

RESEARCH ARTICLE

Effect of various temperatures on the postharvest quality and storage life of persimmon fruit

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ABSTRACT

An experiment was conducted to find out the "effect of various temperatures on the postharvest quality and storage life of persimmon fruit" at Post Harvest Horticulture Laboratory, The University of Agriculture Peshawar, during 2016. The experiment was laid down in Completely Randomized Design (CRD) having two factor replicated thrice. Persimmon fruits were stored at different temperatures (10°C RH=89±1, 20°C RH=79±1 and 30°C RH=69±1) and storage durations (0, 6, 12, 18, 24, 30 and 36 days). Fruits were analyzed for different physico-chemical attributes after each 6 days of storage durations. Temperature show significant effect on the quality attributes of persimmon fruit. Maximum value of fruit firmness (3.75 kg/cm²), ascorbic acid content (37.68 mg/100g), moisture content (71.47%) and titratable acidity (0.24%) with minimum weight loss (8.09%), waste percent (3.8%), color score (3.19), taste score (3.44), total soluble solids (TSS) (17.76 °brix) and pH (5.84) were noted in fruits stored at 10°C. Quality attributes were significantly influenced by storage durations. The highest fruit firmness (4.07 kg/cm²), moisture content (76.81%), titratable acidity (0.30%) and ascorbic acid content (50.44 mg/100g) with minimum value of TSS (15.27 °brix), pH (5.27), weight loss (0.00%), waste percent (0.00%), color score (1.66) and taste score (1.72) were found in fresh fruits. The interaction showed significant effect on all quality parameters. The highest fruit firmness (3.23 kg/cm²), moisture percent (64.22%), titratable acidity (0.18%) and ascorbic acid content (22.22 mg/100g) with minimum value of TSS (21.66 °brix), pH (6.29), weight loss (19.17%), waste percent (17.77%), color score (5.51) and taste score (5.50) were found in fruits on 36 days of storage durations at 10°C. The overall results revealed that fruits stored at 10°C maintained all the qualitative attributes of persimmon fruits up to 36 days storage durations.

Keywords: Persimmon, temperature, storage duration, qualitative attributes and waste percentage

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INTRODUCTION

Persimmon (*Diospyros kaki*) is an important fruit crop belong to the family Ebenaceae. It has been reported that it is originated from China and Japan. It is known as Japanese persimmon or Kaki. It is highly desired fruit due to its unique taste and high nutritional value persimmon fruits are consumed fresh as well as for canning and drying purpose. The nutritional evaluation of the fruit shows that it's rich in minerals, carotenoids, natural antioxidant, ascorbic acid, and dietary fiber which are helpful to reduce degenerative human diseases (Charlotte, 1959; Dongowski, 1994). Persimmon fruit contains 50 mg/100 g ascorbic acid in the fresh pulp and observed that, if ascorbic acid is well retained, the other nutrients will also well retain (Nicoletti et al., 2004). Persimmon fruits are considered as important nutraceutical fruit because they are rich in phenolic compounds, sugars, minerals, dietary fibers, and carotenoids. These phytochemicals plays an important role in

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terms of color, flavor, firmness and pharmaceutical value of the fruit. Phenolics and Carotenoids are known for their good antioxidant power, anti-carcinogenic, anti-mutagenic and cardio-protective effects (Suzuki et al., 2005). Due to its climacteric behavior deterioration of fruit occurs due to weight loss, changes in flavor, texture and loss of nutritional value during respiration transpiration. These processes can be reduced considerably by appropriate management of temperature and relative humidity during transportation and storage. Proper Storage of fruits is very important to reduce postharvest losses, extending its availability in markets, regulating its supply in the market and its transportation to distant markets. Storage treatments like pre-cooling and storage under low temperature should be used to extend the marketing period of the fruit. To maintain quality of fresh produce, temperature management is the key, as it affects the rate of metabolism and respiration which involves the breakdown of stored carbohydrate to produce energy. By lowering the temperature of produce as soon as possible after harvest will slow down the rate of metabolism and therefore will extend the fruits shelf life. Temperature effect the rate of postharvest deterioration and rate of metabolism reactions within the physiological temperature range increase. During the maturation period, temperature is the most important factor in obtaining good fruit quality for the persimmon fruit (Kitagawa and Lucina, 1984). Low temperatures helps to delay fruit ripening prevent deterioration in the case of climacteric fruits (Wills et al., 1998). It is reported that 40–50 % lost occurs in horticultural commodities before they are consumed; this is primarily due to high water loss, bruising and decay incidence during storage (Ray and Ravi 2005; Kitinoja, 2002). Pakistan being a developing country, the postharvest losses of fruits and vegetables are very high. To overcome these postharvest losses, necessary efforts are needed to keep the grower's interest, consumer's preference, processors, traders and retailers. For this purpose, present study was conducted in which persimmon fruits were stored at various temperature (10°C, 20°C and 30°C) to reduce the postharvest loss and maintain the quality of fruit for periods of up to 36 days.

