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Storage behaviour of apple cultivars under ambient conditions

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ABSTRACT

An experiment was conducted at ICAR-CITH, Regional Station, Mukteshwar, Nainital, Uttarakhand in ten apple cultivars to assess the physico-chemical changes and shelf-life at ambient storage conditions for 49 days. The physiological loss in weight, TSS, reducing sugars, total sugars, non-reducing sugars and fruit decay percentage increased, while fruit firmness, titratable acidity, ascorbic acid content and organoleptic score decreased during storage in all cultivars. Cultivar Skyline Supreme exhibited lowest physiological loss in weight (7.77%), highest TSS (14.93 °B) and organoleptic score (7.19) than other apple cultivars. However, the cv. Red Chief exhibited highest ascorbic acid (12.32 mg/100 g), reducing sugars (8.89%) and total sugars (10.59%) and the cv. Bright-N-Early exhibited highest fruit firmness (8.18 lb/in^2) and lowest fruit decay (5.05%) than other apple cultivars. Conclusively, Skyline Supreme, Red Chief and Bright-N-Early have better shelf-life than other apple cultivars under ambient storage conditions.

Key words: *Malus domestica*, shelf-life, physicochemical changes, fruit quality.

INTRODUCTION

Apple (*Malus* × *domestica* Borkh.) belongs to family Rosaceae, is one of the important fruit crops of temperate regions. The postharvest losses in the terms of quality and quantity occur at various stages of fruit handling right from harvesting, till the fruits reach the consumers (Issar *et al*., 5). In Uttarakhand, the apple fruits are harvested from July to September depending upon maturity of cultivars and microclimatic conditions of the region. The optimum fruit quality and storage behaviour depend upon the stage at which fruits are harvested. Physico-chemical changes during storage of fruits are used as important criteria for determining the optimum storage period which are essential to work out the transportation mode from one place of production to distant markets. Thus, there is need to assess the storage potential of commercial cultivars for their better shelf-life. However, post harvest behaviour of apple vary, depending on various factors *viz*., cultivar, rootstock, soil, agro-climatic conditions, growth and development pattern including flowering, fruiting, maturity, chemical composition of fruits as well as storage conditions. Although, some information on apple maturity and storage of fresh fruits has been reported by Pandey *et al*. (9), Issar *et al*. (5), Sharma *et al*. (13) and Sharma *et al*. (12) and but no systematic information is available on apple cultivars belonging to Delicious group, spur type and colour strains. Keeping these facts in view, the present investigation was undertaken to assess the storability of different cultivars of apple at ambient conditions, which may be useful to orchardists, traders, processors and exporters.

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MATERIALS AND METHODS

The present investigation was undertaken during two successive years, 2015 and 2016 at ICAR-Central Institute of Temperate Horticulture, Regional Station, Mukteshwar, situated at 2,200 m above mean sea level in Nainital district of Uttarakhand. Ten apple cultivars belonging to Delicious group, spur type and colour strains *viz*. Golden Delicious, Skyline Supreme, Red Chief, Bright-N-Early, Top Red, Starkrimson, Red Spur, Oregon Spur, Rich-A-Red and Red Delicious were selected for the study and harvested at commercially mature stage (Das *et al*., 3). After harvesting, fruits were washed, air dried, packed in brown paper bags in three replicates consisting of 50 fruits per replication in each cultivar and stored under ambient storage conditions for 49 days. Observations on physico-chemical parameters of fruits were recorded at weekly intervals. Physical attributes like physiological loss in weight (%), fruit decay (%) and fruit firmness (lb/in^2) were recorded during storage. The physiological loss in weight was measured by subtracting the initial weight from final weight and expressed as percentage. Similarly, fruit decay was determined by counting the rotten fruits, divided by total fruits and expressed as percentage. The fruit firmness was measured with the help of a penetrometer (Model FT-327, Italy) using 8 mm stainless steel probe and results were expressed as lb/in^2. The chemical characteristics of the fruits *viz*.

TSS, titratable acidity, ascorbic acid, reducing sugars, total sugars and non-reducing sugars were recorded by using the methods described by Ranganna (11). The overall organoleptic score of the fruits was done by a panel of five judges on the basis of external appearance of fruit, texture, taste and flavour, making use of a 9-point Hedonic scale (Amerine *et al*., 1). Data were recorded and statistically analysed following factorial complete randomized design (Panse and Shukhatme, 10).

