Selcuk Journal of Agriculture and Food Sciences SJAFS

http://sjafs.selcuk.edu.tr/sjafs/index

(2022) 36 (1), 48-57

e-ISSN: 2458-8377

DOI:10.15316/SJAFS.2022.008

Research Article

Studies on Determination of Strawberry Cultivars Suitable for Ereğli-Konya Ecological Conditions**

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ARTICLE INFO[1]

Article history:
Received date: 06.12.2021
Accepted date: 19.01.2022

Keywords:
Strawberry Cultivars,
Yield,
Quality,
Ereğli-Konya

ABSTRACT

In order for strawberry varieties to be recommended in any region, the ecological demands of the varieties must be determined by making adaptation studies. For a successful strawberry production, variety adaptation plays an important role in the growing region. In strawberry cultivation, one of the most important purposes of breeding programs is to regulate yield and fruit quality. This study was carried out in order to determine the yield and quality characteristics of four strawberry cultivars (Albion, Monterey, San Andreas and Portola) using frigo seedlings in the Ereğli district of Konya province in 2019-2020. In the study, the earliest flowering and the highest yield were observed in Portola variety in both years. The highest fruit weight was obtained from Monterey (8.19 g) in the first year and Portola (7.72 g) in the second year. The highest number of fruits per plant was obtained from Portola (11.85-8.20 units/plant) in both years. The highest fruit firmness was determined in Monterey (1.47-1.49 kg/cm^2) cultivar in both years. The highest TSS content was determined in Albion (12.40-15.10%) in both years. In the experiment, the highest L (brightness) values were found in San Andreas (35.77-36.82) variety in both years. The highest C (color intensity) value was determined in San Andreas (41.25-43.53) cultivar in both years. The darkest red fruits were determined in Monterey (h°=30.33) and Portola (h°=32.06) in the first year, and in Portola (h°=31.46) and Monterey (C°=32.15) cultivars in the second year. Titratable acidity was found to vary between 1.09% and 1.15% in the first year and between 1.23% and 1.69% in the second year. As a result, it was concluded that the cultivation of Portola variety is appropriate in terms of yield and quality characteristics in Konya province Ereğli conditions.

1. Introduction

Strawberry is a berry fruit belonging to the Fragaria genus of the Rosaceae family. The fleshy fruit of the strawberry is classified as a bulk fruit. Today, cultivated cultivars are included in the *Fragaria X ananassa* species and constitute a regular part of the diet of millions of people (Martinelli, 1992; Hummer and Hancock, 2009). M.S. in Europe strawberry culture was started in 1300 BC. In the 13th century, the strawberry fruit was used for medicinal purposes by Greek doctors. In the 14th century, strawberry cultivation became widespread among the nobility and the flowers of the strawberry were used more than the fruit. By the 1500s, strawberry began to be studied and classified by botanists. They formed the origin of the cultivated strawberries, *Fragaria virginia*, which was brought to Europe from North America in the 1600s, and *Fragaria chiloensis*, which was brought to Europe from South America in the 1700s (Darrow, 1966).

Strawberry is an important member of the berry group, which is grown in very different ecological conditions due to its high adaptability. Strawberry has become an increasingly important fruit in the world and in our country in recent years. According to 2019 FAO data, the world strawberry production area is 396,401 hectares and the amount of strawberries obtained from this area is 8,885,028 tons. China, which is the most important and top producer country in strawberry production, meets about 36% of the total production. Most of the remaining production is carried out in the USA, Mexico, Turkey, Egypt and Spain. Turkey, which ranked fifth in world strawberry production in 2018 with 440,968 tons, increased its strawberry production by 45,737 tons in 2019 and ranked fourth with 486,705 tons (FAO, 2021).

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**This work is part of first author's MSc thesis

Strawberry production in Turkey was 130,000 tons on an area of 9,465 hectares in 2000, while it reached 486,075 tons on an area of 16,089 hectares in 2019. Strawberry production in Turkey is mostly realized in the Mediterranean, Aegean, Marmara and Central Anatolia regions, respectively. The provinces where the production is intense are Mersin, Aydın, Bursa, Antalya and Konya, respectively (TUIK, 2021).

Many epidemiological studies have shown that a diet rich in fruits and vegetables is often associated with a lower incidence of various chronic pathologies, including obesity, infections, neurological diseases and cancer. Strawberry has an important role among fruits due to its high phytochemical content (Halvorsen et al., 2006). Strawberries are an important source of bioactive compounds due to their high levels of vitamin C, folate and phenolic compounds. Moreover, strawberries are economically and commercially important and are commonly consumed fresh or in processed forms such as jams, juices and jellies. Therefore, it is among the most studied fruits in terms of agronomic, genomic and nutritional aspects (Proteggente et al., 2002).

According to its nutrient profile, strawberries are an extremely healthy food choice. First of all, dietary fiber and fructose content contribute to the regulation of blood sugar levels by slowing down digestion. The fiber content also contributes to controlling calorie intake with its satiating effect. Also, no other fat-soluble vitamins such as tocotrienols have been reported in strawberries. Strawberries have attracted great attention due to their high vitamin C content and have become one of the important sources of this vitamin in human nutrition (Giampieri et al., 2012). Considering that folate, along with vitamin C, is one of the richest natural sources of this essential micronutrient among fruits, it plays a crucial role in highlighting the micronutrient content of strawberries. In addition, strawberries are a source of many other vitamins, including, to a lesser extent, thiamine, riboflavin, niacin, vitamin B6, vitamin K, vitamin A, and vitamin E (Tulipani et al., 2008).