MATERIALS AND METHODS

The research work entitled as "Effect of various temperatures on the postharvest quality and storage life of persimmon fruit" was carried out at postharvest Horticultural Lab, The University of Agriculture Peshawar. The fruit were harvested at physiological maturity from Horticulture Research form during October, 2016. The fruits were carefully transported and defective fruits including wounded fruits and other disorders were removed. Fruits were washed with running tap water to remove dust particles and microbial load from the surface and then air dried. The experiment was laid down in CRD (Completely Randomized Design) with two factors and repeated three times. The data recorded from all parameters were analyzed using software (Statistix 8.1) and means observed were compared using LSD (Least Significance Difference) at 5% level of significance.

Factor A: Temperature:

$$T_1 = (11+11+10+10+10+9+9)/7 = 10^\circ\text{C}, \text{RH} = 89 \pm 1$$

$$T_2 = (22+21+20+20+20+19+18)/7 = 20^\circ\text{C}, \text{RH} = 79 \pm 1$$

$$T_3 = (31+31+30+30+30+30+28)/7 = 30^\circ\text{C}, \text{RH} = 69 \pm 1$$

Temperature range: =10

Factor B: Storage Durations: 0, 6, 12, 18, 24, 30 and 36 days

The following attributes were studied:

Fruit firmness (kg/cm²)

Fruit firmness was determined using hand-held penetrometer. Measurements made in this study involved driving a probe with a convex tip into whole fruit. Probe with specific diameter (mm) was used to measure the firmness of persimmon fruit.

Weight loss (%)

Weight loss was measured by weighting individual fruit weight before and after storage with the help of digital weight balance. Following formula was used to calculate the weight loss (%).

$$\text{Weight loss} = \frac{W_i - W_s}{W_i} \times 100$$

Where;

W_i = initial weight of fruit before storage

W_s = weight of fruit at the end of each sampling period.

Moisture content (%)

Moisture content was obtained by calculation (when from 100% will be deducted % of total dry matters)

$$\text{Moisture content} = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100 - 100$$

Waste per cent /Undesirable fruits (%)

It was calculated according to the following formula:

$$\text{Waste \%} = \frac{\text{Total number of undesirable fruits}}{\text{Total number of fruits}} \times 100$$

pH

pH was measured by pH meter. Standardization of the pH meter was done by dipping the electrode in the buffer solution. The electrode was dipped in the sample of fruit juice and the reading appears on the screen was recorded as the pH of the sample.

Titrateable Acidity (%)

Titrateable acidity was analyzed by neutralization method (0.1 M NaOH solution in the presence of 1% solution of phenolphthalein indicator) as approved by AOAC (1990). Titrateable acidity was calculated by taking 10 ml of fruit juice sample in volumetric flask, and made the volume up to 100ml with distilled water. 10 ml of sample was taken from diluted sample in a conical flask. 2-3 drops of phenolphthalein indicator were added and then titration was done against 0.1N

NaOH solution. Light pink color appearance indicated the end point and ml of 0.1N NaOH used was recorded for all the samples. The titratable acidity was calculated as under.

$$\text{Titratable acidity (\%)} = \frac{T \times N \text{ of NaOH} \times 100 \times 100}{L \times M}$$

Where, T = NAOH used (ml)

L = Sample taken for dilution

M = Diluted sample taken for titration

Ascorbic acid Content

Ascorbic acid content of the fruit was calculated using the method as approved by the AOAC (1990). It was find out in sample of fruit juice by using the dye 2, 6-dichlorophenyl indophenols method.

