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Effect of storage temperature and duration on shelf life and quality of pomegranate fruit

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ABSTRACT

This investigation was carried out during 2009 and 2010 seasons to study the effect of storage temperature *i.e.* low temperature (4°C) and room temperature (22 ± 1°C) on physiological loss in weight %, fruit decay % and physico-chemical properties of the fruits of three pomegranate cultivars namely; Dholka, Bedana and Kandhari. Results showed that physiological loss in weight % and fruit decay % was gradually increased with time during storage and it was significantly higher in fruits stored at room temperature as compared with those stored at low temperature (4°C) and significant differences were observed between the three cultivars in both seasons. The physical properties of the fruits were significantly affected by the storage treatments among the cultivars in most cases. TSS % was significantly higher in fruits stored at room temperature (22 ± 1°C) as compared to those stored at low temperature (4°C). Acidity and ascorbic acid contents were also significantly affected by storage treatments. During storage, at all temperatures, TSS % was gradually increased with rise in temperature. Acidity and ascorbic acid content was decreased and showed a consistent trend. Fruits of pomegranate cultivars could be safely stored up-to 100 days when stored at low temperature (4°C) with minimum reduction in physiological weight loss %, fruit decay % and physic-chemical properties of fruits.

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Key words : Pomegranate, Storage, Temperature, Shelf life, Physic-chemical properties

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the important fruits of tropical and sub tropical regions of the country, which belongs to family punicaceae. It is known for its versatile adaptability, hardy nature, less cost in orchard management, high yield potential. Fine table and therapeutical values made this fruit more lucrative and remunerative. Pomegranate is commercially cultivated in Iran, Afghanistan, Russia, Isreal, North and Latin American countries, Africa and India. Whereas in India, it is majorly cultivated in Maharashtra, Karnataka, Gujarat, Rajasthan, Andhra Pradesh and scattered parts of other states including (J&K, H.P. and Uttarakhand). India is world's leading producing country of pomegranate. It is cultivated in area of 109.2 (000 ha) and contribute 807.2 (000MT) production and productivity is 7.4 MT/ha (NHB, 2009). In India it is largely used as dessert fruit and for fresh juice (Pareek *et al*., 2002). Pomegranate fruit is also used for making delicious juice and health drinks. The edible portion of pomegranate fruit is aril, which is nearly 68% of the total fruit containing 78 per cent moisture, 0.7 per cent mineral matter, 1.6 per cent protein, 0.1 per cent fat, 14.5 per cent carbohydrate and 5.1 per cent fiber. The fruits are rich in vitamins (0.06 mg thiamine, 0.1 mg riboflavin, 0.3 mg niacin and 16.0 mg vitamin c per 100 g pulp) and minerals (10 mg calcium, 12 mg magnesium, 70 mg phosphorus and 0.3 mg iron per 100 g pulp). The juice of wild pomegranate is used to manufacture of citric acid and sodium citrate which is used for medicinal purpose. Ellagic acid which is particularly plentiful in pomegranate prevents carcinogen oxidation of cellular membranes (Annon, 2004). Recently eight improved high yielding varieties introduced in the region and among them Dholka, Bedana and Kandhari performed better in terms of yield and quality attributes (Mir *et al*., 2007). Storage temperature is the most important environmental factor affecting senescence of fruits, because it regulates the rate of all associated physiological and biochemical processes. But very less information is available regarding the storage ability of these three commercial pomegranate cultivars under temperate condition. The effect of storage temperature on the keeping quality of some pomegranate cultivars was studied by Heikel *et al.* (1996) in Egypt, Kader *et al.* (1984) in USA and Al-Mughrabi and Bacha (1986) in Saudi Arabia. Keeping the importance of storage of pomegranate fruits in mind the present investigation was carried out to study the effect of different storage temperatures regime and duration on changes in

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physiological loss in weight %, fruit decay % and fruit physico-chemical properties of three commercial grown pomegranate cultivars namely cv. Dholka, Bedana and Kandhari.

