



Physiochemical attributes of early and late maturing peach cultivars during ripening

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Abstract

Peach is popular summer fruit crop being cultivated in temperate and subtropical region of the world. In Pakistan it is grown in Khyber Pukhtunkhwa, Balochistan and Punjab but less attention has been paid to peach fruit because of high perishability and short postharvest life. Therefore, very little information is available about various changes in physico-chemical quality of peach during fruit ripening. In this regard an experiment was conducted to analyze the ripening behaviour of different peach cultivars during ripening by evaluating their physiological (weight loss, respiration rate, ethylene production), physical (fruit firmness) and biochemical *viz.* Total soluble solids (SSC), titratable acidity (TA), SSC:TA ratio, ascorbic acid (Vitamin C), total sugars, reducing sugars, non-reducing sugars, total carotenoids, antioxidant activity and total phenolic attributes. Fruits of five different peach cultivars were collected from District Swat and Mardan and were kept at ambient conditions in laboratory for five days and were evaluated for various physio-chemical attribute during ripening period. Results revealed that significant variations occurred in fruit quality of all cultivars during ripening at ambient conditions. At day-5 of ripening, cultivar '8-A' exhibited maximum SSC; whereas, lowest SSC was measured in 'Flordaking'. Maximum ascorbic acid content and total sugar were observed in '5-A' fruit at ripening day 5; while, maximum total antioxidant, total phenolic content and total carotenoids content were noted in cultivar 'Tex-6A-69'. Maximum fruit firmness was recorded in cultivars '5-A'. Percent physiological loss in fruit weight was lower in cv. '8-A' and maximum weight loss was recorded in 'Tex-6A-69' from day 1 to 5. Results revealed that cultivars '8-A' and 'Tex-6A-69' had the best physico-chemical properties and better eating quality after 4 days ripening at ambient condition and these cultivars showed by grown and marketed for better consumption

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Introduction

The peach (*Prunus persica* L. Batsch) belong to family 'Rosaceae' is an important summer fruit crop of temperate regions of the world. Peach is commercially produced in more than 23 countries with total 21.51 million MT productions, on an area of 1.44 million ha (FAO, 2010). In Pakistan, peach is mainly cultivated in Khyber Pakhtunkhwa and Punjab and Baluchistan with total production of 52.6 thousand tons on an area of 15.2 thousand ha (Agriculture Statistics of Pakistan, 2010). Commercial cultivars of peach being grown in Pakistan are categorized into early, mid and late season cultivars. Early cultivars include 'Flordaking', 'Early Grand', 'Florida Gold', 'Tex-6A-69', 'Indian Blood'; mid-season cultivars include '2-A', '3-A', '4-A', '5-A', while cultivars '6-A', '7-A', '8-A', 'Shahpasand' and 'Shireen' are categorized as late season maturing cultivars (Zeb and Khan, 2008).

Peach has been reported to be a highly nutritious fruit and contain vitamin A, vitamin B1, vitamin B2, and niacin. It is also a good source of minerals like calcium, phosphorus, iron, and potassium. In recent years due to increased public awareness, fruit dietary value is a significant parameter which describes fruit quality. Peaches have low caloric content, low fat percentage and high level of antioxidants, as compared to mango and banana etc. (Wolfe *et al.*, 2008). The presence of antioxidants in peach fruit helps in preventing cardiac vascular problems, blood pressure and cancer (Ascherio *et al.*, 1992).

Fruit ripening is a complex process that involves several physiological, physical and biochemical changes, such as ethylene production, respiration rate, colour, aroma texture, sugar, organic acid, volatile and aromatic substances (Remorini *et al.*, 2008). Peach is a climacteric fruit possesses 3 to 4 days of shelf life due to high respiration rate when kept at ambient conditions (Wills *et al.*, 2007). Peaches and nectarines exhibit rise in their respiratory activities and a surge of ethylene production during ripening (Brovelli *et al.*, 1999). Various peach cultivars has been reported to show variation in skin colour, textural firmness,

phytochemical such as phenolic compounds, sugar contents during ripening (Cascales *et al.*, 2005). Maximum ethylene production ($0.3825 \mu\text{L g}^{-1} \text{h}^{-1}$) has been reported in July Elberta cultivars during 5th day of ripening (Budde *et al.*, 2000). During the study of quality attributes of various peaches and nectarine it was found that cultivar 'White Lady' showed good firmness (Frecon *et al.* 2002), higher sugars concentration and good aroma of cultivars 'Maruvilha' (Wen an Sherman, 2002) and maximum (24%) Soluble solids content (SSC) (Russel and Topp, 2002). Ripening behaviour of peach cultivar 'Ghiaccio-1' were studied at ambient temperature, it was found that loss of fruit firmness was higher (2.7 kg) during the first two days (Testoni *et al.*, 2006). Significant differences were noticed regarding various phyco-chemical attributes in most of the peach cultivars when analysed at ambient conditions. Maximum ascorbic acid, soluble solids content and dry matter was observed in 'Khounihaste-joda', 'Anjiri-ye maleki' and Anjiri-ye-khouni' (Hajilou and Fakhimrezaei, 2011).