Preparation of Dye-solution:

50mg 2, 6-Dichlorophenols dye and 42mg sodium of Bicarbonate (NaHCO₂) was mixed in a beaker contain distilled water. The mixture was heated and continuously stirrer for 30 minutes. After fully dissolved, the volume was made up to 250ml in a volumetric flask. To be safe, it was stored in a cool storage.

Dye-solution Standardization:

Standardization of the dye solution was done before storage to check either the dye will work or not to find out the ascorbic acid. In 50 ml of 0.4% oxalic solution, 50mg of ascorbic acid was dissolved. 2 ml of sample was taken from this solution in a conical flask and titrated against dye. The pink color appearance indicates the end point. The dye factor was calculated by observing readings of the dye on the burette and following formula was used.

$$\text{Dye factor (F)} = \frac{\text{Ascorbicacid solutions(ml)}}{\text{vol.of Dyesolution used}}$$

To calculate the ascorbic acid, 10ml of fruit juice was diluted in 0.4% oxalic acid prepared solution and the volume was made up to of 100ml. 10ml of the sample from the 100ml solutions was titrated against dye using an indicator (liquid phenopthaline). The appearance of light pink color shows the end point and formula used to calculate the ascorbic acid is as under.

$$\text{Ascorbic Acid} = \frac{F \times T \times 100 \times 100}{D \times S}$$

Where, F = Dye factor

T = ml of Dye sol, used from burette

D = Diluted sample (ml) taken for titration

S = Fruit juice (g) taken for dilution

Total soluble solids (°brix)

Hand-held refractometer was used to determine total soluble solids in the sample solution. A few drops of the sample were putted on the prism and was slid properly. The prism was washed properly with distilled water after each reading.

Color and taste

Hedonic scale (Larmond, 1987) was used to check the taste and color of all the fruits samples. Based on the consistency of judgment, a team of specialists was made. From each sample, fruits of persimmon were selected randomly and were presented to the specialist. Specialists were asked to make the difference between samples by giving the numbers (0 to 10). Following table was used:

Grades	Color	Taste
0 to 2	Green Yellow	Extremely disliked
2.1 to 4	Light yellow	Fair
4.1 to 6.0	Orange Yellow	Good
6.1 to 8.0	Orange red	Very good
8.1 to 10.0	Dark orange red	Excellent

RESULTS AND DISCUSSION

Fruit firmness (kg/cm²)

Fruit firmness was significantly influenced by temperature, storage duration and their interaction. Table 1 publicized that the maximum fruit firmness (4.13 kg/cm²) was observed on first day at 20°C, while minimum fruit firmness (1.10 kg/cm²) was observed on 36 days of storage duration at 30°C (fig 1).

The fruit firmness decreases with an increase in temperature and storage durations. Firmness of persimmon fruit decreases during storage (Monzini and Gorini (1982). Persimmon fruit firmness during postharvest is affected by different factors like cell wall degradations and water loss etc, water loss seems to be main factor influencing firmness. This relationship between postharvest firmness and water loss is influenced by different storage and temperature conditions (Johnston et al., 2001; Grochowicz et al., 2001; Tettet et al., 2004). Firmness of low bush and rabbit eye blueberry have been decreased progressively as the temperature increases, when they were stored at temperature within the range of 0-30°C (NeSmith et al., 2005; Sanford et al., 1991).

Postharvest change in firmness can occur due to the loss of moisture through transpiration, as well as enzymatic changes (Ball, J. A. 1997). In addition, hemicelluloses and pectin become more soluble, which resulted in to disruption and loosening of the cell walls (Paul et al., 1999). Storage temperatures and time had significant effect on fruit firmness. Fruits softened at both temperatures during the storage period. At the higher temperature, the decrease in firmness was more noticeable. A close relationship between the softening of the fruits, higher temperature and extension of storage time was described by many authors (Zhuang et a.,l 2003).

Weight loss (%)

Weight loss was significantly affected by temperature, storage duration and their interaction. Table 1 showed that the maximum weight loss (34.13%) was noticed at 30°C on 36 days, while no loss was found at first day of storage duration (fig 2).

