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Impacts of different planting times on fruit quality and some bioactive contents of different strawberry cultivars

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ABSTRACT

Strawberry fruit quality traits can be affected by genotype–environment interactions, which determine the consumer acceptance of fruits. This factorial experiment was based on completely randomised blocks (RCBD) with two planting dates (5 and 20 April) and cultivars (‘Albion’, ‘San Andreas’ and ‘Portola’) of strawberry with three replications, and some of pomological and qualitative factors of berry were investigated at harvest. The results showed no significant difference on fruit width, length, weight and firmness, while the plant yield and stem diameter (SD) were affected by different cultivars and planting dates. The minimum SD (19.80) was recorded in cv. ‘Portola’ in the planting date of 20 April. Although the lowest fruit yield was achieved in cv. ‘Portola’ at both planting dates, it had the highest titratable acidity (TA) (0.83%) at the first planting date (5 April). The amount of soluble solid concentration (SSC), electrolyte conductivity (EC), pH, TA and chlorophyll were not affected by cultivar and planting dates. The effect of planting dates and cultivar had no significant effect on berry colour. The highest total phenolic (275.44 mg GAE · 100 mL^{-1} FW) was recorded in cv. ‘San Andreas’ on the planting date of 20 April, while the lowest value (251.22 mg GAE · 100 mL^{-1} FW) was recorded in cv. ‘Portola’ on the planting date of 5 April. In general, it is suggested that the least fruit yield in strawberry cv. ‘Portola’ can be correlated with the least SD of the cultivar.

Keywords: berry colour and phytochemicals, *Fragaria* × *ananassa*, genotype, organoleptic quality

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch) is a commercially important fruit in temperate and subtropical areas of the world. Strawberry production has spread to almost all agricultural areas of the world by obtaining many different cultivars with high yield and quality in different ecologies. World strawberry production reached 8,861,381 tons in 2020 (FAO, 2020).

Strawberries are classified as long-day, short-day and day-neutral strawberries according to their photoperiodic demands in terms of flower formation. The main types of strawberries commercially grown are short-day and day-neutral types (Shaw and Famula, 2005). Strawberry is grown in wide areas, but different environmental factors such as hot and dry weather, salinity, winter, spring

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frosts and insufficient cooling affect the productivity of strawberries. One of the most important problems in strawberry cultivation is high temperatures. The optimum temperature for the growth of strawberry plants is between 10 °C and 26 °C (Yeşil et al., 2022).

Colour, fruit size, fruit firmness and fruit shape are among the important quality criteria in strawberry cultivation (Kahramanoğlu et al., 2022). Titratable acidity (TA) and soluble solid content (SSC), as well as their ratio (ripening index), are among the major properties of strawberry fruit quality and have a significant effect on consumers' choices, with a higher demand for the types with higher soluble solids (Salamé-Donoso et al., 2010).

Strawberry is included in the diet because it contains diverse antioxidant components, some of which have been linked to strong antimutagenic and anticancer properties (Hannum, 2004). These antioxidant components, the majority of which are polyphenols (anthocyanins and flavonoids), act as a barrier to solar radiation, preventing or delaying oxidation by scavenging free radicals, stabilising hydrogen peroxide or inactivating radical oxygen. Since light is one of the most significant abiotic elements controlling plant and fruit properties, it is reasonable to assume that fruit antioxidant concentration will increase with high light intensities (Jian-Ming et al., 2010; Pék et al., 2011).

The organoleptic and functional fruit quality parameters of fruit are dependent on the cultivar and environmental factors. The vegetative phase of most strawberry cultivars is 3 months, followed by the reproductive phase. Air temperature has a great impact on the growth period and yield, as well as fruit quality and size. Thus, strawberries cannot tolerate temperatures above 30 °C (Hancock, 1999). The effect of different planting dates on fruit quality parameters and phytochemical contents has been demonstrated in previous research. Sharma et al. (2016) demonstrated that planting time has a significant effect on the antioxidant property, and they recommend 2nd week of May as the optimal planting time of sweet pepper to achieve greater antioxidant activity, phenols and anthocyanin. The results of Zhong et al. (2016) found a variation in the fruit and leaf vitamin C content among different cultivars of strawberry. The time of sampling also influenced the leaf and fruit content. Correlation studies evidenced almost an independent accumulation trend of this compound in the two plant parts. Therefore, choosing an appropriate planting date is one of the most important decision-making steps to achieve the desired quality and performance in strawberry production. Therefore, the aim of the research was to study the influence of different planting times on the fruit dimension, sensory quality and bioactive compounds in three different cultivars of strawberry (*Fragaria* × *ananassa*) to choose the strawberry cultivar with better performance.

MATERIALS AND METHODS

Plant materials

Three day-neutral strawberry cultivars ('Albion', 'San Andreas' and 'Portola') were used as plant materials in the study. Fruits of these cultivars are shown in Figure 1. The study was carried out in Korkuteli district of Antalya province, Türkiye. Strawberry was planted in an open field in double rows on plastic mulch, with a distance of 25 cm apart in two groups on April 5 and 20, 2019.

Soil properties of the study area are presented in Table 1. As shown in Table 1, the soil pH is 7.86, it has a calcareous, organic matter level of 1.82% and a salt-free soil structure. The analysis of soil properties was carried out in laboratuvar of the 'Republic of Türkiye Ministry of Agriculture and Forestry', Antalya.