In Pakistan peach is an emerging stone fruit of temperate regions and its demand is increasing day by day because of its taste, flavour, aroma and nutritional value. The harvesting season of peaches in Pakistan start from May and end in September. The introduction of imported cultivars in Pakistan and establishment of new orchards has significantly increased the productivity of peach. These peach cultivars shows variation in their physical characters like colour, size, texture, biochemical characteristics like SSC, acidity and organoleptic properties like flavor, aroma etc. Peaches being a climacteric fruit, after harvest exhibit rapid ripening and deteriorate within in four to five days. Ripening behaviour may vary from cultivar to cultivar. For melting peaches that soften rapidly after harvesting ripen earlier having short shelf life at ambient condition, while for non-melting peaches that soften slowly have slow ripening process. Similarly ripening behaviour of low chilling varieties also differs from high chilling varieties. The main problem for peaches in Pakistan are too early or late harvesting,

continuous supply to the market that cause glut in the market and improper management and handling during storage and shipment results in poor texture and off flavour which reduces the market value and price which discourage the growers. It has been estimated that postharvest loss in peaches is about 23% for different peach varieties (Khan, 2008). Recently research work has been done on three early cultivar of 'Early Grand', Selection No-3' and Florida Gold' harvested from Nowshehra (Soan Valley), while two late cultivar cultivars 'Maria Delezia' and 'Indian Blood' were harvested from orchard in Swat (KPK). The ripening behavior and physico-chemical properties were discovered at ambient condition and it was concluded among early cultivars 'Florida Gold' showed best results; while, 'Maria Delezia' showed best results among late maturing cultivars. However, still more effort is needed to evaluate commercial cultivars like '5-A' and '8-A' that commercially has high value peaches produced in Swat KPK. The ripening and overall postharvest potential of these peach cultivars along with three early cultivar 'Early Grand', 'Flordaking' and 'Tex-6A-69' should be assessed. Clear knowledge of fruit shelf life and ripening is therefore necessary in order to assist growers to make decisions regarding harvesting and fruit handling practices. Knowledge of biochemical and physiological changes that occur in fruit during ripening of these commercial peach cultivars is necessary to explore storage potential for fresh consumption in domestic as well as export markets (Scalzo *et al.*, 2005; Giorgi *et al.*, 2005). So, the present study was designed to analyze the ripening behaviour of different peach cultivars during ripening by evaluating their physiological, physical and biochemical parameters to determine their optimum ripening stage for best eating quality collected from different location in Khyber Pukhtunkhuwa.

Materials and methods

Experimental treatments

The study was carried out on five commercial peach cultivars. Peach cultivars 'Flordaking', 'Early Grand' and 'Tex-6A-69' (early maturing) were harvested from commercial orchard in District Mardan (34°2027.40 North and 72°1120.05 East) (KPK),

while that of late maturing cultivar '5-A' and '8-A' were harvested at commercial maturity from commercial orchard in Swat (34°4547.95 North and 72°2038.95 East) (KPK). After harvesting, fruit was kept under tree shade to remove field heat. Fruit was packed in corrugated cardboard boxes and transported to Postharvest Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Five treatments were made and each treatment was replicated three times. Ten fruit per replicate was used as experimental unit, subjected to ripening at ambient temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$; 60-65% RH). Data was recorded at five removals that was at 1st, 2nd, 3rd, 4th and 5th day of fruit ripening.

Determination of fruit physiological quality

For determination of respiration rate, five fruits from each replication were arbitrarily selected and kept into a plastic jars sealed for air for 1 h. Respiration rate was calculated by computing CO₂ synthesis using a CO₂ analyzer (Vaisala MI 70, Vaisala Inc., Helsinki, Finland) and expressed as mg CO₂ kg⁻¹ h⁻¹. For monitoring ethylene production, five fruits per replication were randomly selected, weighed initially and placed into a sealed plastic jar for 1 hour.

Ethylene production was determined by using ethylene meter (model ICA-56, International Controlled Atmosphere Ltd, United Kingdom) and expressed as mmole C₂H₄ kg⁻¹ h⁻¹.

Determination of fruit physical quality

Fruit firmness of the fruit was determined with the help of Penetrometer by removing peel from 5 mm area and inserting the probe and was expressed as Newton (N). Fruit weight was recorded gravimetrically using standard digital weight balance (Ohaus EB30, Ohaus Corp.) and physiological weight loss (PWL) was calculated as difference between initial weight (before storage) and final weight (on each removal) and divided by initial weight and was expressed in percentage by using following equation.