The results shows that post-harvest quality attributes of persimmon fruits changes significantly during a period of 36 days stored at 30°C. Desiccation of fruits caused due to weight loss increased with increase in temperature and storage durations. These results are similar to the results reported by (krishnaamurthy and subramanyam 1973) in mango fruits. Higher weight loss at higher temperatures could be related to the higher evapo-transpiration rate and respiration (Lebibet et al., 1995). Blueberries fruits weight loss was 5.3% at 0°C and 17.1% at 20°C (Sanford et al., 1991). In general, weight loss progressively increased with the increasing storage time and temperatures. Postharvest weight loss in fruits is usually due to the loss of water through transpiration. Weight loss can lead to wilting and shrivelling which both reduce market value and consumer acceptability. Our results are in agreement with (De Castro et al., 2006) who tested different storage temperatures and demonstrated that weight loss was proportional to the storage period and storage temperature.

Moisture content (%)

Moisture content was significantly influenced by temperature, storage duration and their interaction. Table 1 showed that the maximum moisture content (76.95%) was noted in the fruits stored at 10°C on first day of storage durations, while the minimum moisture content (50.23%) was observed on 36 days of storage durations at 30°C (fig. 3).

There was significant effect of temperature on moisture content of fruits during storage. During our experiment, decrease in moisture content was observed for fruits stored at 10°C, 20°C, and 30°C. This maximum moisture retention in the fruits stored at low temperature is due to retardation in the process of evapo-transpiration. The losses in fruit moisture content of the fruit were mainly caused by transpiration in which water moved out and resulted in wilted rind and a shriveled appearance (Wills et al., 2007).

Undesirable fruits (%)

The undesirable fruits was significantly affected by temperature, storage duration and their interaction. Table 1 showed that the maximum waste percent (71.10%, 35.55%) was recorded at 30°C and 20°C for 36 days of storage duration respectively, while minimum waste percent (17.77%) developed in fruits stored at 10°C on the 36 days of storage duration (fig. 4). Temperature is the main factor influencing the life span and deterioration of horticultural produce, as it regulates the rate of respiration and ethylene production (Wills et al., 2007). Blueberries deteriorate quickly at the temperature higher than 10°C, developing visible signs of decay (Boyette, 1993). Decay in fruits is a major limiting factor effecting persimmon stored for longer periods. As the temperature and the duration of storage increases, the numbers of infected fruits also get increased. The marketability value and appearance of persimmons fruits are greatly affected by decay and therefore must be considered in evaluating the storage potential of persimmon fruits (Ramin and Tabatabaie 2003). Hence, refrigerated storage considered to maintain the quality of fresh produce to prolong their shelf life.

pH

Fruit pH is the important factor of postharvest. The statistical analysis showed the pH was significantly influenced by temperature, storage duration and their interaction. Table 1 revealed that the maximum fruit pH (6.77) was observed in fruits

stored at 30°C on 36 days, while the minimum fruit juice pH (5.28) was recorded at 10°C on first day of storage durations (fig. 5). With increase in storage duration pH of the fruits also increases in all treatments. The organic metabolism during ripening process results in increase in pH value during storage of persimmon fruits. Similar results were reported for persimmon stored at different temperatures (Woolf et al., 1997).

Table 1: Fruit firmness, weight loss, moisture content, undesirable fruit and pH as affected by different temperature and various storage duration.

Temperature (T)(°C)	Fruit firmness (kg/cm ²)	Weight loss (%)	Moisture content (%)	Undesirable fruits (%)	pH
10	3.75 a	8.09 c	71.47 a	3.80 c	5.84 c
20	3.60 b	10.16 b	68.47 b	9.84 b	5.97 b
30	2.77 c	13.45 a	64.94 c	23.17 a	6.05 a
LSD	0.08	1.19	0.42	2.55	0.02
Storage Duration (Days) (SD)					
0	4.07 a	0.00 f	76.81 a	0.00 d	5.27 g
6	3.98 a	0.16 f	74.30 b	0.00 d	5.51 f
12	3.71 b	6.09 e	72.15 c	0.00 d	5.80 e
18	3.44 c	9.58 d	69.60 d	2.22 d	6.03 d
24	3.13 d	13.85 c	65.73 e	13.33 c	6.19 c
30	2.85 e	18.18 c	62.24 f	28.88 b	6.34 b
36	2.42 f	25.66 a	57.23 g	41.47 a	6.53 a
LSD	0.12	1.18	0.65	3.90	0.04
T×SD	0.22	3.13	1.13	6.76	0.07
Significance	***(Fig.1)	***(Fig.2)	***(Fig.3)	***(Fig.4)	***(Fig.5)

*represent Significance difference at 5% level of significant using least significance difference (LSD) test.