Strawberry is one of the most studied fruit species. For this reason, the number of varieties offered to breeders is increasing rapidly. Besides the use of modern techniques; high-yielding, and disease resistant, large-fruited varieties should be tested under different ecological conditions (Paydaş and Kaşka, 1992). Thanks to the breeding studies carried out in California and Florida in the USA, varieties with superior characteristics in terms of adaptation to various criteria and different ecologies are obtained and offered to breeders. Since the first years of strawberry production in Turkey, strawberry varieties, mostly short-day varieties, were also tested in other regions, especially in the Mediterranean Region. However, as a result of intensive breeding studies in strawberry, the number of varieties increases a lot and the varieties change rapidly. Adaptation studies should be carried out in order to recommend these varieties to producers in a region. It is known that variety adaptation plays a key role for successful strawberry cultivation in any region, and the necessity of growing different varieties of different ecologies with different growing systems (Özbahçali, 2014).

It has been reported in literature studies that yield and quality characteristics of fruits are affected by genetic or environmental conditions. Many successful studies have been carried out in the field of strawberry adaptation in Turkey. As a result of literature research, studies on the adaptation of strawberry cultivars in Ereğli district of Konya province were not found. For this reason, the study was carried out to determine the performance of different strawberry cultivars in Ereğli-Konya ecological conditions.

2. Materials and Methods

This research was carried out in the Alhan neighborhood of the Ereğli district of Konya in the years 2019-2020. Frigo seedlings of Albion, Monterey, Portola and San Andreas strawberry cultivars were used as plant material. Frigo seedlings were obtained from Çiltar A.Ş.

Albion: It was obtained from crossing between Diamante X Cal 94.16-1. It is a moderately neutral day variety. It adapts well to cool and temperate regions. It has good fruit quality and shows this performance all season long. It is an early variety and maintains its fruit size all season (Ateş and Türemiş, 2018).

Monterey: The variety is a medium day neutral variety. It is a hybrid of Albion x Cal 97.85-6. This variety, which is very sweet due to its low acidity, has large and soft fruits. It has a strong plant structure and is sensitive to mildew (Ateş and Türemiş, 2018).

Portola: This variety Cal. 97.93-7 X Cal. it was obtained as a result of hybridization of 97.209-1. In arid and subtropical climates, it shows medium-strong neutral day character under suitable conditions. Performs well in spring and summer plantings. It is moderately resistant to powdery mildew, *Verticillium* wilt and anthracnose (Demirsoy, 2016).

San Andreas: This variety Albion X Cal. it was obtained by crossing 97.86-1. It is a moderately neutral day variety. Its fruits have a good appearance and taste. This variety, which has a nice aroma, is quite early and is resistant to the road. It gives products uninterruptedly and without disturbing the fruit size throughout the season (Erdem and Çekiç, 2017).

Konya province Ereğli district has an area of 2,260 km^2. It is located on the Ereğli Plain, which is the eastward continuation of the Konya Plain, one of the widest plains in Turkey. The district is surrounded by high mountains. The middle part of the Taurus Mountain range in the south, Hasandağı, Karacadağ and Karadağ volcanic masses, which are volcanic mountains in the north, are located. Between these mountain masses is the wide plains of the Ereğli Plain. The slope of the Ereğli Plain, which has a generally flat topography, varies between 0-10% (Allı, 2019).

In Ereğli, between 1990 and 2020, the hottest month is July and the highest average temperature is 24.1 °C. The annual average temperature of 2019, in which the

research was conducted, was 13.1 °C, the highest average temperature was determined in August (24.3 °C) and the lowest average temperature was determined in January (0.6 °C). In 2020, the annual average temperature is 13.5 °C, the highest average temperature is in July (25.7 °C) and the lowest average temperature is in January (0.8 °C) (Table 1).

Table 1
Some meteorological data of Ereğli (Anonymous, 2021)