Determination of fruit biochemical quality

For the determination of biochemical components, all the fruits of each replication were peeled off with a stainless steel knife. The juice was extracted from each sample and homogenized to study the biochemical parameters. Digital Refractometer (Atago Japan PAL-1) was used for determination of SSC. The instrument was calibrated every time with distilled water before and during use. A drop of juice was placed on the prism of refractometer and SSC (°Brix) was noted directly from the digital refractometer scale at ambient temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$; 60-65% RH). Titratable acidity (TA) was determined as stated by Hortwitz (1960). Ten mL fruit juice was taken from each sample in a 100 mL beaker, diluted (1:4) with distilled water and titrated against N/10 NaOH solution after adding 2-3 drops of phenolphthalein ($\text{C}_{20}\text{H}_{14}\text{O}_4$) as indicator till end point was achieved. Calculations were made by following formula:

Where 0.0064 = correction factor

SSC: TA ratio was calculated in each sample by dividing the SSC with the corresponding values of TA i.e. SSC: TA ratio = SSC/TA .

Ascorbic acid in the peach pulp was determined using method reported by Ruck (1969). Juice of each sample was filtered by using Whatman filter paper. Ten mL aliquot was placed in round bottom flask having capacity of 100 mL. The volume was made up to mark (100 mL) by adding 0.4% oxalic acid. After being filtered through filter paper, 5 mL aliquot was shifted in a beaker and titrated against dye (2, 6-dichlorophenol indophenol) with light pink colour as end point which persisted for 10-15 seconds. For the preparation of dye, 42 mg of baking soda (NaHCO_3) and 52 mg of 2, 6-dichlorophenol indophenol were dissolved in distilled water in volumetric flask and volume was made upto 200 mL. Following formula was used for determination of ascorbic acid:

$$\text{Ascorbic Acid (mg } 100\text{g}^{-1}) = \frac{D_1 \times V \times 100}{D \times A \times B}$$

Where

D_1 = mL of dye used in titration of aliquot

D = mL of dye used in titration of 1 mL standard ascorbic acid solution prepared by adding 1 mL of 0.1% ascorbic acid + 1.5 mL of 0.4% oxalic acid

A = mL of juice used

V = volume of aliquot made by addition of 0.4% oxalic acid

B = mL of aliquot used for titration

Method given by Hortwitz (1960) was used to determine total sugars, reducing sugars and non-reducing sugars in peach. Three solutions *viz.* juice filtrate, invert sugar solution and Fehling's solution was used for the determination of sugars. Antioxidants were determined according to the method described by Zaharah and Singh (2011). Peach pulp sample (5 g) stored in aluminum foil at -80°C was weighed with digital weight balance (Model TK-500, Japan) and was thoroughly homogenized in mortar and pestle. Then 10 mL of extraction buffer (methanol:water 80:20) was added in homogenized pulp sample and shifted in falcon tube. These falcon tubes were centrifuged at 15,000 rpm for 15 min. Sample was prepared by adding 50 μL supernatant and 950 μL DPPH solution. The prepared samples were fed to UV-visible spectrophotometer (IREMCO UV-Vis U 2020, USA) at 515 nm wavelength to determine their absorbance. Total antioxidants were expressed as mM Trolox Equivalent Antioxidant Activity (TEAA) 100 g^{-1} FW basis. Total phenolic contents were determined by the procedure and protocols lined out by the Rebeiro *et al.* (2007) and were expressed as mg Gallic Acid Equivalents g^{-1} fresh weight. Samples were stored at -80°C for 1-2 months. After removing samples, one gram of each sample was weighed by digital weight balance (Model TK-500, Japan) and 10 mL extraction mixture (methanol: water 60:40) were taken and homogenized with the help of mortar and pestle and homogenous mixture was prepared with 20 mL methanol. The homogenous mixture was poured into the falcon tubes and was vortexed for 2-3 min. Then samples were centrifuged for 3-5 min.

After centrifuge 500 μL supernatant was taken and 500 μL F-C reagents was added into the falcon tubes containing samples and shaking was done again for 1-2 min with the help of vortex then 500 μL supernatant, 500 μL F-C reagent and 500 μL of 7.5% Na_2CO_3 were added into the samples in apendrops and incubation was done for 30 minutes. After incubation absorbance was recorded by spectrophotometer (IREMCO UV-Vis U 2020) at 765 nm. A standard or blank was also run independently. A standard curve was made from the blank corrected A_{765} of the gallic acid standards and total phenolic contents were calculated as gallic acid equivalents using regression equation between the gallic acid standards and A_{765} . Total carotenoids were estimated according to method reported by Lalel *et al.* (2003) with some modifications using silica sand for grinding. One gram of homogenized ripe fruit pulp with 0.05 g of magnesium carbonate was ground in silica sand (under laminar flow hood avoiding light and fumes) using glass mortar and pestle and centrifuged at 10,000 rpm. Two extractions were made using 20 mL of acetone: n-hexane (75:60 v/v) mixture per sample. The pool extract was collected in separating funnel and washed with a 40 mL of 10% NaCl and 2 x 40 mL of distilled water to remove acetone. The hexane extract was measured for its absorbance at 436 nm using UV-visible

spectrophotometer (IREMCO UV-Vis U 2020, USA) and was expressed as $\mu\text{g g}^{-1}$ of β -carotene equivalent from a standard curve of β -carotene.