Pomological properties

Matured strawberry fruits were harvested based on their morphological properties such as fruit width (mm), fruit length (mm), fruit weight (FW) (g), yield (g · plant^{-1}), fruit firmness (kg) and stem diameter (SD) (mm). Fruit width (mm), fruit length (mm) and SD (mm) were measured using a digital caliper. FW (g)

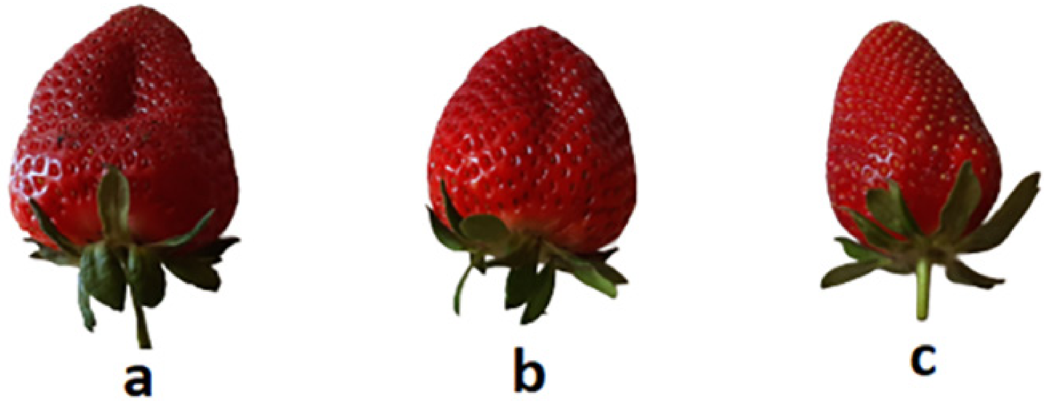

Figure 1. Fruits of strawberry cultivars: (A): 'Albion'; (B): 'San Andreas'; (C): 'Portola'.

Table 1. Soil properties of the study area.

Parameter	Value	Comment
pH	7.86	Alkali
Lime	16.36%	High chalky
Organic matter	1.82%	Poor
Structure	64.90%	Clay loam
Salinity	0.051%	Without salt
P_2O_5 (phosphorus)	10.72 ppm	Medium
K_2O (potassium)	179.79 ppm	High
Ca (calcium)	43.50 ppm	Rich
Mg (magnesium)	406.50 ppm	Rich
Fe (iron)	1.72 ppm	Little
Zn (zinc)	1.16 ppm	Very high
Mn (manganese)	0.78 ppm	Insufficient
Cu (copper)	2.54 ppm	Sufficient

and yield (g · plant^{-1}) were determined using a digital precision balance (0.00 g). Firmness was measured using a handheld penetrometer (LUTRON FR-5120, Taiwan) with a 3-mm probe. Firmness was determined on the opposite sides along the equatorial region of five individual fruits for each replicate and was expressed as kg · cm^{-2}.

SSC, pH, EC, TA and chlorophyll

SSC was measured using a digital refractometer (USA Inc. Kirkland, USA, designated ATAGO PR-32) and expressed in degrees Brix. electrolyte conductivity (EC) and TA were measured according to the methods described by Liu et al. (2014). pH was examined using a handheld pH meter (Model HI-96100 Hanna, Germany https://sciendo.com/article/10.2478/fhort2018-0010) at room temperature. The total leaf chlorophyll content was measured by using a chlorophyll meter (SPAD-502, Minolta, Camera Co. Ltd., Osaka, Japan), which is presented by SPAD readings. The average of three measurements from different spots of a single leaf was considered.

Fruit Colour 'L', C and h°*

The fruit colour of selected strawberry fruits (4–5 fruits per replication) was determined using a 3NH NR20XEPrecision Colorimeter (Shenzhen Threenh Technology Co., Ltd., Shenzhen, China). Fruit outer colour values were measured as '*L*' (darkness-lightness), *C** (chroma) and *h*° (hue angle), and the results were recorded.

Total phenolic content

Total phenolic compounds were measured according to the methods described by Spanos and Wrolstad (1990). For this purpose, 100 µL of extracts were transferred into glass tubes with sealed lids, where 900 µL of distilled water, 5 mL of Folin–Ciocalteu solution (diluted 10 times with distilled water) and (after a 3 min waiting period) 4 mL of 7.5% Na_2CO_3 solution. The obtained mixture was vortexed for 30 s and then left for 2 hr at room temperature in the dark. After vortexing, the absorbance of the reaction mixture was measured in the spectrophotometer (Specord UV-VİS L 40, Carl Zeiss, Jena, Germany) at a wavelength of 765 nm against a reagent blank. The analysis was done in triplicate, and the obtained absorbance values were calculated as mg GAE · 100 mL^{-1} based on the curve formed with gallic acid solutions.

Ascorbic acid content

To determine the value of ascorbic acid, the extraction of the samples was carried out with 6% metaphosphoric acid. A measure of 5 mL of fruit juice, 5 mL of acetate buffer (pH 4.0) solution, 1 mL of 2.6 dichlorophenolindephenol solution and 10 mL of xylene were added into the Falcon tubes. Later, the samples were centrifuged at 8,600 × *g* for 10 min at 4 °C. In addition, a tube containing 5 mL of acetate buffer (pH 4.0) solution, 1 mL of 2.6 dichlorophenolinindephenol solution and 10 mL of xylene was prepared as a control. The absorbances of the samples were read at 500 nm against xylene, and the amount of ascorbic acid was calculated using the following equation (Cemeroglu, 2010):

$$\text{Ascorbic acid (mg} \cdot \text{kg}^{-1}) = ((A2 - A1)/a) \cdot SF$$

where A1 denotes the absorbance of samples, A2 denotes the absorbance of the control, SF is the dilution factor and a is the slope of the ascorbic acid standard curve.

Anthocyanin content

Total monomeric anthocyanin of strawberry juice was determined spectrophotometrically by using the pH differential method. The principle of the method is the predominance of the coloured oxonium form of monomeric anthocyanins at pH 1.0 (AOAC, 2002). The samples were diluted according to the dilution factor determined at the beginning of the experiment using two different buffer solutions adjusted to pH 1 (0.025 M potassium chloride) and pH 4.5 (0.4 M sodium acetate) and were kept for about 20 min at room temperature. At the end of this period, the absorbances of both diluted samples were measured at λis-max 514 nm and 700 nm against pure water. The total amount of monomeric anthocyanin in strawberry juice was calculated in terms of dominant pelargonidin-3-glucoside.