Titrateable Acidity (%)

Titrateable acidity was significantly influenced by temperature, storage duration and their interaction. Table 2 showed that the maximum titrateable acidity (0.31%) was recorded at 10°C followed by (0.30%) stored at 20°C on first day of storage duration, while the minimum titrateable acidity (0.03%) was recorded at 30°C on 36 days of storage durations (fig. 6).

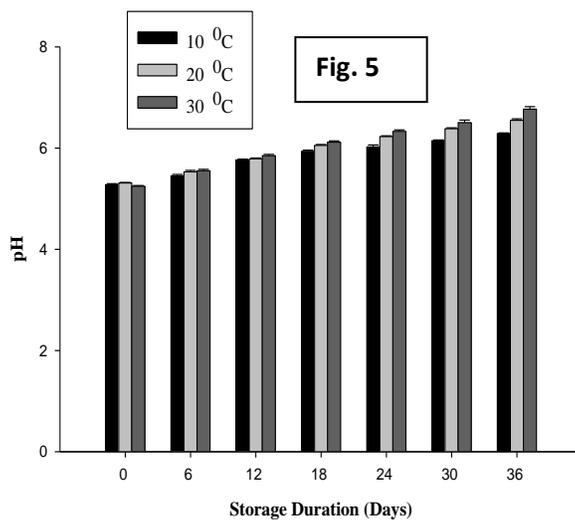
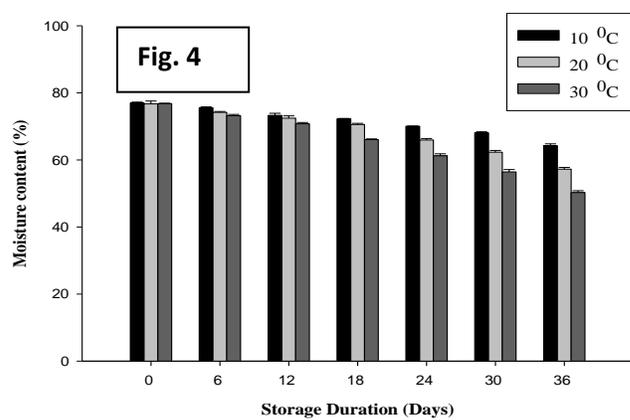
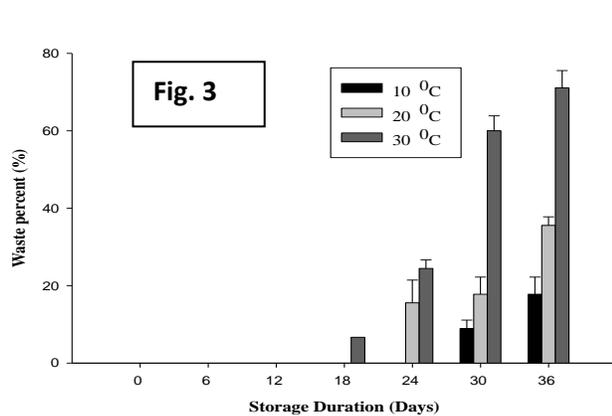
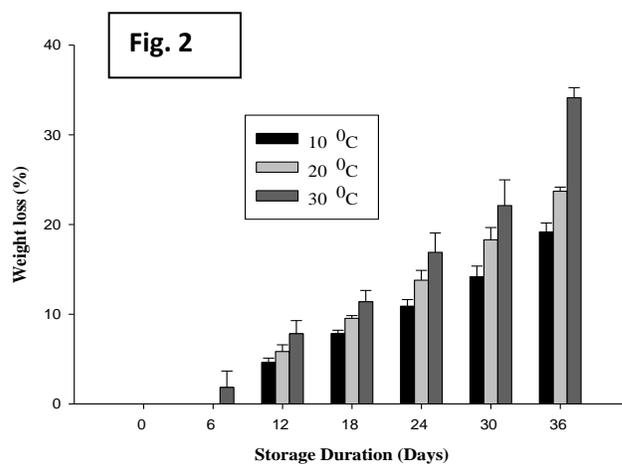
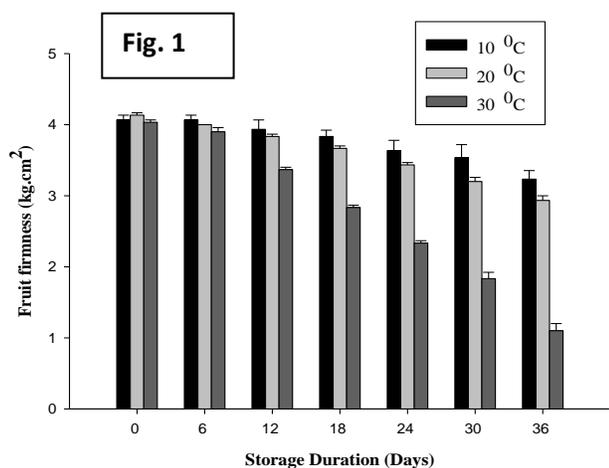