RESULTS AND DISCUSSION

The physiological loss in weight (% PLW) recorded at different intervals differs significantly among the different apple cultivars (Table 1). The PLW increased gradually in all the cultivars with the advancement of storage period. It is evident that lowest mean PLW exhibited by cv. Skyline Supreme (7.77%) followed by Starkrimson (8.76%) and Oregon Spur (9.06%), while highest in cv. Top Red (14.57%) followed by Red Delicious (13.56%) and Golden Delicious (13.29%) during storage. The critical observation showed that the rate of loss in weight was much faster in cv. Top Red, which attained highest level of 24.82% on 49th day of storage. Increasing loss in weight on prolonging storage period might be attributed to rapid loss of moisture through evapo-transpiration and respiration (Maini *et al*., 7). The variation in loss in weight among cultivars may also be attributed to genetical, textural and skin characteristics (Singh *et al*., 15). Pandey *et al*. (9) have also reported increase in PLW in apple following storage either at room

Table 1. Changes in PLW and fruit decay during storage in apple cultivars at ambient conditions (pooled mean).

Cultivars	Storage period (days)								
	0	7	14	21	28	35	42	49	Mean
Physiological loss in weight (%)									
Golden Delicious	0.00	2.55	6.48	10.58	13.43	16.22	20.25	23.50	13.29
Skyline Supreme	0.00	1.45	3.12	4.92	7.45	10.06	12.23	15.14	7.77
Red Chief	0.00	2.04	6.28	8.57	11.56	14.81	18.18	23.34	12.11
Bright-N-Early	0.00	1.71	4.47	7.08	9.95	12.21	14.87	18.48	9.82
Top Red	0.00	3.29	8.61	12.16	14.65	17.37	21.08	24.82	14.57
Starkrimson	0.00	1.37	3.95	6.00	8.34	10.94	13.42	17.33	8.76
Red Spur	0.00	1.94	5.36	7.54	11.52	13.78	15.93	20.94	11.00
Oregon Spur	0.00	2.04	4.23	5.94	7.96	10.82	13.46	18.96	9.06
Rich-A-Red	0.00	2.00	6.29	8.24	11.30	13.69	17.07	20.61	11.31
Red Delicious	0.00	3.52	7.29	9.77	13.02	15.80	20.99	24.57	13.56
Mean	0.00	2.19	5.61	8.08	10.92	13.57	16.75	20.77	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.99			1.10		NS	
Fruit decay (%)									
Golden Delicious	0.00	0.00	0.00	10.00	13.70	43.77	59.12	76.33	28.99
Skyline Supreme	0.00	0.00	0.00	13.33	32.23	36.76	46.59	56.71	26.52
Red Chief	0.00	0.00	0.00	0.00	3.40	9.90	20.11	23.00	8.06
Bright-N-Early	0.00	0.00	0.00	0.00	3.45	5.21	8.45	18.24	5.05
Top Red	0.00	0.00	0.00	3.25	13.34	24.54	32.70	55.81	18.52
Starkrimson	0.00	0.00	0.00	0.00	3.35	9.90	16.41	40.00	9.95
Red Spur	0.00	0.00	0.00	3.35	9.90	14.72	25.11	50.00	14.73
Oregon Spur	0.00	0.00	0.00	0.00	0.00	16.67	20.00	36.67	10.48
Rich-A-Red	0.00	0.00	0.00	3.36	7.18	17.35	19.56	26.69	10.59
Red Delicious	0.00	0.00	0.00	3.18	13.27	37.14	46.09	71.00	24.38
Mean	0.00	0.00	0.00	3.65	9.98	21.60	29.41	45.44	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.29			0.33		0.93	

temperature or in cold storage. In general, fruit decay percentage increased consistently on prolonging the storage period (Table 1). Lowest mean fruit decay (%) was observed in cv. Bright-N-Early (5.05%) followed by Red Chief (8.06%) and Starkrimson (9.95%), while the highest was observed in Golden Delicious (28.99%) followed by Skyline Supreme (26.52%) and Red Delicious (24.38%) during storage. The occurrence of fruit decay was faster in Skyline Supreme (13.33%) and Golden Delicious (10.00%) after 21st day and increased consistently up to 49th day of storage. However, rapid rise in fruit decay was observed in Golden Delicious (76.33%) on 49th day of storage. Fruits in open may have higher chances of microbial infection than those in containers; hence they decayed at a higher rate (Maini *et al*., 7). Pandey *et al*. (9) have also reported increase in decay following storage of apples at ambient conditions.

Fruit firmness, in general, followed a declining trend commensurated with advancement in storage period (Table 2). The highest mean fruit firmness was found in Bright-N-Early (8.18 lb/in^2) followed by Red Chief (7.98 lb/in^2) and Red Delicious (7.88 lb/in^2), while lowest in cv. Rich-A-Red (6.36 lb/in^2) followed by Skyline Supreme (6.50 lb/in^2) and Oregon Spur (6.76 lb/in^2) during storage. Softening of fruits is caused either by breakdown of insoluble protopectins into soluble pectin or by hydrolysis of starch. The gradual decreasing trend in all the physical parameters was very much pronounced up to 7-14 days and thereafter it was gradually slow in all the cultivars during storage. This might be

Table 2. Effect of storage on fruit firmness and TSS in apple cultivars at ambient conditions (pooled mean).