Statistical analysis

Raw data of the experimental research were extracted in Microsoft Excel to calculate mean and standard deviations and to draw figures. Thus, the SPSS 22.0 (IBM, Armonk, NY, USA) statistical package program was used to perform statistical comparison of the strawberry cultivars and planting dates. Analysis of variance (ANOVA) and Tukey's (HSD) multiple range test at a 5% significance level were performed separately for each study parameter. Moreover, R 4.2.2 (R Core Team, 2021) software and its free packages were used for several further analyses. Functions of corrplot from the corrpolot R package were used to compute and visualise correlations, functions of res.hcpc<- HCPC(res) from the FactoMineR R (Lê et al., 2008) package were used to compute and visualise cluster analysis and functions of fviz_pca_ind () from the factoextra R (Kassambara and Mundt, 2020) package were used to compute and visualise the PCA biplot analysis.

RESULT AND DISCUSSION

Pomological properties

The results of pomological properties obtained from strawberry cultivars are shown in Figure 2. Different planting dates did not have a significant impact on fruit width (Figure 2A), length (Figure 2B), weight (Figure 2C) and firmness (Figure 2E), total yield (Figure 2D) and SD (Figure 2F) were significantly affected. Fruit width of 'Albion' (29.20 mm) and 'Portola' (26.33 mm) strawberry cultivars was higher in the planting date of 20 April than in 5 April. In the 'San Andreas' strawberry cultivar, approximately the same values were found on both dates. However, there was no statistical difference among cultivars in fruit width. The fruit height was found to be, on average, 38.75 mm in 'Albion', 32.20 mm in 'Portola' and 40.30 mm in 'San Andreas' on 5 April planting date. The FWs were determined for the planting date of 5 April as 12.60 g in 'Albion', 8.17 g in 'Portola' and 13.10 g in 'San Andreas'. The FW was determined as 14.63 g, 9.83 g and 12.20 g in 'Albion', 'Portola' and 'San Andreas', respectively, for the planting date of 20 April. 'Albion' and 'San Andreas' for the planting date of 5 April and 'San Andreas' for the planting date of 20

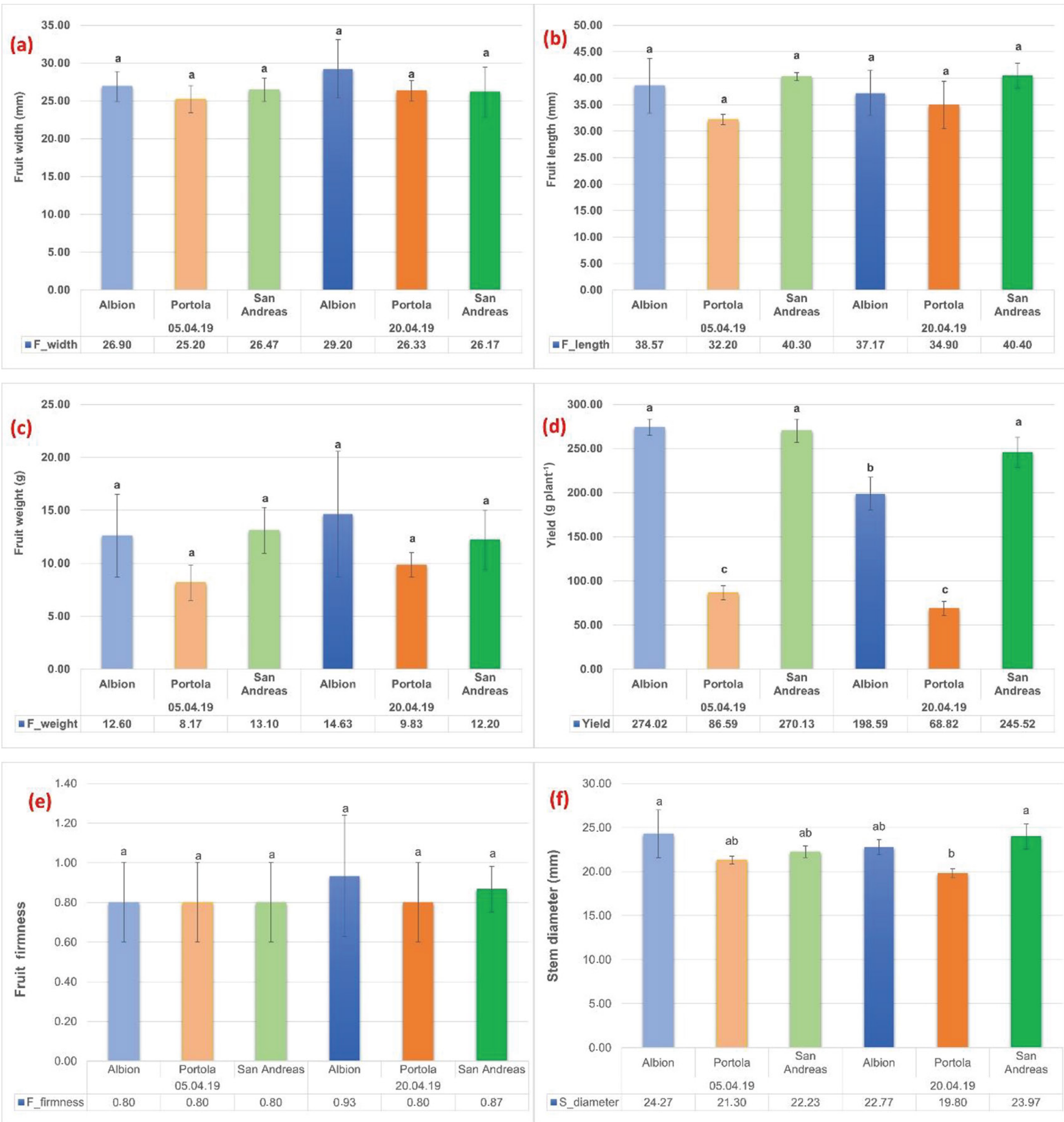

Figure 2. Impacts of different planting times on the fruit width, length, weight and firmness of strawberry fruits and total yield of per plant, SD of plants (A): fruit width (mm), (B): fruit length (mm), (C): FW (g), (D): yield (g · plant^{-1}), (E): fruit firmness (kg · cm^{-2}) and (F): stem diameter (mm)). FW, fruit weight; SD, stem diameter.