MATERIALS AND METHODS

Pomegranate fruits used in this investigation were obtained from 8-year old trees grown at the orchard of the Experimental cum Research Farm at Central Institute of Temperate Horticulture (CITH), Srinagar during the growing seasons of 2009 and 2010. Three pomegranate cultivars namely cv. Dholka, Bedana and Kandhari were used in this study. Four similar vigour trees were selected from each cultivar; each tree was represented as one replicate. All trees were subjected to the same cultural practices during both years of the study. At ripening stage (September 23, 2009 and September 25, 2010), 135 fruits from each tree of the three cultivars were harvested. Fruit samples were washed several times with sodium hypochlorite solution at concentration of 0.5 % for 5 minute then thoroughly rinsed with tap water and left to dry at room temperature. A sample of 30 fruits was taken from each tree (replicate) and weighed before the beginning of the storage treatments. These fruit samples were then kept in a corrugated fiber box for the determination of physiological loss in weight (PLW %) and fruit decay % at 10 day intervals. A sample of 15 fruits was taken from each tree for the determination of physic-chemical properties before the beginning of the storage treatments. The remaining fruits (90 fruits from each tree) were divided into 3 lots of 30 fruits each and were kept in corrugated fiber boxes of 5 gauge thickness. The fruit samples for physiological loss in weight % , fruit decay % and fruit quality determinations were placed under two storage temperature regimes, low temperature (4°C) and room temperature (22 $\pm$ 1°C) with R.H. (70 $\pm$ 2 %) . Fruit samples (15 fruits from each tree) were taken after every 10 days interval from the beginning of the storage treatments for the determinations of physico-chemical properties. The physical properties included, fruit weight loss (%), fruit decay (%), diameter (mm) whereas, chemical properties included, total soluble solids (TSS ^{o}brix) , acidity (%) and ascorbic acid (mg/100 ml juice). Total soluble solids (TSS) were determined using atago digital refractometer. Acidity was determined by Ruck (1963). Ascorbic acid was determined using phenol indophenol dye method (AOAC, 1994). The experiment was laid out in factorial completely randomized design with three replications. The data (average of two years) was statistically analyzed using FRBD by Online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hissar).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Physiological loss in weight (PLW %):

Data from present study indicated that physiological loss in weight (%) was gradually increased during storage of fruits stored at low temperature (4°C) and room temperature (22 $\pm$ 1°C) in both seasons (Table 2). In addition, physiological loss in weight (%) was significantly higher in fruits stored at room temperature (22 $\pm$ 1°C) than those stored at 4°C temperature. Among selected cultivars minimum weight loss was recorded in Dholka followed by Kandhari and Bedana under 4°C storage however, different trend was recorded under room temperature storage and minimum physiological loss in weight % recorded in Bedana followed by Dholka and Kandhari. Data regarding storage intervals showed that there was a gradual increase in weight loss percentage during storage in all three selected cultivars. After 100 days of storage maximum physiological loss in weight % (12.00, 7.37, and 12.23) at low temperature (4°C) storage was recorded in cv. Dholka, Kandhari and Bedana, respectively and 34.13, 30.06 and 29.16 at room temperature (22 $\pm$ 1°C) storage in cv. Bedana, Dholka and Kandhari, respectively) as compared to 0 day of storage *i.e.*, 0.0%. Similar results were obtained by Heikel *et al.* (1996), Kader *et al.* (1984) and Al-Mughrabi and Bacha (1986) in different pomegranate cultivars and stated that weight loss of pomegranate fruits was increased with increasing storage temperature and duration.