Figure 1 up-to 5 indicates fruit firmness, weight loss, moisture content, waste percent and pH as affected by different temperature and various storage duration.

Titrate acidity decreased with an increase in temperature and storage duration. This is due to the presence of excessive amount of acids, which are degraded during respiration, thus decreasing titrate acidity of the citrus fruit during storage (Hussain et al., 2004). The higher acidity in the fruits stored at low temperature is due to lesser utilization of the acids in the respiration process during the storage whereas fruits stored at high temperature had minimum acids was due to faster utilization of the acids in the respiration process during storage. The changes in titrate acidity are significantly affected by the rate of metabolism (Clarke et al., 2003) especially respiration, which consumed organic acid and thus decline acidity during storage (Ghafir et al., 2009). Amount of organic acids usually decreases during maturity, because organic acids are substrates of respiration (Wills et al., 1981).

Ascorbic Acid (mg/100g)

Ascorbic acid was positively affected by temperature, storage duration and their interaction. Table 2 showed that the maximum ascorbic acid content (51.57mg/100g), followed by (50.13 mg/100g) were recorded at 10°C and 30°C on first day of storage duration, while the minimum ascorbic acid content (9.27 mg/100g) was observed on 36 days of storage durations at 30°C (fig. 7).

Ascorbic acid also known as vitamin C is one of the main nutritional characteristics in numerous horticultural fruits and regulates several biological process in the human body and its concentration in fruits and vegetables can be influenced by postharvest handling procedures (Seung and Adel 2000). The ascorbic acid in fruits is sensitive to storage temperature or duration and its degradation is enhanced by storage conditions such as higher temperatures and low relative humidity (Adisa, 1986). Beside abiotic factors, the ascorbic acid can be irreversibly oxidized (Pardio-Sedas et al., 1994), which decreases the edible quality and increases susceptibility to different physiological disorders during storage (Jung and Watkins, 2008).

Total Soluble Solids (°Brix)

Total soluble solids was significantly affected by temperature, storage duration and their interaction. Table 2 revealed that the maximum TSS (26.33°Brix) followed by TSS (24.33°Brix) were recorded at 30°C and 20°C on 36 days of storage duration respectively, while the minimum TSS (15°Brix) was observed at 10°C on first day of storage duration (fig. 8).

TSS of fruits is the main quality attribute which is correlated with the composition and texture (Kamiloglu, 2011). TSS of fruits increased continuously with storage durations and increased temperature. Conversion of starch into sugars results increase in total soluble solids of fruits. (Beaudry et al., 1989; Crouch, 2003) or due the hydrolysis of cell wall polysaccharides (Ben and Gaweda, 1985). Persimmon fruit kept at 15°C showed the highest total soluble solids than those stored at 1°C and 8°C (Arnal and Del Río (2004). Similar results were found by other authors in other fruits like bananas, fruit stored at a temperatures of 20°C have maximum TSS than those stored at lower temperatures of 14°C (Ahmad et al., 2001). TSS content in fruits is an indicator of sweetness, although sugars are not the sole soluble component it measures (Renquist et al., 1998). TSS content increases with fruit maturity through biosynthesis process or degradation of polysaccharides (Salunkhe et al., 1974).