Cultivars	Storage period (days)								
	0	7	14	21	28	35	42	49	Mean
Fruit firmness (lb/in^2)									
Golden Delicious	10.59	9.41	8.82	7.95	7.60	7.40	6.90	6.30	7.77
Skyline Supreme	9.15	8.53	7.37	6.80	6.60	5.70	5.50	5.00	6.50
Red Chief	11.69	10.77	9.90	7.70	7.40	7.00	6.70	6.40	7.98
Bright-N-Early	10.40	9.80	9.34	8.92	8.40	7.70	7.20	5.90	8.18
Top Red	11.06	10.37	8.90	7.63	6.63	5.83	5.23	4.40	7.00
Starkrimson	9.79	8.79	8.30	8.03	6.90	6.30	5.80	5.50	7.09
Red Spur	10.03	9.47	8.87	7.73	6.73	6.30	5.90	5.60	7.23
Oregon Spur	9.57	8.70	8.23	7.80	7.00	6.40	4.90	4.30	6.76
Rich-A-Red	9.80	8.47	8.07	7.40	6.20	5.10	4.80	4.50	6.36
Red Delicious	10.50	9.50	8.97	8.40	8.00	7.50	7.30	5.50	7.88
Mean	10.26	9.38	8.68	7.84	7.15	6.52	6.02	5.34	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.31			0.34		0.98	
TSS (°B)									
Golden Delicious	11.90	12.30	13.80	14.00	14.40	14.57	15.00	14.53	13.81
Skyline Supreme	13.80	14.00	14.80	15.40	15.93	15.00	15.40	15.10	14.93
Red Chief	10.26	11.20	11.60	12.90	13.43	14.60	12.60	11.90	12.31
Bright-N-Early	10.11	11.00	11.90	12.80	13.00	13.40	13.00	12.90	12.26
Top Red	11.26	12.25	13.60	14.10	14.60	16.40	15.20	13.30	13.83
Starkrimson	11.29	12.00	13.00	14.00	15.00	13.80	13.70	13.50	13.28
Red Spur	13.50	14.00	14.40	14.90	16.00	14.80	14.20	14.20	14.50
Oregon Spur	13.00	13.34	13.70	14.50	15.10	14.00	12.80	12.20	13.58
Rich-A-Red	11.00	11.59	12.00	12.90	13.50	14.80	10.20	11.00	12.12
Red Delicious	12.00	12.25	13.40	14.60	15.20	15.90	12.90	12.50	13.42
Mean	11.81	12.39	13.22	14.01	14.62	14.73	13.50	13.11	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.16			0.18		0.51	

due to slow loss of water resulting shrinkage and softening as well as decrease in respiration rate and solubilising enzymatic activity. The soluble enzyme activity pattern in softening of tissue of apple was described by Kang *et al*. (6). Iglesias *et al*. (4) also tried to correlate the anthocyanin content with fruit firmness and reported that high colouring strains like Red Chief, Elite and Early Red One had relatively high firmness at commercial harvest than Oregon Spur and Top Red. These results are in accordance with the findings of Issar *et al*. (5) and Sharma *et al*. (12).

The TSS content increased gradually up to 42nd day of storage and decreased thereafter in all the cultivars up to 49th day of storage except Rich-A-Red (Table 2). The highest mean TSS content was recorded in Skyline Supreme (14.93 °B) followed by Red Spur (14.50 °B) and Top Red (13.83 °B), while lowest was in Rich-A-Red (12.12 °B), Bright-N-Early (12.26 °B) and Red Chief (12.31 °B) during storage. The increase in TSS might be associated with transformation of pectic substances, starch, hemicelluloses and other polysaccharides into soluble sugars as well as dehydration of fruits (Bhullar *et al*., 2). The titratable acidity consistently decreased in all the cultivars up to 49th day of storage (Table 3). The lowest mean titratable acidity was recorded in cv. Red Delicious (0.30%) followed by Bright-N-Early (0.33%) and Red Chief (0.34%), while highest in cv. Starkrimson (0.42%) followed by Top Red (0.41%)

Table 3. Changes in titratable acidity and ascorbic acid content during storage in apple cultivars at ambient condition (pooled mean).