April were statistically significant in terms of yield per plant. Fruit firmness values were statistically significant for the same group for the two planting dates. The highest SD was determined in the 'Albion' (24.27 mm) cultivar for the planting date of 5 April and in 'San Andreas' (23.97 mm) for planting date of 20 April and was labelled as the statistical group 'a'. Other cultivars were categorised under the statistical group 'ab'.

Kim et al. (2013) found that the fruit size increased in all strawberry cultivars until the full maturity duration. They also found that the fruit length values were between 44.5 mm and 55.3 mm, and the width values were between 34.5 mm and 40.1 mm during the red period (full maturity). In another study, Gasperotti et al. (2013) recorded that the fruit width values of strawberry were 28.1 mm ('Alba') and 33.2 mm ('Darselect'). In addition, they found that their length values ranged from 33.5 mm ('Clery') to 40.3 mm ('Darselect'). Gasperotti et al. (2013) recorded that FWs vary between 10.4 g ('Clery') and 15.8 g ('Portola'). Liu et al. (2007) showed that the average strawberry FW ranged from 21.50 g ('Tochiotome') to 35.00 g ('Benihoppe'). In another study, Gasperotti et al. (2013) recorded that FWs vary between 10.4 g ('Clery') and 15.8 g ('Portola').

It is suggested that different yields of cultivars planted at different dates might be due to different climatic conditions during the vegetative growing phase (Zahid et al., 2021). Late planting of strawberries in an open field resulted in a decrease in the fruit yield due to insufficient time for enough vegetative growth. On the other hand, there was an increase in the plant performance in the early planting date (5 April), which may be attributed to the higher and stronger growth of plants and more biomass, which are necessary for early fruit growth (Kirschbaum et al., 2012). In the subsequent examination of the effect of planting date and cultivar, planting date was found to affect the yield more than cultivar (Ruan et al., 2011), although the effect of cultivar on fruit yield was also considerable in our experiment. The effect of cultivar on strawberry performance was previously demonstrated by Rahman et al. (2013), who reported that fruit yield in strawberries varied significantly among the germplasm studied. In most cases, the plant yield in the early planting date (5 April) had the higher value than in the late planting date (20 April); this might be due to the higher air temperatures, which hinders fruit yield in strawberry (Khammayom et al., 2022). Also, earliness is more meaningful in increasing market price than extending the season into late June, so considering to the early yield of strawberry is more important.

SSC, pH, EC, TA, SSC/TA and chlorophyll

SSC, pH, EC and chlorophyll were insignificant for different planting dates, while the value of TA was significant. Values of the soluble solid concentration, pH, EC, TA and chlorophyll are presented in Figure 3. Soluble solid concentrations were between 9.27% and 11.10%. It was determined that the SSC values of the strawberry cultivars planted on 5 April were higher than those planted on 20 April. The results are similar to those reported by Rahman et al. (2014), who reported that fruits of early planted plants contained more SSC and ascorbic acid than late planted plants. pH value was determined between 3.54% and 3.95% in cultivars. pH values of strawberry planted on 20 April was higher than those planted on 5 April. The value of the EC of the studied cultivars varied in the range from 1388 to 1,546.67. In 'Albion' and 'Portola' cultivars, values of the EC were higher for those planted on 5 April, while in the 'San Andreas' cultivar, the value of the EC was higher for those planted on 20 April.

Organoleptic attributes of strawberry were highly influenced by air temperature and cultivar. Although there were no significant differences in SSC (Figure 3A), pH (Figure 3B) and EC (Figure 3C), plants planted on 5 April had higher amounts of SSC, and by contrast, plants planted on 20 April had the lowest pH and EC. It was assumed that early plantings had more favourable conditions and sufficient time to accumulate soluble solids as increasing temperatures caused a decrease in the SSC content at the end season (Khammayom et al., 2022). On the other hand, all cultivars had a soluble solid content in the range from 8% to 12%, indicating good quality (Khammayom et al., 2022). In contrast to the higher SSC, a lower pH in early-planted strawberry can also be also expected. Early-planted fruits had firmer cell membranes due to lower EC. It can be observed that low temperatures are more suitable for having more TA, as found in all cultivars planted on 5 April compared to those planted on 20 April. The same results were reported by Santacruz Oviedo et al. (2018), who demonstrated that vernalisation of strawberry plants had no effect on berry shape or SSC, although it caused an increase in TA. Strawberry plants planted on 5 April had a higher chlorophyll content, which is represented as an indicator of leaf photosynthesis (Okatan et al., 2022).

Fruits with higher TA were softer than the fruits with less TA, as illustrated in Figure 2E and Figure 3D. Our results were in agreement with Dong et al. (2020) findings. The ratio of soluble solid concentration to TA was evaluated as an index of strawberry ripeness, which represents the strawberry taste. Unfavourable conditions during strawberries cultivation resulted in the activation of glycolytic enzymes and alcoholic fermentation enzymes such as alcohol dehydrogenase (ADH) and pyruvate decarboxylase (PDC) to provide the necessary energy for cellular respiration, which subsequently led to change in the ripening index (SSC/TA).