Statistical analysis

The experimental data were subjected to analysis of variance (ANOVA) using Statistix 9 for windows software with two factorial arrangements including cultivars, fruit ripening periods. The effects of treatments were determined from the least significant differences test (LSD) at $P \leq 0.05$.

Results

Analysis of variance indicated that various peach cultivars significantly differed for physiological weight loss, ethylene production, respiration rate, fruit firmness, soluble solid contents, titratable acidity, SCC: TA ratio, total sugars, reducing sugars, non-reducing sugars, ascorbic acid, total antioxidants, total carotenoids and total phenolics. Similarly, all these physical, physiological and biochemical parameters were significantly different among various days at which the peach fruits were analyzed. However the interaction of peach cultivars with the days of analysis was only significant for ascorbic acid, total sugars, reducing sugars, non-reducing sugars, fruit firmness, ethylene production and respiration rate; interaction being non-significant among remaining physiological and biochemical traits.

Table 1. Mean changes in SSC for cultivars, ripening period and interaction between cultivars and ripening period.

Cultivars	Day 1	Day 2	Day 3	Day 4	Day 5	Cultivar mean
Early Grand	8.60	9.30	10.30	10.97	10.73	9.98C
Flordaking	8.47	8.67	9.37	9.73	10.00	9.25D
Tex-6A-69	10.17	11.17	11.50	11.80	11.97	11.32A
5-A	9.17	9.53	10.37	11.27	12.07	10.48B
8-A	9.50	10.30	11.13	11.93	12.57	11.09A
Mean (D)	9.18D	9.79C	10.53B	11.14A	11.47A	

Means followed by different letters for a given parameter for cultivars and ripening period significantly different at $P \leq 0.05$ (LSD test).

Changes in fruit firmness weight loss and

Fruit firmness exhibited a significant decreasing trend as ripening period proceeded, for cultivars and ripening period and interaction between ripening period and cultivars (Fig. 1A & 1B).

Lowest fruit firmness was recorded 'Tex-6A-69' (Fig. 1A) at day 5 fruit ripening; while maximum fruit firmness was observed in 8-A (Fig. 1B) at day 1 almost 5-fold greater day-5 among all cultivars. Fruit weight loss showed exhibited significant variation for cultivars and ripening period.

Moreover, significant results were also obtained for interaction between the cultivars and ripening period (Fig. 1). Maximum physiological weight loss was observed in 'Tex-6A-69' (Fig. 1C) while it was minimum in 8-A followed by 5-A (Fig. 1D).

Changes in respiration rate and ethylene production

Respiration rate and ethylene production showed significant increasing trend as the ripening period progressed (Fig. 2).

Fruit showed their ethylene production and respiration peaks on day-5 of fruit ripening irrespective of ripening period and cultivars.

Table 2. Mean changes in titratable acidity (%) for cultivars, ripening period and interaction between cultivars and ripening period.

Cultivars	Day 1	Day 2	Day 3	Day 4	Day 5	Cultivar mean
Early Grand	0.81	0.77	0.67	0.61	0.56	0.68A
Flordaking	0.72	0.69	0.61	0.55	0.46	0.61C
Tex-6A-69	0.61	0.59	0.54	0.51	0.49	0.54D
5-A	0.76	0.70	0.65	0.58	0.55	0.65B
8-A	0.67	0.63	0.55	0.48	0.43	0.55D
Mean (D)	0.71A	0.68B	0.60C	0.54D	0.50E	

Means followed by different letters for a given parameter for cultivars and ripening period significantly different at $P \leq 0.05$ (LSD test).

Table 3. Mean changes in Total antioxidants (mM Trolox g^{-1}) for cultivars, ripening period and interaction between cultivars and ripening period.

Cultivars	Day 1	Day 2	Day 3	Day 4	Day 5	Cultivar mean
Early Grand	2.29	1.88	1.68	1.35	1.25	1.69A
Flordaking	1.79	1.62	1.44	1.43	1.32	1.52AB
Tex-6A-69	2.50	2.07	1.81	1.46	1.55	1.88A
5-A	1.70	1.52	1.22	1.07	0.93	1.29BC
8-A	1.24	0.89	0.94	0.79	0.80	0.93C
Mean (D)	1.90A	1.60AB	1.42BC	1.22BC	1.17C	

Means followed by different letters for a given parameter for cultivars and ripening period significantly different at $P \leq 0.05$ (LSD test).

Maximum respiration rate was recorded in 'Tex-6A-69' at day-5 (Fig. 2A), while it was minimum in 5-A followed by 8-A at day-1 (Fig. 2B). Maximum ethylene production was recorded in 'Tex-6A-69' at day-5 (Fig. 2C), while it was lowest in '5-A' (Fig. 2D) at day 1 followed by 'Early Grand' and 'Flordaking' at day 2 and 'Early Grand' at day 3 (Fig. 2C).

