Türkben et al. (2007) found the fruit weight as 0.26 g-0.19 g in their study. Çelik (2008) determined in his study that the Brigitta variety had 3.46 g, 3.11 g and 3.32 g fruit weights from high to low altitude. He also stated that Nelson with 2.07 g and Blujay with 1.61 g followed in the order. Molina et al. (2008) found the fruit weights to 1.2 g in O'neal, 1.4 g in Sharpblue, and 0.9 g in Misty. Aslan (2019) determined that the variety with the largest fruit width among the blueberry varieties studied in Giresun province was Chandler (18.53 mm) and the variety with the smallest width was Northland (12.58 mm). Starst et al. (2009) found the widest grains in Bruni, Nui, Chandler (20 mm) varieties, and the shortest grains in Putte, Northblue (13 mm) varieties based on their measurements in terms of fruit width. Akbulut et al. (2013) found the fruit width to be the highest in Bluegold with 15.5 mm, and the lowest in Leo with 10.13 mm. Starst et al. (2009) determined Denise Blue (14 mm) as the longest and Northblue (8 mm) as the shortest varieties in their study on fruit length. Aslan (2019), in their studies on some blueberry varieties in Giresun province, determined that the variety with the most extended fruit length was Brigitta with 13.18 mm, and the variety with the shortest fruit length was Jersey with 9.82 mm. Akbulut et al., (2013) found the most extended fruit length in S. Blue (11.58 mm) and Bluecrop (11.50 mm) varieties, and the shortest in Leo (8.76 mm). Medeiros et al. (2017), in their study in Brazil, determined the fruit length values between 13.67 (Bluegem) and 16.14 (Woodard) mm in the 2013/2014 production season and between 12.48 (Aliceblue) and 15.03 (Woodard) mm in 2014/2015.

In our study, the L value expressing brightness in fruit color measurements was found to be the highest in Duke (32.25) variety, and the lowest in Patriot (27.23) variety; the a value expressing the change from green to red was found to be the highest in Bluecrop (2.84), and the lowest in Patriot (2.27) variety. The b color value expressing the change from blue to yellow was the highest in Blurcrop (-3.98), and the lowest in Duke (-6.29). The determined values are shown in Table 2.

Table 2. Fruit colour measurement

Varieties	L	a	b
Duke	32,251 a	2,799 a	-6,291 b
Darrow	30,6285 ab	2,673 a	-5,8985 ab
Patriot	27,2355 c	2,276 a	-4,2735 ab
Bluecrop	28,758 bc	2,848 a	-3,9895 a

In his study, Aslan (2019) found the L value to be between 30.58 (Berkeley) and 25.03 (Jersey), the a value to be between 2.35 (Brigitta) and 0.63 (Northland), and the b value to be between -0.17 (Patriot) and -2.68 (Bluegold). In a study conducted by Ritchie (1956) on Çobağrazümü, fruit color (L, a, b) was found to be 95.33, 0.28, and

3.09, respectively.

In our study, titratable acidity (TEA), soluble solids content (SSC) and pH values of the varieties are presented in Table 3. While the highest titratable acidity was found in Darrow (2.97%), the lowest was found in Duke (1.26%). Türkben et al. (2007) found titratable acid values between 1.23% and 0.90% due to their evaluations. Ateş (2011) determined titratable acidity values in the range of 1.14% (Darrow) - 0.35% (Patriot) in his study. Aslan (2019) found titratable acid values to vary between 1.42% and 0.62%, and the highest acidity value was found in Darrow and the lowest acidity value was found in Berkeley. In their studies conducted in Brazil, Medeiros et al. (2017) determined the titratable acidity values between 0.60% (Climax) and 1.00% (Woodard) in the 2013/2014 production season, and between 0.67% (Delite) and 1.88% (Woodard) in 2014/2015.