The interaction between different planting dates and strawberry cultivars is given in Table 2. According to the results, 'Albion' planted on early planting date (5 April) and 'San Andreas' planted on both planting dates (5 and 20 April) had the best taste index according to the SSC/TA ratio. Moreover, 'Portola' had the least SSC/TA ratio compared to other cultivars, and it was independent of the time of planting. The SSC/TA

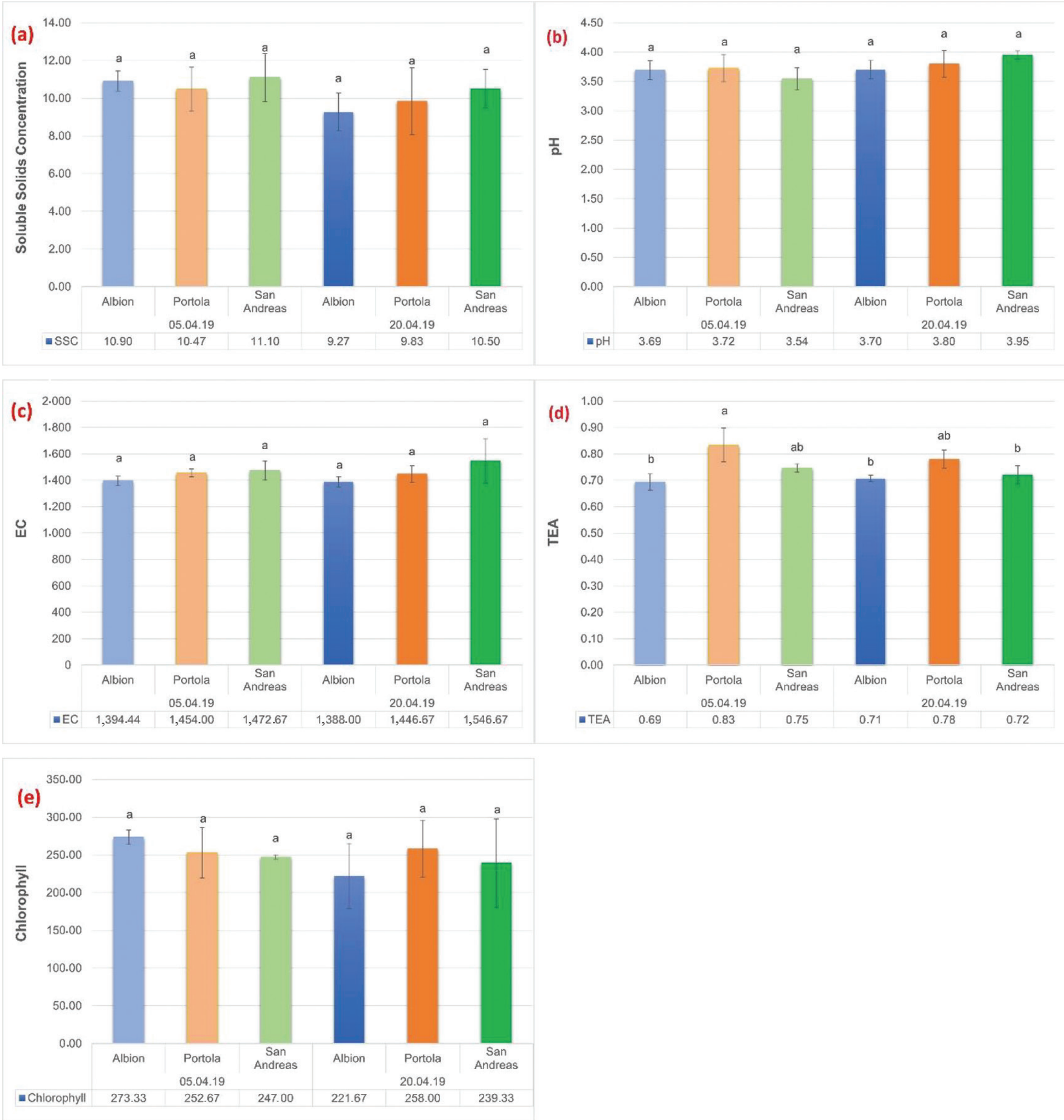

Figure 3. Values of soluble solid concentration, pH, EC, TA and chlorophyll of strawberries (A): SSC (%), (B): pH (%), (C): EC, (D): TA (%), and (E): chlorophyll (SPAD)). EC, electrolyte conductivity; TA, titrable acidity.

Table 2. Mean comparison of the effect of different planting dates on the SSC/TA ratio (ripening index) of different cultivars of strawberry.

Planting time	Strawberry cultivars	SSC/TA
05.04.19	Albion	15.8 a
	Portola	12.61 d
	San Andreas	14.8 b
20.04.19	Albion	13.06 c
	Portola	12.6 d
	San Andreas	14.58 b

Means with a common letter in each column have no significant difference ($p \leq 0.05$).
TA, titrable acidity.

ratio (fruit flavour intensity) of individual fruit is a good predictor of the sweetness, sourness and flavour intensity of the fruit (Gunness et al., 2009). According to Gunness et al. (2009), the taste of strawberries are categorised based on sourness.

Different planting dates had insignificant ($p < 0.05$) effect on L, C and $h°$ colour values of strawberry cultivars (Figure 4). All cultivars planted on 20 April had the highest colour L value compared to those planted on 5 April. In the 'Albion' cultivar, the colour C value was highest for plants planted on 5 April, while the highest values of 'Albion' and 'San Andreas' cultivars were determined for plants planted on 20 April. It can be assumed that the clean and fresh appearance of strawberries planted on 20 April was partly due to their higher chroma and lightness (Figures 4A and 4B). The highest colour h values were found for in all strawberry cultivars planted on 5 April. As stated by Dong et al. (2020), 'San Andreas' strawberries were reddest, while 'Albion' strawberries were least red; however, cultivar differences were not evident in our results.