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12	Average
Minimum Temperature (°C)													
1990-2020	-13.9	-13.2	-6.4	-1.3	4	8.2	11.8	11	5.5	0.1	-6.3	-11.5	-1.9
2019	-16.6	-3.7	-5.1	-0.3	4.3	12.9	11.7	12	4	3	-7	-4.1	0.9
2020	-8.4	-12.1	-4.8	-1	3	7.7	13.1	11.7	11.5	6.6	-5.7	-6.1	1.2
Maksimum Temperature (°C)													
1990-2020	14.1	17.2	22.5	27.0	30.9	34.4	37.0	36.6	33.6	29.2	21.4	16.6	26.7
2019	14	15.2	19.9	24.3	35	36.3	37.4	37.1	32.9	29.4	24	18.5	27.0
2020	13.8	17.4	23.9	25	33.9	34.4	37.3	36.6	39.6	31.8	19.1	15.4	27.3
Average Temperature (°C)													
1990-2020	0.1	1.9	6.9	11.8	16.5	20.8	24.1	23.7	19.3	13.6	6.7	2.1	12.2
2019	0.6	4.6	6.8	10.0	18.6	22.3	23.3	23.4	19.4	15.7	9.1	3.8	13.1
2020	0.8	3.2	7.8	11.5	17.4	21.3	25.7	23.9	22.8	17.9	5.9	4.8	13.5
Average Humidity (%)													
1990-2020	77.0	71.5	62.2	58.2	57.2	52.0	45.4	47.3	52.1	61.1	70.1	77.1	60.9
2019	78.2	73.1	61.7	66.7	44.3	51.2	41.3	46.7	46.1	57.1	65.7	84.1	59.7
2020	82.3	74.2	66.8	60.6	48.6	43.5	37.1	33.5	42.7	33.9	73.7	73	55.8
Total Precipition (mm=kg÷m²)													
1990-2020	33.2	27.8	33.2	36.0	34.2	27.1	8.8	7.5	14.7	21.7	29.9	38.9	313
2019	66.8	36.0	20.0	47.8	3.4	23.2	0	6.4	4.6	15.0	15.4	51.6	290.2
2020	50.4	21.3	40.2	33.3	18.8	9.5	0.4	0	3.0	1.6	30.0	14.0	222.5

3. Results and Discussion

Between 1990 and 2020, the average humidity value in Ereğli is 60.9%. In the year 2019, when the research was conducted, the average humidity is 59.7%, the lowest humidity is July (41.3%) and May (44.3%), and the highest is December (84.1%), January (78.2%) and February (73.1%) were determined as months. In 2020, the average humidity is 55.8%, the lowest humidity is August (33.5%) and September (33.9%), and the highest is January (82.3%), February (74.2%) and November (73.7%) months (Table 1).

The total amount of precipitation in Ereğli between 1990 and 2020 is 313 kg/m^2. The highest total precipitation was seen in December (38.9 kg/m^2) and April (36 kg/m^2), the least in August (7.5 kg/m^2) and July (8.8 kg/m^2). The total amount of precipitation in 2019, when the research was conducted, was 290.2 kg/m^2. The least total precipitation was in July (0 kg/m^2) and May (3.4 kg/m^2), and the highest total precipitation was in January (66.8 kg/m^2) and December (51.6 kg/m^2). In 2020, the total amount of precipitation is 222.5 kg/m^2. The least total precipitation was in August (0 kg/m^2) and July (0.4 kg/m^2), and the highest total precipitation was in January (50.4 kg/m^2) and March (40.2 kg/m^2) (Table 1).

When the data of 2019, in which the research was carried out, are examined, it is seen that the average temperature value (13.1 °C) has increased compared to the long-term average, the average humidity level (59.7%) and the amount of precipitation per square meter (290.2 kg) decreased. Similarly, in 2020, it is seen that the average temperature value (13.5 °C) increased compared to the long-term average, while the average humidity level (55.8%) and the amount of precipitation per square meter (222.5 kg) decreased. Compared to the long-term average, 2019 and 2020 were hotter in Ereğli and especially 2020 was drier in terms of precipitation.

The analysis of the soil sample taken from a depth of 0-30 cm to represent the trial area was carried out in the Şemsi Bayraktar Analysis Laboratory within the Karaman Chamber of Agriculture. Analysis results are given in Table 2. Accordingly, the soil of the trial area is clayey loam textured, slightly alkaline (pH 7.31), low EC, very calcareous (30.84%), moderately organic matter (4%), rich in P and K. According to the results of the analysis, burnt farm manure and base manure were applied to the trial area before planting the strawberry seedlings.

Table 2
Soil analysis results of the research area

Analysis Name	Unit	Result	Comment
Constituency	%	53.10	Clay loam
pH (Saturation)		7.31	Slightly alkaline
EC (Saturation)	µS/cm	961	Low
$CaCO_3$ (Loam)	%	30.84	Too much
Organic matter	%	4	Medium
Phosphorus (P)	mg/kg	190	Very high
Potassium (K)	mg/kg	827	Very high

Strawberry seedlings were planted on the prepared bobbins 60 cm wide and 16 m long, with 30 cm row spacing and 30 cm row spacing. The experiment was established in 3 replications according to the randomized blocks design and 20 seedlings were used in each replication. Before planting the seedlings, the tops of the bobbins are covered with black plastic mulch. The water required during the development period of the plants in the plots was given by drip irrigation system. In the first year of the research, refrigerated seedlings were planted in open field on 14.04.2019. All of the inflorescences and branches that occurred in 2019 were plucked. The

first flowering of these plants in 2020 occurred on 8 May. Strawberries started to ripen on 29.05.2019. In the second year of the research, refrigerated seedlings were planted in open field on 10.03.2020. The first flowering was seen on 01.05.2020. The date when the strawberries start to ripen is 25.05.2020.