Changes in SSC, TA and SSC: TA Ratio

Different peach cultivars and ripening periods showed significant change in SSC,

TA and SSC: TA of peach fruit during ripening at ambient conditions. Maximum soluble solid contents and SSC:TA ratio was recorded in 'Tex-6A-69' followed by 8-A while they were lower in Early Grand (Table 1).

Maximum titratable acidity was recorded in 'Early Grand' while it was lowest in 'Tex-6A-69' and '8-A' (Table 2); while, highest SSC:TA ratio was recorded in 'Tex-6A-69' (Fig. 3A).

Maximum ascorbic acid contents were recorded in 'Flordaking' at day-1; being minimum in 'Tex-6A-69' at day 5 (Fig. 3C).

Maximum total sugars and non-reducing sugars were recorded in '5-A' at day-5 while they were minimum in 'Early Grand' and 'Flordaking' at day-1 (Fig. 4B, 4E). Maximum reducing sugars were recorded in 8-A at day-5 (Fig. 4D); however they were minimum in 'Tex-6A-69' at day-1 (Fig. 4C).

Changes in total antioxidants, total phenolic contents and total carotenoids

Maximum total antioxidants were recorded in 'Tex-6A-69' followed by 'Early Grand'; being lowest in '8-A' followed by '5-A' (Table 3). Total phenolics were highest in '5-A' followed by 'Tex-6A-69', while lowest in 'Flordaking' followed by Early Grand (Table 4). Total carotenoids were lowest in 'Early Grand' while were highest and statistically similar all other peach cultivars (Table 5).

Table 4. Mean changes in Total phenolic (mg 100 g⁻¹) for cultivars, ripening period and interaction between cultivars and ripening period.

Cultivars	Day 1	Day 2	Day 3	Day 4	Day 5	Cultivar mean
Early Grand	11.95	14.29	17.92	20.00	22.08	17.25BC
Flordaking	11.98	13.62	14.92	16.41	16.98	14.78C
Tex-6A-69	15.62	23.74	23.82	25.53	28.29	23.40AB
5-A	20.53	22.47	24.65	26.44	27.20	24.26A
8-A	18.74	21.50	23.29	25.32	26.67	23.10ABC
Mean (D)	15.77	19.12	20.92	22.74	24.24	

Means followed by different letters for a given parameter for cultivars and ripening period significantly different at $P \leq 0.05$ (LSD test).

Table 5. Mean changes in Total carotenoids (mg 100 g⁻¹) for cultivars, ripening period and interaction between cultivars and ripening period.

Cultivars	Day 1	Day 2	Day 3	Day 4	Day 5	Cultivar mean
Early Grand	0.47	0.47	0.45	0.44	0.42	0.45B
Flordaking	0.54	0.51	0.51	0.48	0.48	0.50A
Tex-6A-69	0.51	0.51	0.48	0.50	0.50	0.50A
5-A	0.52	0.50	0.47	0.44	0.44	0.47A
8-A	0.52	0.50	0.51	0.49	0.49	0.50A
Mean (D)	0.51A	0.50AB	0.49AB	0.47BC	0.47BC	

Means followed by different letters for a given parameter for cultivars and ripening period significantly different at $P \leq 0.05$ (LSD test).

Discussion

Wight loss, Fruit Firmness

This variation in physical, physiological and biochemical traits might be due to genetic differences in the peach cultivars. We noted that physiological fruit loss increased with the passage of time in peach cultivars which might be due to high transpiration rate when fruits were stored under ambient conditions (Akbudak and Eris, 2004).

In this study, fruit firmness decreased with time which might be due to several physiological activities such as that turgor pressure, starch degradation and cell wall breakage during ripening at ambient conditions that result in loss of textural firmness (Hussain, 2010).

Respiration rate and Ethylene Production

Respiration rate also increased with the passage of time. We also noted that initially respiration rate was high in early maturing cultivars.

Similarly, overall respiration rate was also higher in these cultivars during ripening period, as compared to late maturing cultivars which concluded that the increasing trend of respiration rate was higher in early maturing cultivars. Maria *et al.* (2009) also stated that respiration rate increases with the passage of time in peach.

There was a rapid increase in peach cultivars with the passage of time which might be due to higher temperature at which fruits were handled because temperature is considered as the most important external factor for stimulating climacteric rise or ethylene production (Watkins, 2003).