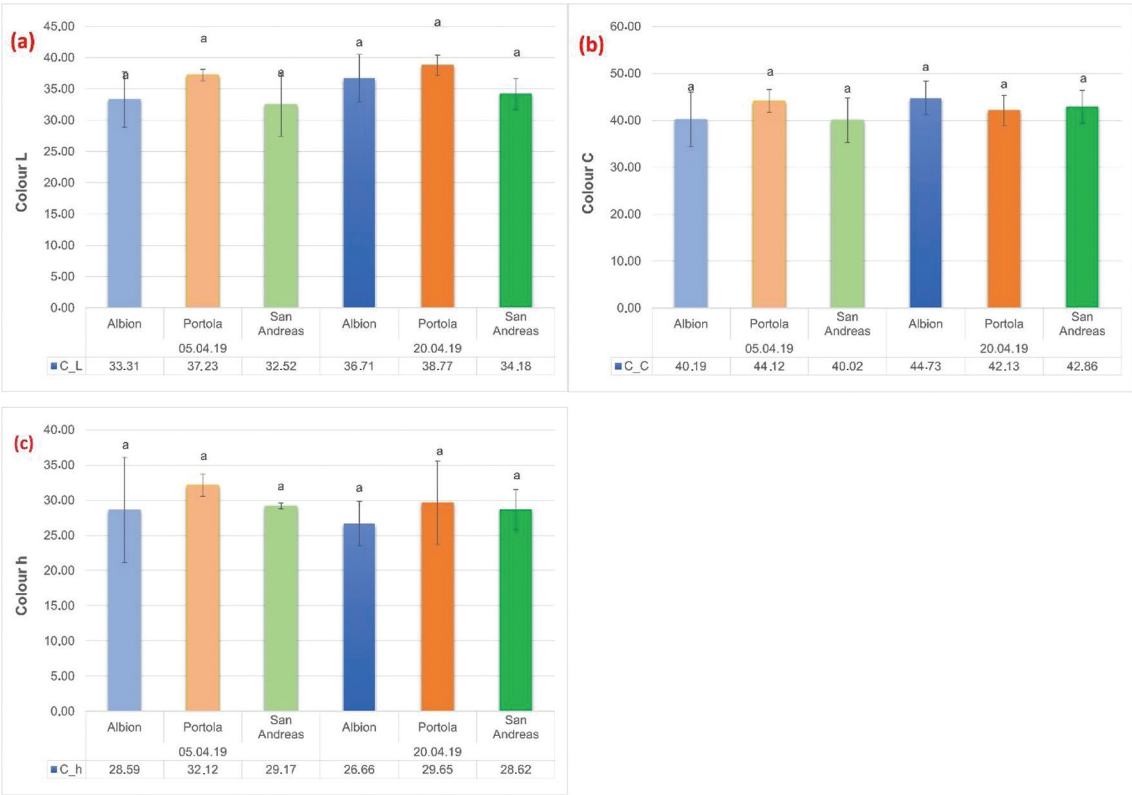

Figure 4. Values of colours of strawberry fruits [(A): *L*, (B): *C* and (C): *h*].

Ascorbic acid, total phenolic compound and total anthocyanin

Values of ascorbic acid, total phenolic compound and total anthocyanin were statistically insignificant for plants planted on both planting dates (Figure 5). Ascorbic acid values were between 60.23 mg · 100 mL^{-1} and 65.36 mg · 100 mL^{-1} in cultivars (Figure 5A). The highest total phenolic compound value was 295.24 mg GAE · 100 mL^{-1} FW in 'San Andreas' cultivar planted on 5 April (Figure 5B), whereas the lowest value was 251.22 mg GAE · 100 mL^{-1} FW in 'Portola' cultivar on planted 5 April. Values of total anthocyanin were found between 6.03 mg Peg-3-glu · L^{-1} and 7.36 mg Peg-3-glu · L^{-1} FW in strawberry cultivars (Figure 5C).

Phenolic compounds are a large group of secondary metabolites that have different chemical structures and functions. In general, it has been recognised about 8,000 phenolic compounds in plants and their frequency are dependent on the genotype, and storage and environmental conditions (Luthria et al., 2006). In addition to the effect of cultivar on strawberry phenolics, the effect of planting date was considerable as the highest amount of TPC was observed in 'San Andreas' planted early; this is likely due to the lack of UV wavelengths at this time, which is suitable for accumulating phenolics (Dong et al., 2020). Temperature is one of the important factors that affect the accumulation of anthocyanin in flowers and fruits both pre- and post- harvest, and the decrease in temperature causes an increase in the anthocyanin content, as previously described by Matsushita and Ikeda (2016). Therefore, it can be concluded that higher amounts of anthocyanins in strawberries planted on 5 April than other late-planted groups, especially 'San Andreas', are because of lower temperatures early in spring. Hancock (1999) reported that the optimum air temperature for strawberry plants ranges from 15 to 26 °C, which is dependent on cultivars and developmental stages, and temperatures below 20 °C are more suitable for flower initiation. The biosynthesis of anthocyanins in plants is promoted by a light wavelength of 640 nm to 670 nm, i.e., the red-light interval (Siegelman and Hendricks, 1958).

Relationships between study cultivars and planting dates

Hierarchical clustering of present findings resulted in three clusters (Figure 6). The first cluster includes 'Portola' cultivar at both planting dates. Our results indicated that planting date had the lowest significant impact on this cultivar. A similar result was noted for 'San Andreas', and the earlier planting date (5 April) of 'Albion' was also found to have a similar impact on the 'San Andreas' cultivar. The most significant difference was found for cultivar and planting date combination of 'Albion' (20 April).