Flowering onset dates in cultivars were determined by observation. The first flowering date was taken as the date when 5% of the flower petals opened and 70% of the flower petals were opened as the full bloom date. During the growing period, the fruits harvested from each plant were weighed on a scale with an accuracy of 0.1 to determine the yields and average fruit weights per plant. The number of fruits per plant was determined by counting the ripe fruits harvested from each plant (İpek et al., 2009). The hardness of ten randomly selected fruits for pulp firmness (kg/cm²) was measured with a penetrometer, and a 5 mm (0.2 cm2) probe was used for the measurement (Agar et al., 1991). Fruit color of ten fruits from each replication was determined by Minolta Konica CR-400 cromometer (Pérez-Sánchez et al., 2010). It was determined as % by refractometer from the fruit juice of the fruits selected from each application (İpek et al., 2009). The titratable acid content of the fruit juice (%) was determined by the titrimetric method. The H+ concentration in the juice of the sampled fruits was determined using a Hanna brand table-type pH meter (İpek et al., 2009). The ascorbic acid content in the samples was determined by the spectrophotometric dichlorophenol indophenol method (mg/100 g) defined by Pearson (Pearson, 1976).

The effects of the applications were examined with three replications. The data obtained were evaluated with the 5% Duncan test using the SPSS statistical program.

3. Results and Discussion

Flowering dates

In the study, the first flowering showed changes according to the cultivars. The earliest flowering in 2019 was observed on 8 May in Portola cultivar. This variety was followed by Monterey (May 9), Albion (May 10) and San Andreas (May 11). In 2020, the earliest flowering started on May 1 in Portola variety, followed by Albion and Monterey (May 3), and then San Andreas (May 4) (Table 3).

Table 3
Flowering dates of strawberry cultivars

Cultivars	Flowering Dates	
	2019	2020
Albion	10 May	3 May
Monterey	9 May	3 May
Portola	8 May	1 May
San Andreas	11 May	4 May

Yield per plant (g/plant)

Yield values per plant (g/plant) and yield per decare (kg/da) of strawberry cultivars for the years 2019 and 2020, in which the research was conducted, are given in Table 4. In 2019, the highest yield per plant was obtained from Portola (94.14 g/plant). This cultivar was followed by San Andreas (55.01 g/plant), Albion (54.21 g/plant) and Monterey (54.03 g/plant), respectively, and the difference between the cultivars was found to be statistically significant.

Yield per plant in 2020 showed a slight decrease compared to the first year. The most productive variety this year was Portola (63.27 g/plant), as in 2019, followed by Monterey (51.35 g/plant), San Andreas (46.11 g/plant) and Albion (43.80 g/plant). When the varieties were evaluated statistically, it was determined that the difference between them was significant (Table 4).

Table 4
Yield per plant (g/plant) of strawberry cultivars

Cultivars	Yield per plant (g/bitki)	
	2019	2020
Albion	54.21 b*	43.80 c
Monterey	54.03 b	51.35 b
Portola	94.14 a	63.27 a
San Andreas	55.01 b	46.11 c

*: There is no difference between the averages shown with the same letter in the same column

Many studies have been carried out on strawberry cultivation in different regions of our country. In a study conducted in Kayseri, the highest yield values per plant were found in Crystal cultivar in 2011 with 70.1 g, and the highest in Fern cultivar in 2012 with 914.2 g (Alan, 2013). Cekic et al. (2003), the yield per plant in Tokat was determined as 273.8 g in Maraline cultivar in 2002, 382.3 g in Tudla cultivar in 2003, 392.8 g in Muir and 405.6 g in Maraline cultivar. Again, in a study conducted in Erzurum conditions, the highest yield was obtained from Kabarla (296.2 g), and the lowest yield was obtained from Rubygem (98.6 g) cultivar (Özbahçali, 2014). In the study carried out in Merzifon district of Amasya, the highest yield per plant was found in Monterey (307.8 g), followed by Albion (283.7 g) and San Andreas (243.7 g), respectively. Oğuz (2019) obtained the highest yield per plant from Kabarla (635.88 g) and the lowest yield from Redlans Hope (362.71 g) in Eskişehir. In another study conducted in Kayseri, the highest yield was obtained from the Fern with 843.85 g, followed by Kabarla (660.25 g), Albion (629.85 g) and Sweet Ann (514.5 g), respectively (Çolak et al., 2019). It is seen that the yield values per plant obtained from the strawberry cultivars used in the research in 2019 and 2020 differ from the previous studies. It is thought that the differences in yield value per plant between the studies also differ according to the climate and soil characteristics, ecological factors and cultural measures applied. In addition, very high lime-induced plant growth problems in the research area also negatively affected the yield.

Fruit weight

The highest average fruit weight in 2019 was Monterey (8.19 g), followed by Portola (7.94 g), San Andreas

(7.39 g) and Albion (5.84 g), respectively. It was determined that the difference between the cultivars was statistically significant. In the second year of the study, while the average fruit weight of Albion and San Andreas cultivars increased slightly compared to the first year, it was determined that it decreased slightly in Monterey and Portola cultivars. When the average fruit weights of the cultivars were examined in 2020, it was determined that it varied between 6.33-7.72 g. Average fruit weights were obtained from the lowest Albion and highest Portola cultivars (Table 5).

Table 5
Average fruit weight of strawberry cultivars

Cultivars	Average fruit weight (g)	
	2019	2020
Albion	5.84 d	6.33
Monterey	8.19 a	6.43
Portola	7.94 b	7.72
San Andreas	7.39 c	7.56
		N.S.