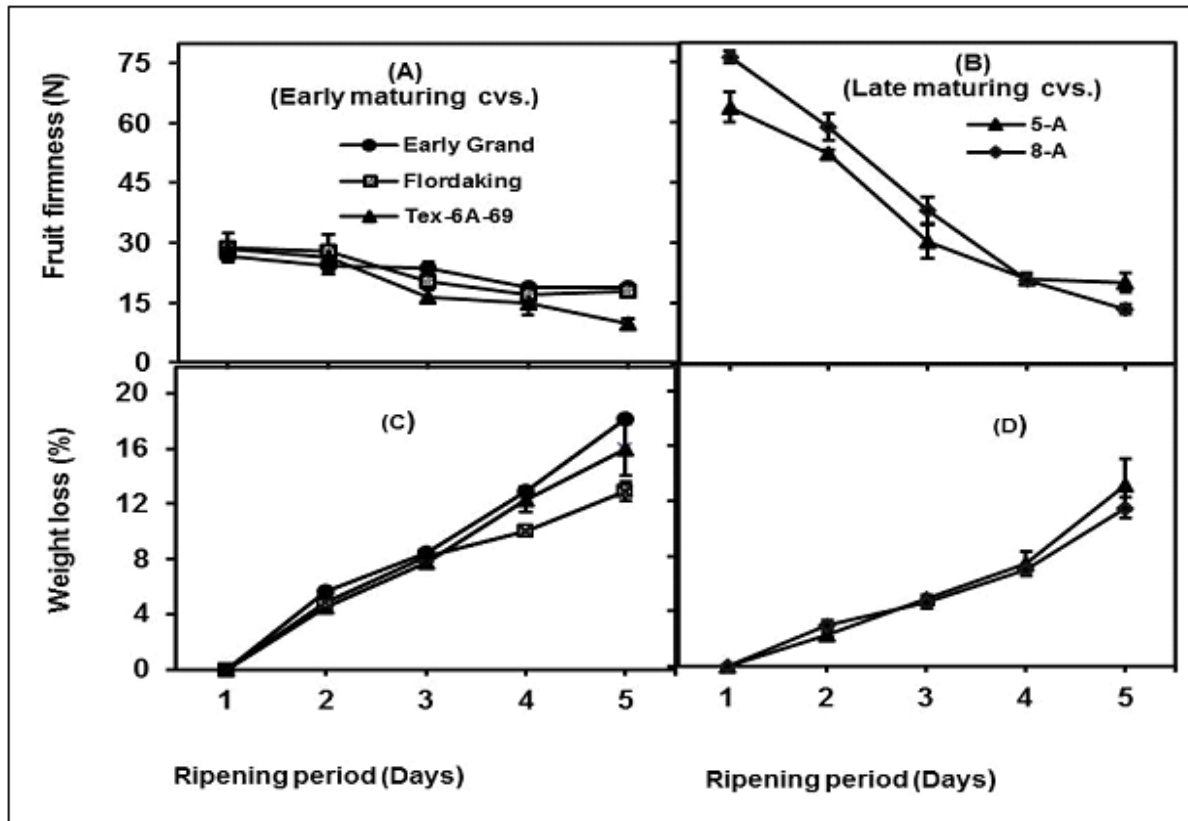


Fig. 1. Changes in fruit firmness of early (A, B) and fruit weight loss (C, D) of early and late season maturing peach cultivars during ripening at ambient conditions. Vertical bars represent \pm SE of mean $P \leq 0.05$. $n = 3$ replicates.

Sloube Solids Content (SSC), Titaratable Acidity and SSC: TA

SSC increased after harvest when fruit are stored at ambient temperature condition. Bhakti *et al.* (2011) also reported that SSC was higher during ripening in peach cultivars at ambient conditions. It was observed that TA of peach fruits decreased during maturation and ripening.

This decrease in TA might be due to metabolism of acid during ripening period (Akbudak and Eris, 2004). SSC: TA ratio of in peach fruit increased during ripening which was due to increase in (SSC) and decrease in (TA) (Serrano *et al.*, 2005).

Ascorbic acid contents and sugars (Total, reducing and non-reducing sugars).

Ascorbic acid contents were reduced during ripening and this reduction in ascorbic acid content may be due to high temperature and low relative humidity at ambient condition. Mateja *et al.* (2005) also reported that during ripening at ambient conditions, ascorbic acid contents were reduced in cultivar 'Spring Red'.

The rise in total sugars during ripening might be due to accumulation and biosynthesis of sucrose in peach fruit during ripening period (Esti *et al.*, 1997).

Total antioxidants, total phenolic contents and total carotenoids

The antioxidant activity of different peach cultivars is significantly influenced by cultivar type, ripening stage, ripening time. High antioxidant activity was measured in 'Nectapink' ($711.73 \mu\text{g } 100 \text{g}^{-1}$), 'Fercluse' while cultivar 'Grenat' had the lowest ($566 \mu\text{g } 100 \text{g}^{-1}$) total antioxidants activity (Reig *et al.*, 2013).

Our results related to total phenolic contents are close to the findings of Infante *et al.* (2011) who evaluated two different peach cultivars 'Elegant Lady' and 'Carson' during ripening period and concluded that the concentration of total phenols was higher in 'Elegant Lady' and 'Carson' showed the lowest total phenolic contents.