According to correlation studies (Figure 7), the highest positive correlation was found between fruit width (Fwi) and FW, with 0.88. In addition to this, some other parameters also had strong positive relationships, such as colour *L* value and colour *C* value (with 0.79),

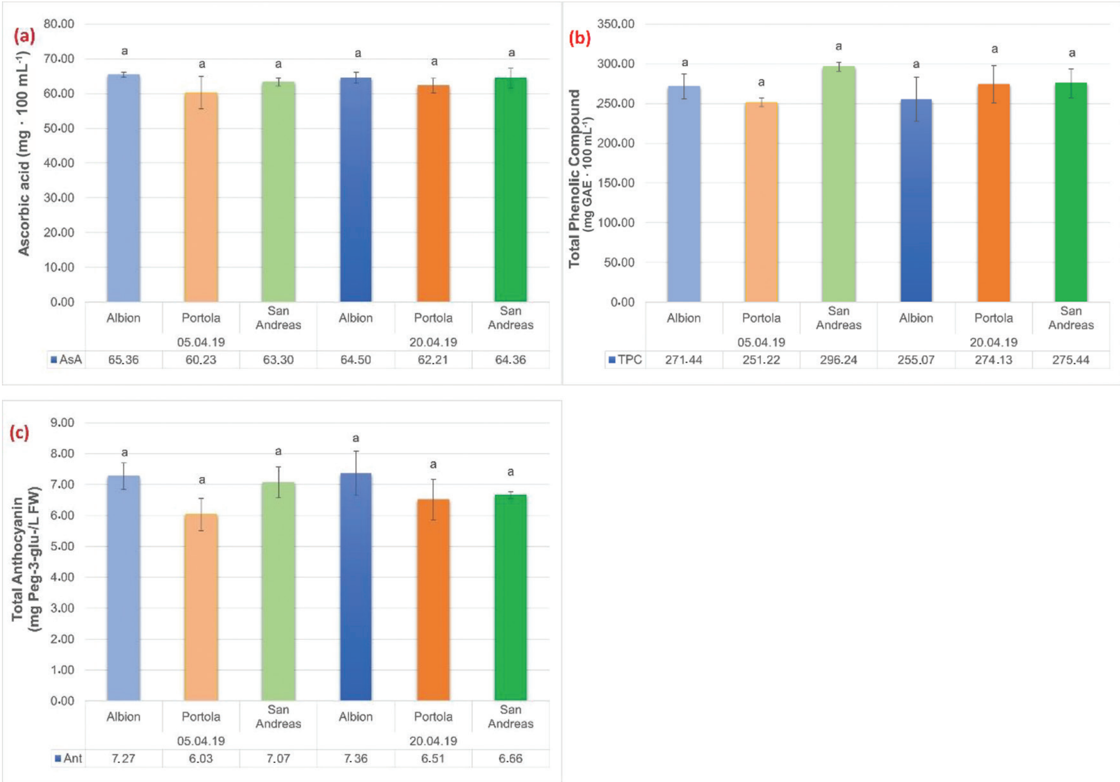

Figure 5. Values of ascorbic acid (A), total phenolic compound (B) and total anthocyanin (C).

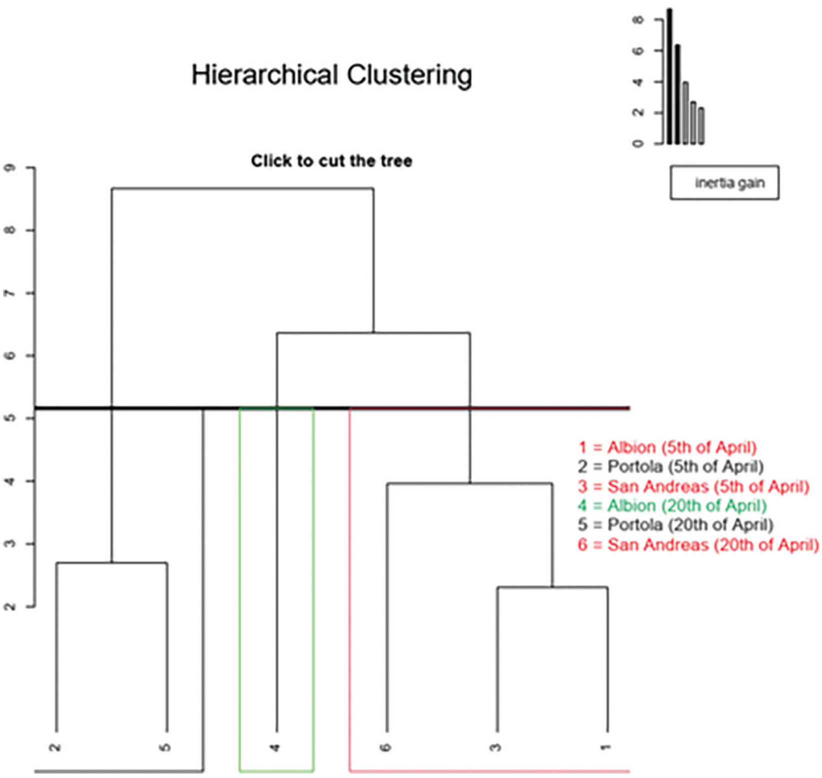

Figure 6. Hierarchical clustering for grouping study cultivars and planting dates.

and yield and SD (with 0.70). A moderate positive correlation was noted for fruit width and fruit firmness, fruit length and fruit firmness, FW and fruit firmness, FW and total anthocyanin, leaf number and SSC, and ascorbic acid and total anthocyanin. In addition to these positive correlations, some of the study parameters