N.S.: Non-significant.

Although fruit weight is considered a genetic factor due to the characteristic of the strawberry variety, it can be affected by climatic conditions and growing techniques. Among similar studies on fruit weights giving different values in different climatic conditions, in a study conducted in Adana, the largest fruit was 36.0 g and belonged to the H-1 cultivar (Türemiş, 2000), and in a study in Hatay Yayladağı, the highest average fruit weight was 16.0 g. It has been determined that they belong to Muir and Tudla with 15.7 g (Özdemir et al., 2003). In the study conducted under Tokat conditions, it was observed that Rubygem produced the largest fruits with 19.67 g in the first yield year, and Camarosa cultivar 12.47 g in the second year (Saraçoğlu, 2013). In a study conducted in Erzurum, fruit size was determined as 9.0 g in Sweet Ann, 8.3 g in Rubygem, 7.8 g in Crystal, 7.7 g in Kabarla, and 6.5 g in Redlans Hope cultivar (Özbahçali, 2014). Macit et al. (2011) obtained the largest fruits from Redlans Hope (10.09 g) and Kabarla (9.27 g) cultivars in their study in Samsun. In a study conducted in Kayseri, the highest fruit weight was found in the Fern cultivar (8.86 g) (Alan, 2013). In another study conducted in Latvia, the highest fruit weight was obtained from the San Andreas cultivar with 13.3 g (Laugale et al., 2014). Oguz et al. (2017) reported that the average fruit weight of strawberry cultivars ranged from 5.31–7.67 g (Monterey–San Anderas) in their study conducted in Nevşehir conditions. In the study carried out in the Merzifon district of Amasya province, it was observed that the largest fruits were in the Albion (12.8 g) and the smallest fruits were in the Sweet Charlie (7.39 g) cultivar (Geçer et al., 2018). In a study conducted in Eskişehir, it was determined that average fruit weights ranged between 15.0-19.51 g (Kabarla-San Andreas) (Oğuz, 2019). When the results obtained and the results of the literature studies are compared, it is seen that the fruit size of the strawberry cultivars grown in Konya-Ereğli conditions is at an average level.

Number of Fruits per Plant

The highest number of fruits per plant in 2019 was Portola (11.85 units/plant), followed by Albion (9.28 units/plant), San Andreas (7.45 units/plant) and Monterey (6.60 units/plant). It was determined that the statistical difference between the number of fruits per plant of the cultivars used in the study was significant. When the fruit numbers per plant obtained in the second-year research were examined, the highest variety was Portola (8.20 units/plant), followed by Monterey (7.98 units/plant), Albion (6.92 units/plant) and San Andreas (6.10 units/plant). It has been determined that the number of fruits obtained from Monterey and Portola varieties is higher than Albion and San Andreas cultivars and they are in the same group statistically (Table 6).

Table 6
Number of fruits per plant of strawberry cultivars

Cultivars	Number of fruits per plant	
	2019	2020
Albion	9.28 b	6.92 b
Monterey	6.60 d	7.98 a
Portola	11.85 a	8.20 a
San Andreas	7.45 c	6.10 c

It can be said that the number of fruits per plant in strawberry depends on the eco-physiological characteristics of the place of study and the characteristics of the cultivated cultivar. Güleryüz et al. (1991) in their study conducted in Erzurum determined that the lowest number of fruits per plant was in Pocahontas (9.38 units/plant) and the highest in Aliso (28.61 units/plant). Gülsoy (2003) found the number of fruits per plant in open cultivation as 8.73 pieces/plant in Sweet Charlie in Van. In the study conducted in Tekirdağ, Gül (2011) reported that the highest number of fruits per plant was Fern with 9.19 units/plant and the lowest number of fruits per plant was Camarosa with 4.46 units/plant. In another study conducted in Van, Aromas (19.49 pieces/plant) and Sweet Charlie (20.10 pieces/plant) cultivars had higher fruit numbers (Geçer and Yılmaz, 2011).

Fruit Firmness

In 2019, it was determined that the fruit firmness values of the cultivars were statistically in 3 groups. It was determined that the statistical differences of Portola and San Andreas cultivars were not significant. The lowest fruit firmness was obtained in Albion with 1.20 kg/cm² and the highest fruit firmness in Monterey with 1.47 kg/cm². In the second year of the study, fruit firmness values were found to vary between 1.21-1.49 kg/cm². The lowest fruit firmness values were obtained from Albion and the highest Monterey. Portola and San Andreas were found to be in the same group statistically (Table 7).