Fruit decay %:

Fruit decay loss also showed significant difference in fruit decay % under both the storage condition (Table 1). Per cent fruit decay appeared higher at room temperature (22 $\pm$ 1°C) than low temperature (4°C). Among selected cultivars, minimum fruit decay was recorded in Dholka (10.3%) followed by Kandhari (11.60%) and Bedana(12.33%) under low temperature (4°C) storage however, different trend was recorded for fruit weight loss under room temperature (22 $\pm$ 1°C) in cv. KANDHARI followed by Dholka and Bedana. Data regarding storage intervals showed that there was a gradual increase in fruit decay percentage during storage in selected cultivars. After 100 days of storage maximum fruit decay % under 4°C storage (11.60 %, 10.63 %, and

Table 1: Effect of storage condition, days of interval and cultivars on percentage fruit decay of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	0	0	0	0	0	0
10	0	0	0	1.03	1.36	1.06
20	2.06	1.03	2.06	3.10	2.06	4.16
30	4.13	3.10	2.76	6.20	4.13	8.16
40	5.16	3.10	3.80	8.26	8.26	10.16
50	6.20	4.13	5.86	12.04	10.36	14.46
60	7.23	6.20	7.93	16.05	15.72	19.16
70	8.96	7.23	9.70	17.05	18.73	21.67
80	10.16	9.30	10.70	19.06	20.73	25.20
90	10.43	10.03	11.83	23.07	24.75	29.26
100	11.60	10.63	12.33	29.09	30.77	35.20

Temperature (A) = 0.093
Days Interval (B) = 0.217
Cultivars (C) = 0.114
Interaction (A x B) = 0.307
Interaction (A x C) = 0.161
Interaction (B x C) = 0.377
Interaction (A x B x C) = 0.533

Table 2: Effect of storage condition, day of interval and cultivars on percentage physiological loss in weight of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	0	0	0	0	0	0
10	3.1	2.17	2.60	10.30	8.64	7.07
20	4.37	3.08	4.40	13.65	9.38	11.32
30	6.40	3.33	6.66	17.05	11.16	15.20
40	7.52	4.16	8.30	18.36	16.31	17.13
50	8.31	4.45	9.16	20.29	18.36	19.09
60	9.25	5.16	9.57	23.02	20.31	20.16
70	11.14	6.58	11.38	26.12	23.38	22.09
80	11.20	6.60	11.45	28.06	25.33	23.16
90	11.60	7.16	11.63	30.16	29.06	25.16
100	12.00	7.37	12.23	34.13	30.06	29.16

Temperature(A) = 0.096
Days Interval (B) = 0.214
Cultivar (C) = 0.117
Interaction (A x B) = 0.303
Interaction (A x C) = 0.166
Interaction (B x C) = 0.371
Interaction (A x B x C) = 0.524

12.33 %) was recorded in Kandhari, Dholka and Bedana, respectively and at room temperature storage (29.09 % , 30.77 % , and 35.27 % in Kandhari, Dholka and Bedana, respectively) as compared to 0 day of storage *i.e.*, 0.0%. High percentage of fruit decay at room temperature (22 ± 1°C) might be due to higher chances of infection by microbes then low temperature (4°C). Similar trend was previously obtained by Fataliev (1985) who found that per cent spoilage was increased with increasing of storage period in apple fruits.

Fruit diameter (mm):

The rate of reduction in fruit diameter was significantly different in both the storage condition and maximum reduction noted at room temperature than 4°C storage (Table 3). Among selected cultivars maximum fruit diameter (62.3 mm) was recorded in Bedana followed by Kandhari (59.25) and Dholka (57.16) under 4°C storage, however under room temperature storage maximum fruit diameter (53.33 mm) was recorded in Dholka followed by Kandhari (51.16 mm) and Bedana

(50. 66 mm). Storage condition significantly affected the rate of decrease in fruit diameter during storage and the maximum fruit diameter (59.25, 57.16 and 62.3 mm in Kandhari, Dolka and Bedana, respectively) was recorded under 4°C, whereas (51.16, 53.33 and 50.60 in Kandhari, Dolka and Bedana, respectively) was recorded at room temperature after 100 days of storage. The possible reason may be that low temperature minimizes evapo-transpiration and rate of respiration. Results are in accordance with the Kher *et al.* (2005) reported that fruit diameter decreased with the increase in storage period.