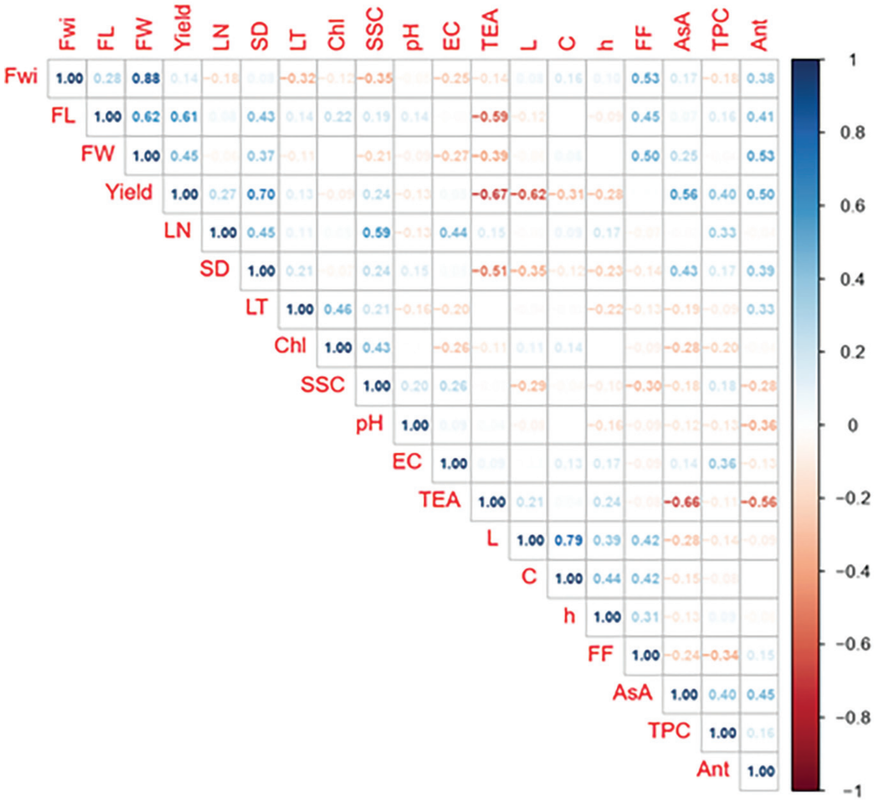

Figure 7. Correlation analysis of the study parameters and cultivars. EC, electrolyte conductivity; FW, fruit weight; SD, stem diameter.

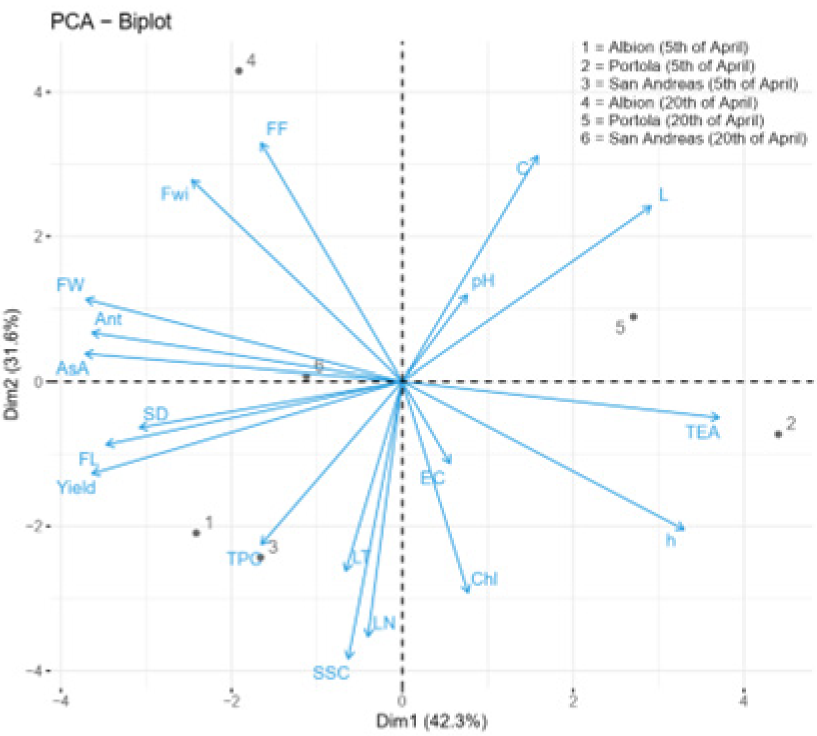

Figure 8. PCA biplot analysis of the study parameters, cultivars and planting dates.

were noted to have moderate negative correlations, namely, fruit length and TA, yield and TA, yield and colour *L* value, SD and TA, TA and ascorbic acid, and TA and total anthocyanin.

Detailed analysis of the PCA biplot (Figure 8) was used to analyse the relationships between the cultivars and study parameters and identify the parameters that were superior for different cultivars. It is clear from Figure 8 that 'Albion' and 'San Andreas' cultivars planted on 5 April had similar quality parameters. Both the cultivars had superior TPC, yield, fruit length, SD, leaf temperature, leaf number and SSC, while those planted on 20 April had the superior fruit firmness, fruit width, FW, total anthocyanin and ascorbic acid. Moreover, the results showed that there is not much difference among the superior parameters of 'Portola' when planted early or late. On both early and late planting conditions, 'Portola' showed the most superior TEA and good colour *h* and colour *L* values.

CONCLUSION

The study provided insight into the role of cultivar and climatic conditions on edible quality and accumulation of vitamin C, anthocyanin and total phenolics of strawberry fruits. Cultivar and planting dates had no significant effect on fruit dimension and nutritional quality. However, plant performance and SD were significantly affected. Strawberry cv. 'Portola' at both planting dates and cv. 'Albion' at the late planting date (20 April) had the least plant performance. Strawberry cv. 'Portola' fruits had the highest TA. Considering the short growth cycle of strawberry plants to produce appropriate yields and the quality of berry in terms of SSC, phenolics, SSC/TA and anthocyanins, planting 'Albion' on 5 April and 'San Andreas' on 5 or 20 April are recommended for the climatic condition of Korkuteli district. 'Albion' was the superior in terms of yield and was considered the most appropriate for early planting in this region.

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AUTHOR CONTRIBUTIONS

N.U. and V.O. – conceptualisation, methodology, investigation, and writing and review of the manuscript. V.O., J.B. and H.S.H. – review and editing, and data analysis. I.K. – investigation and validation. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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