Table 7
Fruit firmness of strawberry cultivars

Cultivars	Fruit firmness (kg/cm^2)	
	2019	2020
Albion	1.20 c	1.21 c
Monterey	1.47 a	1.49 a
Portola	1.34 b	1.35 b
San Andreas	1.30 b	1.32 b

Fruit flesh firmness is one of the most important quality criteria in strawberries. Due to its advantages in harvest, transportation and post-harvest applications, hard fruit varieties are preferred by producers. Fruit firmness is affected by many factors such as ecological factors, fertilization, genotype, growing conditions, fruit size, fruit composition, storage and fruit temperature. Fruits grown in very hot, humid and long-day conditions are soft, while those grown in short-day conditions are hard-fleshed (Mısır, 2016). Gündüz and Özdemir (2012), in their study in Hatay, determined that the hardest fleshy fruits were from Camarosa, Carmine and Kabarla, and the softest fleshy fruits were from the Ottoman. Alan (2013), in Kayseri, the lowest fruit firmness values are with Kabarla (0.50 kg/cm²) with Redlanshope (0.76 kg/cm²) and the highest Fern (1.61 kg/cm²) with Crystal (1.38 kg/cm²) were detected in cultivars. Aguero et al. (2015), in their study in Argentina, the lowest fruit firmness was obtained from Ventana (88.6 g/mm^2) and the highest from Candonga (99.6 g/mm^2). Mısır (2016) determined that among the varieties used in Samsun, Fortuna (0.54 kg/cm^2) had the highest fruit firmness value. Kandemir (2016) found that the hardest fruits were obtained from the Amiga (0.61 kg/cm^2), Fortuna (0.41 kg/cm^2), Monterey (0.43 kg/cm^2), Benicia (0.43 kg/cm^2), in the study he conducted using refrigerated seedlings under plastic greenhouse conditions reported that the San Andreas (0.44 kg/cm^2) cultivars had the lowest hardness value.

Fruit Color (L, C, h°)

The L value, which indicates the brightness of the upper colors of the fruits, is given in Table 8. The differences between the cultivars were found to be statistically significant. In 2019, the highest brightness (L) among cultivars were determined in San Andreas (L=35.77). This cultivar was followed by Portola (L=34.34), Albion (L=33.21) and Monterey (L=31.51), respectively. In the second year of the study, as in the first year, the highest brightness (L) was determined in San Andreas (L=36.82). This cultivar was followed by Portola (L=34.91), Albion (L=33.54) and Monterey (L=31.46), respectively (Table 8).

Table 8
Fruit color L (brightness) values of strawberry cultivars

Cultivars	Fruit color L (brightness)	
	2019	2020
Albion	33.21 bc	33.54 c
Monterey	31.51 c	31.46 d
Portola	34.34 ab	34.91 b
San Andreas	35.77 a	36.82 a

One of the most important quality factors in strawberries is fruit color. In addition to other quality features, fruit appeal is also very important in the supply of fresh strawberries to the market, increasing the demand for fruit. The outer color of strawberry fruits is accepted as an indicator of maturity and quality in the market. For this reason, studies have been carried out on the subject. In the study conducted in Kayseri, Alan (2013) determined the average fruit L value with the lowest 28.51 in Crystal and the highest 33.90 in Fern cultivars. In a study in Korea, the highest 'L' value was found in San Andreas and Rubygem cultivars (Ruan et al., 2013). Mısır (2016) found the highest L value in Rubygem with 75.1 and the lowest value in Sweet Ann with 52.7 in his study. Oğuz (2019) determined that Sweet Ann (33.44) and San Andreas (32.27) were the cultivars with the highest brightness (L) values among the varieties in his study in Eskişehir conditions.

Differences in fruit color C (color intensity) values were determined between cultivars (Table 9). In 2019, the cultivar with the highest fruit color 'C' was determined as San Andreas (C=41.25). This variety was followed by Portola (C=36.98), Albion (C=35.64) and Monterey (C=32.38), respectively. In the second year of the study, the cultivar with the highest fruit color 'C' was determined as San Andreas (C=43.53). This cultivar was followed by Portola (C=37.89), Albion (C=37.15) and Monterey (C=34.13), respectively (Table 9).

Table 9
Fruit color C (color intensity) values of strawberry cultivars

Cultivars	Fruit color C (color intensity)	
	2019	2020
Albion	35.64 b	37.15 b
Monterey	32.38 c	34.13 c
Portola	36.98 b	37.89 b
San Andreas	41.25 a	43.53 a

Mısır (2016) found the highest C value in Sweet Ann (31.8), Fortuna (31.1) and Amiga (30.0) cultivars. The lowest C value was followed by Festival (17.0) and Rubygem (18.6). The values of Albion (C=22.5), Monterey (C=25.1) and San Andreas (C=27.9) cultivars used in this study were found to be lower than our study. In another study conducted in Samsun, the highest C value was found in Amiga (38.6) and the lowest in Benicia (29.8). In other cultivars used, C values were determined as Fortuna (36.5), Monterey (34.9), Camarosa (34.0), Rubygem (33.0), Albion (32.4), Festival (32.0), San Andreas (31.9) and Sweet Ann (31.0) respectively (Kandemir, 2016). Oğuz (2019) determined the varieties with the highest fruit color “C” in Eskişehir conditions as San Andreas (35.80) and Sweet Ann (35.76).

The h° value, also known as the color angle value, which indicates the lightness or darkness of the fruit colors, is given in Table 10. It is known that the smaller the color angle value (h°), the darker the fruit color, and the larger it is, the lighter the fruit color.

In the first year of the study, the cultivar with the darkest fruit among the varieties was Monterey, and the

lightest colored cultivar was San Andreas. In other cultivars, it was determined as Portola (h°=32.06) and Albion (h°=32.92) from dark to light, respectively. In the second year, the variety with the darkest fruit among the varieties was determined as Portola, and the lightest colored variety was determined as San Andreas, as in the first year. Monterey (h°=32.15) and Albion (h°=32.98) were determined in other cultivars from dark to light, respectively (Table 10).