Total soluble solid (°Brix):

The results showed that after 100 days of storage period, TSS (°Brix) was significantly higher in fruits stored at 4°C compared to fruits stored at room temperature (Tables 4). It was also noticed that TSS (°Brix) was gradually increased with increasing storage period (100 days) at 4°C storage, however at room temperature , the TSS (°Brix) increased initially up to 60 days, then it showed

Table 3: Effect of storage condition, day of interval and cultivars on fruit diameter (mm) of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	71.26	70.66	75.65	64.60	76.24	78.65
10	68.63	70.59	74.13	64.03	75.16	75.43
20	66.22	70.56	72.34	63.58	71.15	72.22
30	66.11	70.15	71.16	63.10	69.30	70.16
40	66.08	70.06	69.24	60.32	68.14	68.36
50	66.06	69.06	68.14	57.06	65.25	65.16
60	65.25	65.16	66.45	56.36	64.00	62.31
70	64.23	61.13	65.24	55.20	62.30	60.16
80	62.35	60.03	64.23	54.20	60.33	57.33
90	61.25	58.45	64.10	52.33	57.00	53.66
100	59.25	57.16	62.3	51.16	53.33	50.66

Temperature(A) = 0.116
Days Interval (B) = 0.273
Cultivar (C) = 0.143
Interaction (A x B) = 0.386
Interaction (A x C) = 0.202
Interaction (B x C) = 0.473
Interaction (A x B x C) = 0.669

Table 4: Effect of storage condition, days of interval and cultivars on TSS (°brix) of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	12.22	10.37	8.53	13.22	11.36	9.45
10	12.35	11.36	8.64	15.33	12.06	10.06
20	12.50	11.43	9.34	15.46	14.16	10.33
30	13.40	12.09	10.00	15.56	15.13	10.60
40	13.57	12.64	11.03	15.68	15.63	11.26
50	15.40	13.16	11.13	16.55	16.03	12.06
60	16.26	14.15	11.33	16.62	16.40	13.13
70	16.40	15.44	11.60	14.20	14.06	14.03
80	16.40	15.52	11.60	13.16	13.33	13.13
90	16.53	15.52	12.33	12.06	13.13	12.03
100	16.56	16.13	14.03	11.80	13.03	11.06

Temperature(A) = 0.086
Days Interval (B) = 0.202
Cultivar (C) = 0.106
Interaction (A x B) = 0.286
Interaction (A x C) = 0.149
Interaction (B x C) = 0.351
Interaction (A x B x C) = 0.496

decreasing trend. Regarding the differences among the three cultivars, TSS (°Brix) also different significantly and recorded maximum (16.56, 16.13 and 14.03 in Kandhari, Dholka and Bedana, respectively) when stored at 4°C while in room temperature maximum (13.03, 11.80 and 11.06 in Dholka, Kandhari and Bedana, respectively). This increasing trend of TSS in response to prolonged storage was probably due to hydrolysis of polysaccharides and concentrated juice content as a result of dehydration. This gradual increase in total sugar percentage might be due to increase IN dehydration in fruits, which results more concentrated juice. These results are supported by (Badshah *et al*., 1994; Gul *et al*., 1990) they found that sugar content of apples and mango increased with storage.