Table 3. TA, TSS and pH values of fruits belonging to blueberry varieties

Varieties	TA	SSC	pH
Duke	1,26 d	7,73 d	4,47 a
Darrow	2,97 a	10,07 b	4,05 b
Patriot	2,43 c	11,17 a	4,06 b
Bluecrop	2,91 b	9,1 c	4,01 c

Patriot had the highest SSC value among the blueberry varieties with 11.17%, while Duke had the lowest. Pepe et al. (2023) determined the highest SSC value as Camellia (10.23%) in their research on blueberry varieties. Akbulut et al. (2013) determined the SSC content as 7.5-12.0%, Türkben et al. (2007) determined the SSC (%) values as 11.00% and 9.00% as a result of their studies. Aslan (2019) found the SSC contents to vary between 6.54% and 9.75% in his study on blueberries and found the highest SSC value to belong to Berkeley and the lowest SSC value to Northland. Among the varieties, Duke had the highest pH value with 4.47, while Bluecrop had the lowest pH with 4.01. Aslan (2019) found that the pH value was highest in the Berkeley variety with 3.13, while the pH value was lowest in the Darrow variety with 2.66, according to the average values of 2015 and 2016. Türkben et al. (2007) determined the pH value to be between 2.95-2.77 as a result of their evaluations.

In our study, ascorbic acid, total phenolic substance and antioxidant contents of blueberry varieties are presented in Table 4. Among the varieties, the highest ascorbic acid content was determined in Blucrop with 1.38 g/l, while the lowest content was determined in Duke with 1.14 g/l. Spinardi et al. (2009) analyzed the ripening indices and antioxidant compounds of two blueberry varieties (Brigitta and Duke) grown at two different altitudes (450 m and 650 m) in their studies conducted in Valtellina, Northern Italy in 2005 and 2006. They found that color development and fruit size of Duke variety grown at high altitudes were lower than those at low altitudes, and ascorbic acid content was higher.

Table 4. Ascorbic acid, total phenolic substance and antioxidant amounts

Varieties	Ascorbic acid mg/100 g	Total Phenolic mg/GAE100g	DPPH
Duke	1,14 d	0,20 b	3,25 a
Darrow	1,27 c	0,35 a	3,03 c
Patriot	1,32 b	0,183 c	2,97 d
Bluecrop	1,38 a	0,20 b	3,17 b

Türkben et al., (2007) made determinations on Vaccinium myrtillus L. populations known as blueberry growing in Bursa-Uludağ in 2005. In the study, they determined the ascorbic acid value between 1.38 g/l - 0.88 g/l.

Among the varieties, the highest phenolic content was determined as Darrow (0.35), the lowest as Patriot (0.183) and the highest antioxidant content in fruits was determined as Duke (3.25) and the lowest as Patriot (2.97). Güzel (2011) in his study named as Determination of phytochemical properties of jam and marmalade produced from blueberry, worked on determining changes in some phytochemical properties of two different blueberry varieties (Brigitta and Darrow) fruits and jams and marmalades produced from these fruits and stored for 6 months. In the study, water soluble solids (WSM), pH, titratable acidity, total phenolics, antioxidant capacity (TEAC, FRAP), total anthocyanin, polymeric color and HMF analyses were carried out in fresh blueberry fruits at the beginning and in jams and marmalades produced from these fruits at 0, 2, 4 and 6 months of the 6-month storage period. During storage, it was determined that the average phenolic substance, average antioxidant capacity (TEAC, FRAP) and average anthocyanin values in jam and marmalade samples of Blueberry varieties were the highest in samples of Darrow variety (Aslan, 2019). In his study with blueberry varieties, Okan (2016) determined the phenolic compounds of fruits and leaves of *Vaccinium arctostaphylos* L., *Vaccinium myrtillus* L. species naturally grown in the Eastern Black Sea region and *Vaccinium corymbosum* L. varieties cultivated culturally in different years (2011-2012) and regions and the nutritional values of fruit juices produced from these varieties. The highest antioxidant capacity in both fruits and leaves was detected in natural species. Fructose and glucose were detected in all fruits (Aslan, 2019). As a result of our study and the data obtained from other literature sources, it was seen that pomological and chemical properties among the varieties, the region where the fruits are grown, altitude, maintenance conditions and varieties are effective factors.

Conclusions

At the end of the study, the largest fruits were observed in the Duke variety. The highest TA value was observed in the Darrow variety, the highest SSC value was observed in the Patriot variety. The highest ascorbic acid was determined in the Bluecrop variety, the highest total phenol in the Darrow variety and the highest DPPH in the Duke variety. Blueberry has become one of the important fruit species for our country. Recently, gardens have begun to be established in large areas. This study is an important study for the Istanbul region. It will be used in the literature for future studies. Studies on cultivation and application need to be increased.

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Author's Contributions

The authors contributed equally to this manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

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