Table 10
Fruit color h° (color angle value) values of strawberry cultivars

Cultivars	Fruit color h° (color angle value)	
	2019	2020
Albion	32.92 a	32.98 ab
Monterey	30.33 b	32.15 ab
Portola	32.06 ab	31.46 c
San Andreas	33.57 a	34.76 a

Mısır (2016), the darkest red fruits in Sweet Ann (h°=55.4) and Amiga (h°65.5); the lightest red fruits were determined in Festival (h°=127.7), Rubygem (h°=119.9), Camarosa (h°=115.9) and Benicia (h°=109.2) cultivars, respectively. Kandemirli (2016), in his study, determined that Sweet Ann (h°=59.1) had the lightest colored fruit, while Camarosa (h°=39.2) had the darkest fruit. In addition to these cultivars, he determined other measurements as h°=40.3 in Monterey, h°=49.7 in Albion and h°=56.9 in San Andreas. In the study conducted by Oğuz (2019), in Eskişehir conditions, it was determined that the cultivars with the darkest fruit were Redlans (h°=23.30) and Albion (h°=23.41), and the cultivar with the lightest fruit was Sweet Ann (h°=32.22) has done.

Total soluble solids (TSS) (%)

In 2019, it was determined that the amount of TSS in cultivars varied between 8.60-12.40%. The lowest amount of water-soluble dry matter was found in Monterey with a value of 8.60%, and the highest amount of water-soluble dry matter was determined in Albion with a value of 12.40%. It was determined that Monterey and Portola cultivars were in the same group statistically (Table 11). TSS value of cultivars in 2020 varied between 13.00-15.10%. The lowest amount of water-soluble dry matter was found in Monterey with 13.00% and the highest in Albion with 15.10%. It was determined that the TSS values obtained in the second year of the study were above the values obtained in the first year. It was determined that the statistical differences in the amount of soluble dry matter between the varieties in the second year were significant (Table 11).

Table 11
TSS amounts of strawberry varieties (%)

Cultivars	TSS values (%)	
	2019	2020
Albion	12.40 a	15.10 b
Monterey	8.60 c	13.00 a
Portola	9.20 c	13.10 a
San Andreas	10.40 b	14.80 b

TSS ratios are important in terms of affecting the taste of fruits. Therefore, it has been studied in many studies. Alan (2013), in his study in Kayseri, determined the amounts of TSS in the range of 8.46% (Redlanshope) and 10.13% (Fern). Özbahçali (2014), in his study in Erzurum, reported that TSS values ranged between 7.3% (Kabarla) and 9.5% (Rubygem). Mısır (2016) determined the highest TSS content in Albion with 6.8% in the study conducted in Samsun. In another study conducted in Samsun conditions, the highest TSS content among the cultivars was determined in Festival (6.8%), Rubygem (6.7%), Monterey (6.5%) and Albion (6.5%) (Kandemir, 2016). Oğuz (2019), in his study in Eskişehir, found the highest TSS content in Sweet Ann (7.98%) and the lowest in San Andreas (6.26%). Zanin et al. (2019) reported in a study conducted in Brazil that the contents of TSS varied between 7.50 and 9.50%. In this study, Albion was determined as 8.53%, Monterey 8.00% and Portola 7.63%. Özok (2021), in his study conducted in Bursa, determined that the amounts of TSS varied between 6.4% and 9.9%. When the results we have obtained are compared with the results of the studies on the subject, it can be said that the rates of TSS are generally high.

Titratable Acidity (%)

In 2019, the titratable acidity values of the cultivars were determined to vary between 1.09% and 1.15%. The highest titratable acidity value of the cultivars was found in San Andreas (1.15%), followed by Albion and Portola (1.14%), and the lowest (1.09%) in Monterey. According to the statistical evaluation, only Monterey variety was in a different group from other varieties. According to 2020, the differences between the titratable acidity values of the cultivars were found to be statistically significant. In the second year, it was determined that the titratable acidity of the cultivars varied between 1.23% and 1.69%. The lowest titratable acidity value was determined in Portola (1.23%) and the highest in Albion (1.69%) (Table 12).

Table 12
Titratable acidity values of strawberry cultivars

Cultivars	Titretable acidity (%)	
	2019	2020
Albion	1.14 a	1.69 a
Monterey	1.09 b	1.47 a
Portola	1.14 a	1.23 b
San Andreas	1.15 a	1.36 b

Titratable acidity values of strawberry juices are between 0.05% (Redlanshope) and 0.09% (Fern) in the conditions of Alan (2013), Kayseri conditions, between 0.48% (Fortuna) and 0.75% (Albion) in Mısır (2016), Samsun, Oğuz (2019) reported that it varies between 0.38% (Redlans Hope) and 0.43% (Sweet Ann) in Eskişehir. In another study conducted in Samsun conditions, they found the titratable acidity value to be 0.70% in San Adreas and 0.69% in Albion and Monterey cultivars (Soysal et al., 2019). Özok (2021), in his study under Bursa conditions, determined the highest titratable acidity value in Pineberry (0.91%), while the lowest

value was found in Monterey (0.53%). The values obtained in our study are generally compatible with the literature data.

pH

In 2019, the pH values of the cultivars changed between 3.75-3.83, the lowest pH was 3.75 in San Andreas and the highest pH was 3.83 in Portola cultivars. When the pH values of the cultivars were examined in 2020, it was determined that they ranged between 3.81-3.85. The lowest pH value was determined in Monterey (3.81) and the highest in San Andreas (3.85) cultivars. The pH values between the cultivars were statistically found in the same group (Table 13).