Color score

Color of fruit is important factor that enhance or decline the consumer demand. From the statistical analysis it was observed that color score was significantly influenced by temperature, storage duration and their interaction. Table 2

showed that the maximum fruit color (8.33) was observed at 30°C, followed by color score (6.66) on 36 days of storage duration, while the less fruit color (1.66) was observed at 10°C on first day of storage duration (fig. 9). Color of fruit is an important characteristic which is mostly used as one of the major criteria to determine whether the fruit is unripe or ripe. The loss of the green color and yellowness appearance is associated with an almost complete loss of chlorophyll content and increase in carotenoids. The color of persimmon changes during storage durations. Kitagawa and Glucina (1984) studied the interaction between temperature and harvesting, they measured the fruit color and discovered that early harvested fruit stored at 25°C developed the same color as fruit harvested 10 days later and stored at temperature (15°C). Medicott et al., 1986 reported the similar results in mango fruits. Vazquez-Salinas and Lakshminarayana (1985) reported that yellowness color in fruits increases with increase in temperature and durations. Ahmad et al., (2001) also studied the interaction of temperature with ethylene and found that banana ripened at higher temperature developed high color than those ripened at lower temperature. The colour evaluation in fruits corresponds to a fall in chlorophyll and an increase in carotenoid accumulation (Pretel et al., 1995), reflecting the transformation of chloroplasts to chromoplasts (Leshem et al., 1993). The color development rate of fruits increased with increasing maturation (Batu, A. 2003).

Table 2. Titratable acidity, ascorbic acid, TSS, color score and taste score as affected by different temperature and various storage duration.