Acidity (%):

Storage regime treatments significantly affected acidity content of the pomegranate fruits during storage (Table 5). Acidity (%) showed a consistent decreasing trend during storage period in both the condition. Minimum

Table 5: Effect of storage condition, days of interval and cultivars on acidity (%) of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	0.455	0.531	0.721	0.512	0.588	0.655
10	0.441	0.530	0.633	0.507	0.581	0.650
20	0.439	0.520	0.563	0.503	0.573	0.622
30	0.436	0.524	0.473	0.500	0.563	0.505
40	0.433	0.521	0.593	0.491	0.541	0.511
50	0.431	0.519	0.584	0.456	0.521	0.495
60	0.429	0.517	0.571	0.434	0.510	0.495
70	0.427	0.515	0.570	0.424	0.502	0.491
80	0.427	0.513	0.567	0.415	0.487	0.487
90	0.425	0.511	0.561	0.409	0.473	0.456
100	0.424	0.508	0.561	0.396	0.453	0.435

Temperature(A) = 0.001
Days Interval (B) = 0.003
Cultivar (C) = 0.001
Interaction (A x B) = 0.004
Interaction (A x C) = 0.002
Interaction (B x C) = 0.005
Interaction (A x B x C) = 0.007

Table 6: Effect of storage condition, days of interval and cultivars on ascorbic acid (mg/100ml juice) of pomegranate fruits

Days of interval	Low temperature (4°C)			Room temperature (22 ± 1°C)		
	Kandhari	Dholka	Bedana	Kandhari	Dholka	Bedana
0	10.53	10.60	11.16	9.40	10.26	10.16
10	10.40	10.33	11.13	9.26	10.06	10.13
20	10.33	10.13	11.08	9.06	9.93	9.33
30	10.13	10.06	11.03	8.33	9.33	9.13
40	10.06	9.53	10.38	8.06	9.06	8.33
50	10.13	9.46	10.16	7.46	8.33	8.06
60	9.46	9.33	10.13	7.20	8.06	7.93
70	9.33	9.26	10.08	7.13	7.93	7.53
80	9.26	9.13	10.06	6.93	7.53	7.40
90	9.20	9.06	9.38	6.73	7.33	7.30
100	9.13	8.96	9.08	6.43	7.26	7.26

Temperature(A) = 0.069
Days Interval (B) = 0.163
Cultivar (C) = 0.085
Interaction (A x B) = 0.230
Interaction (A x C) = 0.120
Interaction (B x C) = 0.282
Interaction (A x B x C) = 0.398

acidity (0.393, 0.435, and 0.453 %) was recorded in Kandhari, Bedana and Dholka, respectively at room temperature whereas (0.424, 0.508 and 0.561 %) was recorded in Kandhari, Dholka and Bedana, respectively at room temperature. Regarding the differences among the three cultivars, data showed that Kandhari (0.424 %) cultivar had significantly lower acidity values as compared to other two cultivars cv. Dholka and Bedana in both the storage condition. Results are in accordance with the Kader *et al.* (1984) who stated that acidity decreased during cold storage.

Ascorbic acid (mg/100ml juice):

Storage treatments significantly influenced vitamin C content of pomegranate fruits in both storage conditions. Furthermore, ascorbic acid content was gradually decreased in all cultivars during the storage period in both storage condition but rate of decrease was faster at room temperature than 4°C (Tables 6). Maximum ascorbic acid (mg/100 ml juice) recorded (8.96, 9.08 and 9.13) in Dholka, Bedana and Kandhari, respectively at low temperature (4°C) as compared to room temperature (6.43, 7.26 and 7.26) in Kandhari, Dholka and Bedana, respectively. The possible reason may be that low temperature delayed the oxidation of fruits resulting in more ascorbic acid content. Concerning the differences among the three cultivars, data showed that Kandhari cultivar had almost higher (9.13) ascorbic acid content than the other two cultivars *i.e.* Bedana (9.08) and Dholka (8.96) in 4°C storage condition while Dholka (7.26) and Bedana (7.26) at room temperature storage condition even after 100 days of storage. These results are in agreement with Rana *et al.* (1992) who reported that juice and ascorbic acid contents of apples decreased with storage, Khalil *et al.* (1972) and Ishak *et al.* (1979) on lime fruits.

From the foregoing data, it could be concluded that fruits of Dholka, Bedana and Kandhari pomegranate cultivars could be stored safely without shriveling and with a minimum decrease in fruit quality at 4°C up to 100 days.

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