Table 13
pH values of strawberry varieties

Cultivars	pH values	
	2019	2020
Albion	3.78 ab	3.83
Monterey	3.79 ab	3.81
Portola	3.83 a	3.83
San Andreas	3.75 b	3.85
		N.S.

N.S.: Non-significant

Gidemen (2003) found the highest pH content in Sweet Charlie as 3.59 in the study conducted by the summer planting method in the high tunnel in the Amik Plain. Alan (2013) reported that the highest pH amount in Kayseri conditions was in Redlans Hope (3.60). Özbahçali (2014) determined that pH values varied between 2.3 (Kabarla) and 2.9 (Rubygem) in Erzurum conditions. Oguz et al. (2017) determined that the pH was in the range of 3.61-3.85 (San Andreas–Monterey) under Nevşehir conditions. Kılıç and Yılmaz (2017) determined that pH values varied between 2.69 and 3.75 in Kayseri ecological conditions. Colak et al. (2019) observed that the highest pH value was found in Sweet Ann (3.06) cultivar in Kayseri conditions.

Vitamin C

In 2019, the vitamin C values in the cultivars varied between 54.42-68.22 mg/100 g, the lowest vitamin C value was found in San Andreas with 54.42 mg/100 g and the highest vitamin C value was found in Portola cultivars with 68.22 mg/100 g. When the vitamin C values in varieties were examined in 2020, it was determined that they ranged between 43.06-54.28 mg/100 g. The lowest vitamin C value was determined in San Andreas (43.06) and the highest in Monterey (54.28). Vitamin C values between the varieties were found to be statistically significant (Table 14).

Table 14
Vitamin C values of strawberry varieties

Cultivars	Vitamin C (mg/100 g)	
	2019	2020
Albion	54.77 c	50.91 b
Monterey	58.26 b	54.28 a
Portola	68.22 a	50.91 b
San Andreas	54.42 c	43.06 c

Fresh fruits are an important source of vitamin C, which is important for human health. Strawberry fruit is known to contain high vitamin C in general. In the studies, Kaynaş and Günay (2003), 16.5-68.9 mg/100g; Gidemen (2003), 45.6-48.9mg/100g; Özbahçali (2014) found it between 38.0-56.0 mg/100g. Kandemir (2016) reported that in the study conducted in Samsun conditions, the content of vitamin C varied between 12.4-33.6 mg/100g, the highest vitamin C value was obtained from Rubygem with 33.6 mg/100g, followed by Benicia with 24.4 mg/100g. In the study conducted in Giresun province, the highest value in terms of vitamin C was obtained from Fortuna (101 mg/100g) (Islam et al., 2019). Temocico et al. (2019) reported that they obtained the highest vitamin C value from Garda (96.80 mg/100 g) in Romanian conditions. Our findings on vitamin C content within the current literature are around the averages given for strawberries.

4. Conclusions

Strawberry has an important share among berry fruits in the world. Turkey is an important country in world strawberry production. The interaction of environment and genotype is particularly important in strawberry. In order for a cultivar to be recommended to a region, adaptation studies must be done. In this study, the characteristics of some strawberry cultivars in Ereğli district of Konya province were investigated.

The highest yield was obtained from Portola in two years in the cultivars included in the experiment. The difference in the yields obtained in the experimental area from the previous studies was due to the very high lime-induced plant growth problems in the area. Chlorosis is seen in calcareous soils because calcium prevents iron intake. It was determined that although the plants were given Iron (Fe) during the growing period, the deaths continued and significantly affected the yield.

In the experiment, the highest fruit weight was obtained from Monterey (8.19 g) in the first year and from Portola (7.72 g) in the second year. The highest number of fruits per plant was obtained from Portola (11.85-8.20 units/plant) in both years. The highest fruit firmness was determined in Monterey (1.47-1.49 kg/cm^2) in both years. The highest SSCM content was determined in Albion (12.40-15.10%) in both years.

Color is one of the important quality criteria in terms of marketability in strawberries. In the experiment, the highest L (brightness) values were observed in San Andreas (35.77-36.82) in both years. The highest C (color intensity) value was determined in San Andreas (41.25-43.53) in both years. The darkest red fruits were observed in Monterey (h°=30.33) and Portola (h°=32.06) in the first year, and in Portola (h°=31.46) and Monterey (h°=32.15) in the second year.

When the data obtained in the study were evaluated in general, it was concluded that Portola can be recommended among the cultivars examined for strawberry cultivation in the open under the conditions of Konya

province Ereğli. Considering that new strawberry cultivars are introduced to the market almost every year, we can say that adaptation studies of varieties for the region should be continued.

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