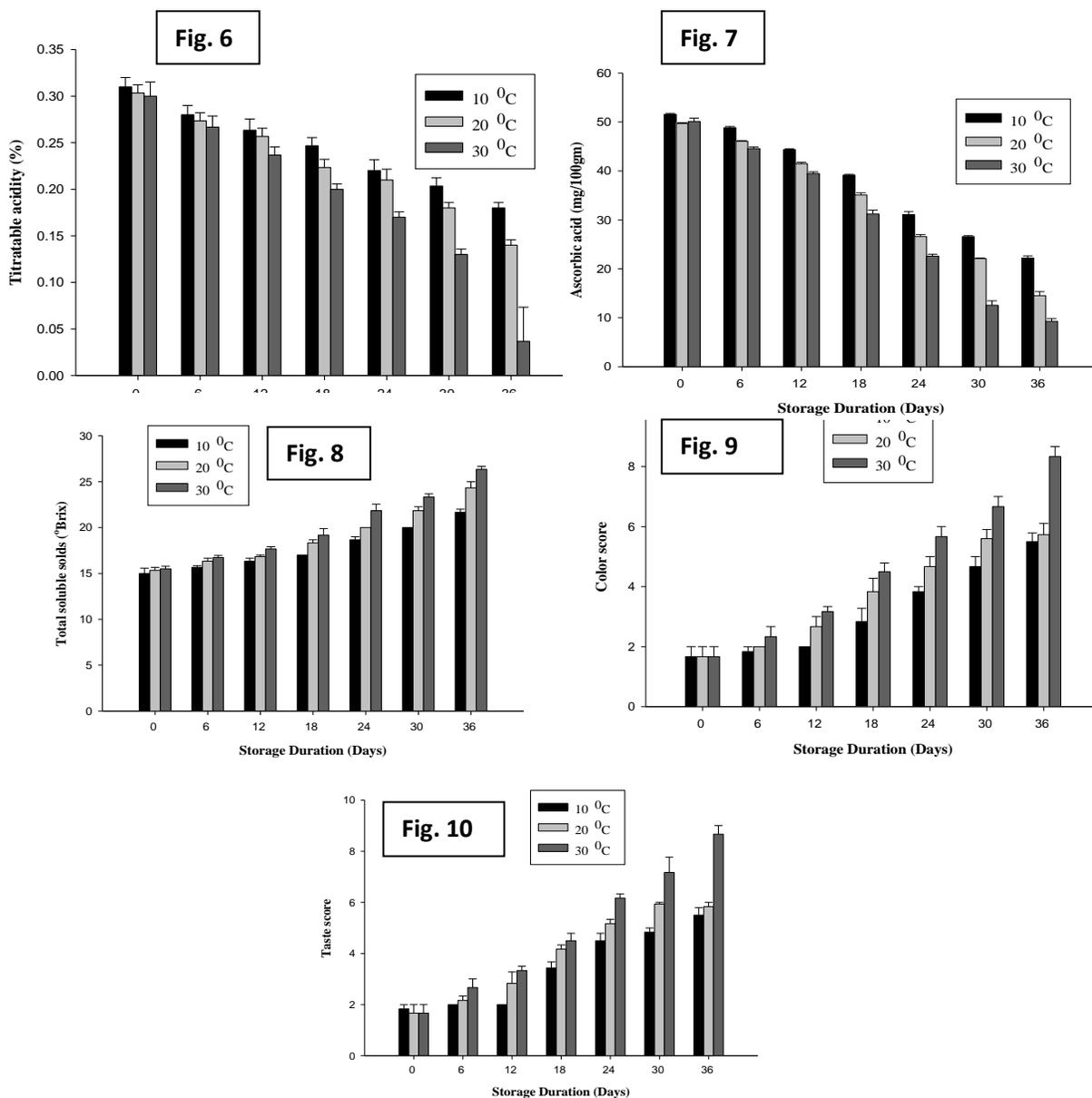
Temperature (T)(°C)	Titrateable acidity (%)	Ascorbic Acid (mg/100g)	TSS (°Brix)	Color score	Taste score
10	0.24 a	37.68 a	17.76 c	3.19 c	3.44 c
20	0.22 b	33.65 b	19.00 b	3.73 b	3.96 b
30	0.19 c	29.97 c	20.08 a	4.61 a	64.88 a
LSD	0.01	0.47	0.42	0.08	
Storage Duration (Days) (SD)					
0	0.30 a	50.44 a	15.27 g	1.66 f	1.72 f
6	0.27 b	46.50 b	16.24 f	2.05 f	2.27 e
12	0.25 c	41.76 c	16.94 e	2.61 e	2.72 e
18	0.22 d	35.14 d	18.16 d	3.72 d	4.03 d
24	0.20 e	26.75 e	20.16 c	4.72 c	5.27 c
30	0.17 f	20.41 f	21.72 b	5.64 b	5.97 b
36	0.11 g	15.32 g	24.11 a	6.52 a	6.66 a
LSD	0.02	0.72	0.64	0.13	0.45
T×SD	0.03	1.25	1.11	0.23	0.78
Significance	*** (Fig.6)	*** (Fig.7)	*** (Fig.8)	*** (Fig.9)	*** (Fig.10)

*represent Significance difference at 5% level of significant using least significance difference (LSD) test

Taste Score

Taste score was significantly affected by temperature, storage duration and their interaction. Table 2 revealed that the maximum value of taste score (8.66) was noted at 30°C followed by taste score (7.16) on 36 and 30 days of

storage duration respectively, while the minimum taste score (1.66) was observed at 20°C and 30°C on first day of storage duration (fig. 10). The different temperatures affected the taste score of persimmon fruits. Persimmon stored at higher temperature consistently better taste than fruits stored at low temperatures. The Panelists gave higher scores marks to persimmons, which were stored at higher temperatures than those stored at low temperatures. Ahmad et al., (2001) reported similar results in Bananas fruits stored at 14°C and 16°C and 20°C, highest score was achieved by banana stored at higher than those stored at low temperature.



From figure 6 up-to 10 revealed titratable acidity, ascorbic acid, total soluble solids, color score and taste score as affected by different temperature and various storage duration.

CONCLUSION

The effect of different temperature and various storage duration showed a significantly influenced the quality attributes. Fruit stored at 10°C (89±1) significantly delayed weight loss, waste percent, color score, taste score, TSS and pH, while retained moisture content, ascorbic acid content, titratable acidity and fruit firmness of the fruit juice up to 36 days of storage duration. Quality attributes of persimmon fruits were not maintained in the fruit stored at 30°C (69±1) and were mostly deteriorated after 30 days of storage duration. The harvested fruits if stored at 10°C (RH: 89±1) retained all the quality attributes. Without deteriorated for 36 days of storage durations.

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