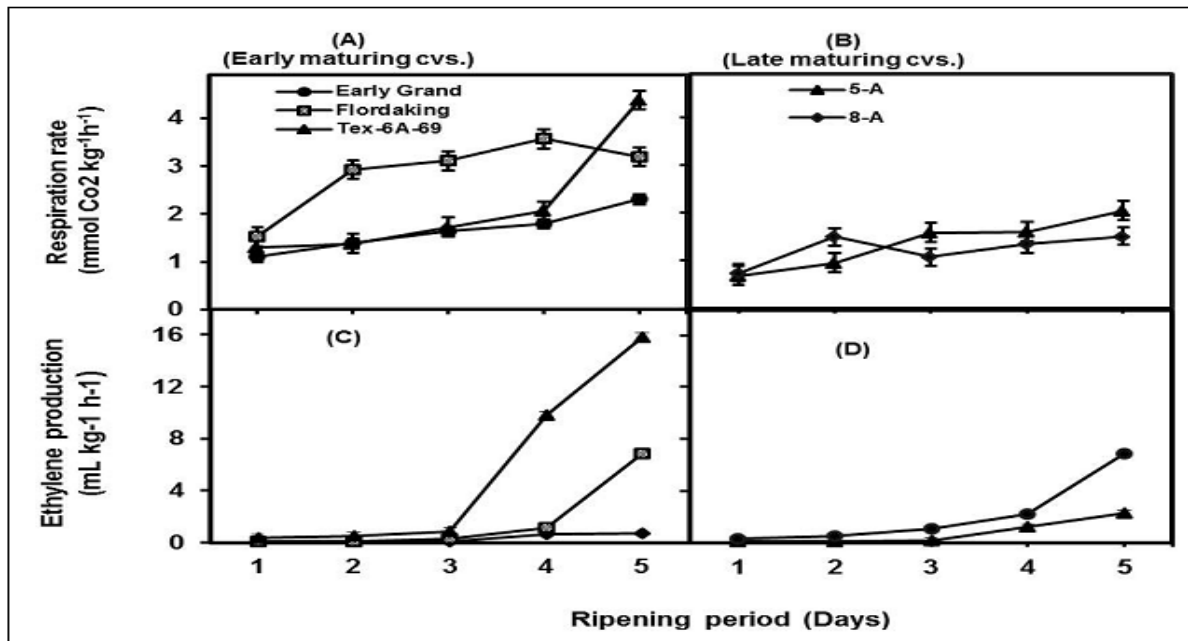


Fig. 2. Changes in respiration rate (A, B) and ethylene production (C, D) of early and late season maturing peach cultivars during ripening at ambient conditions. Vertical bars represent \pm SE of mean $P \leq 0.05$. $n = 3$ replicates.

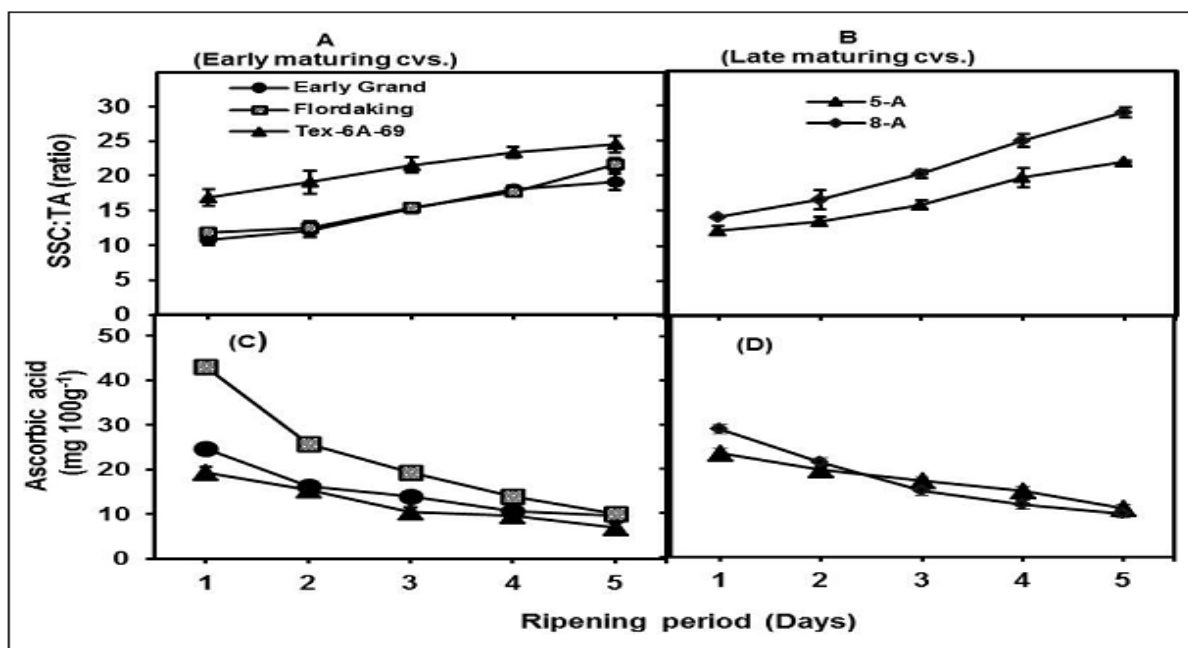


Fig. 3. Changes in SSC: TA (A, B) and ascorbic acid content (C, D) of early and late season maturing peach cultivars during ripening at ambient conditions. Vertical bars represent \pm SE of mean $P \leq 0.05$. $n = 3$ replicates.

Our results related to total carotenoids are in agreement with the findings of Maria *et al.* (2002) who revealed that the concentration of total carotenoids were higher for yellow-flesh peaches

(71-210 $\mu\text{g } 100 \text{ g}^{-1}$); while, it was minimum for nectarine during ripening period. It was also observed that irrespective of cultivars and total carotenoids decrease during ripening period (Scalzo *et al.*, 2005).

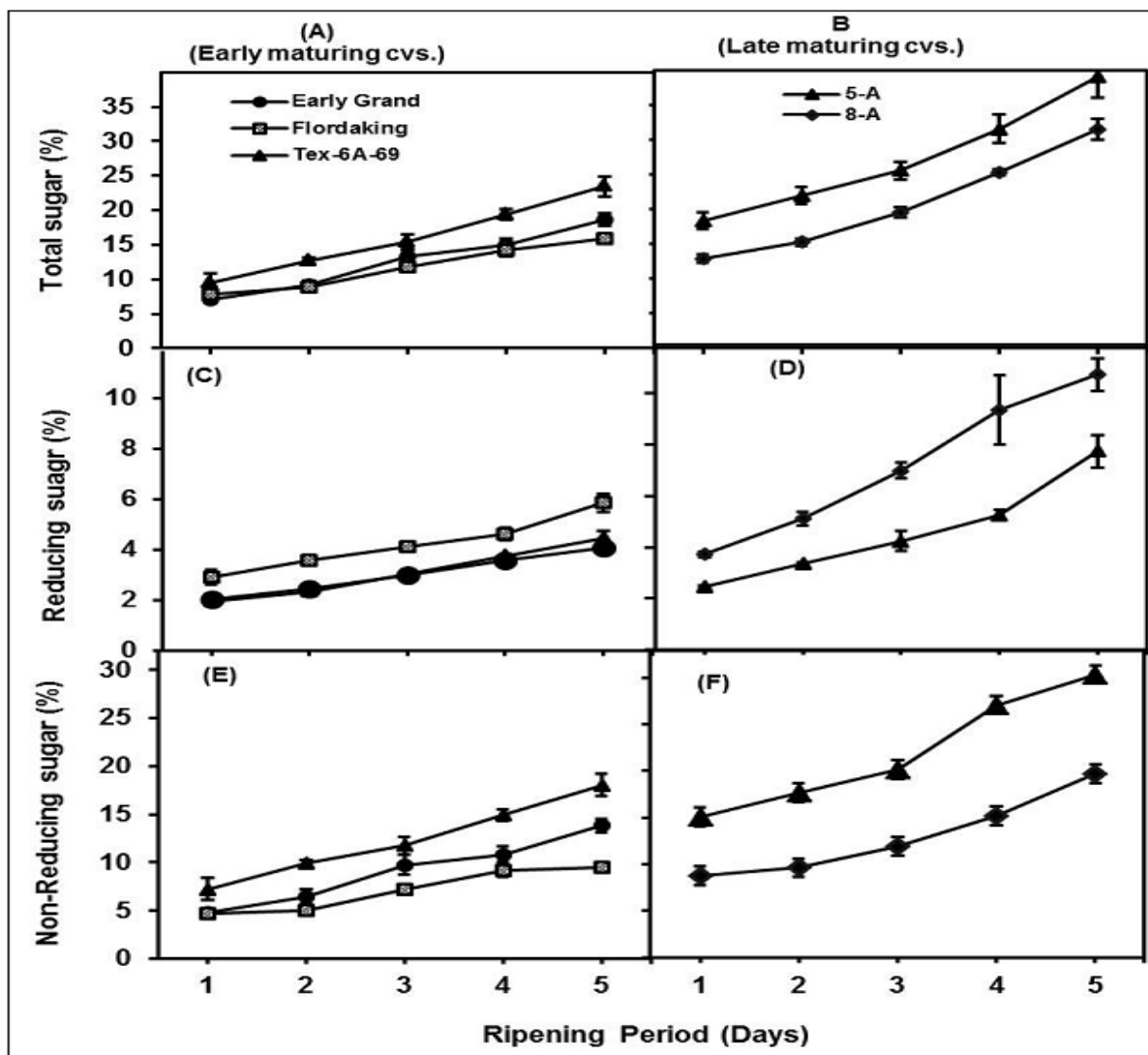


Fig. 4. Changes in total sugars (A, B), reducing sugars (C, D) and non-reducing sugars (E, F) of early and late season maturing peach cultivars during ripening at ambient conditions. Vertical bars represent \pm SE of mean $P \leq 0.05$. $n = 3$ replicates.

Conclusion

In conclusion cultivars and ripening period significantly influenced the various physical, physiological and biochemical quality attributes different peach fruit cultivars. Among early season maturing cultivar 'Tex-6A-69' and late maturing cultivars '8-A' exhibited superior fruit quality attributes than other early and late maturing peach cultivars with better eating quality.

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