Cultivars	Storage period (days)								
	0	7	14	21	28	35	42	49	Mean
Titratable acidity (%)									
Golden Delicious	0.52	0.51	0.50	0.44	0.37	0.36	0.23	0.20	0.39
Skyline Supreme	0.56	0.55	0.54	0.37	0.34	0.20	0.20	0.19	0.37
Red Chief	0.51	0.50	0.47	0.34	0.34	0.20	0.19	0.18	0.34
Bright-N-Early	0.49	0.43	0.37	0.32	0.32	0.27	0.23	0.21	0.33
Top Red	0.56	0.52	0.50	0.44	0.40	0.30	0.29	0.27	0.41
Starkrimson	0.51	0.47	0.44	0.34	0.40	0.40	0.40	0.40	0.42
Red Spur	0.52	0.51	0.50	0.43	0.33	0.27	0.25	0.22	0.38
Oregon Spur	0.49	0.46	0.40	0.37	0.30	0.33	0.33	0.32	0.37
Rich-A-Red	0.50	0.43	0.40	0.39	0.33	0.30	0.30	0.28	0.36
Red Delicious	0.46	0.41	0.37	0.30	0.27	0.20	0.18	0.18	0.30
Mean	0.51	0.48	0.45	0.37	0.34	0.28	0.26	0.24	
			Storage period (S)			Cultivar (C)			S×C
C.D. 0.05			0.006			0.006			0.018
Ascorbic acid (mg/100 g)									
Golden Delicious	18.96	18.25	17.14	13.72	9.14	6.86	5.72	4.89	10.82
Skyline Supreme	19.23	18.23	17.14	9.14	8.00	8.00	6.86	6.11	10.50
Red Chief	22.39	22.00	21.72	18.29	6.86	6.86	5.72	4.79	12.32
Bright-N-Early	24.00	23.56	22.86	6.86	5.72	5.72	5.72	4.57	10.71
Top Red	20.23	19.00	18.29	6.86	6.86	6.86	6.86	4.57	9.90
Starkrimson	23.00	22.53	21.72	12.57	8.00	6.86	6.86	5.21	11.96
Red Spur	16.59	15.23	14.86	8.00	8.00	8.00	6.86	5.72	9.52
Oregon Spur	20.00	19.56	18.29	12.57	6.86	5.72	5.72	5.23	10.56
Rich-A-Red	15.21	14.23	13.72	13.72	9.14	8.00	6.86	6.12	10.26
Red Delicious	20.00	19.25	18.29	13.72	10.23	6.86	5.72	5.11	11.31
Mean	19.96	19.18	18.40	11.54	7.88	6.97	6.29	5.23	
			Storage period (S)			Cultivar (C)			S×C
C.D. 0.05			0.18			0.20			0.56

and Golden Delicious (0.39%) during storage. The decline in titratable acidity during storage may be associated with bio-conversion of organic acids to sugars. Similar pattern in change of TSS and titratable acidity level during storage was reported by Sharma *et al*. (13) and Singh *et al*. (14).

Initially, after harvest highest ascorbic content was found in cv. Bright-N-Early (24.00 mg/100 g) followed by Starkrimson (23.00 mg/100 g) and Red Chief (22.39 mg/100 g), whereas lowest in cv. Rich-A-Red (15.21 mg/100 g). Overall, ascorbic acid contents decreased significantly on advancement of storage period in all the cultivars (Table 3). However, highest mean retention of ascorbic acid was found in Red Chief (12.32 mg/100 g) followed by Starkrimson (11.96 mg/100 g) and Red Delicious (11.31 mg/100 g), while lowest was in Red Spur (9.52 mg/100 g) and Top Red (9.90 mg/100 g) till termination of storage. Large variation in decreasing trend of ascorbic acids might be associated with genetic variability among the cultivars. The decreasing ascorbic acid content upon prolonged storage might also be associated with differential ascorbic acid oxidase activity in fruits (Mapson, 8). Similar results were also reported by Singh *et al*. (14).

The changes in the levels of reducing sugars, total sugars and non-reducing sugars showed a sharp increase during storage in all the cultivars (Table 4 and 5). However, the increase was more prominent up to 28th to 35th day of storage in most

Table 4. Effect of storage on reducing and total sugars content in apple cultivars at ambient storage conditions (pooled mean).

Cultivars	Storage period (days)								
	0	7	14	21	28	35	42	49	Mean
Reducing sugars (%)									
Golden Delicious	6.00	6.23	6.76	8.62	8.77	8.89	9.35	10.12	8.39
Skyline Supreme	6.06	6.12	7.35	8.93	9.61	9.80	7.35	7.11	8.04
Red Chief	6.23	7.12	8.73	9.26	10.00	10.42	8.67	8.06	8.89
Bright-N-Early	6.95	7.42	8.20	8.29	8.35	8.47	8.62	7.76	8.16
Top Red	6.46	7.11	8.33	8.47	10.64	11.11	6.33	5.15	8.16
Starkrimson	6.82	7.86	8.06	8.51	9.43	9.43	8.06	7.57	8.42
Red Spur	6.25	7.12	7.57	8.62	9.09	8.77	7.57	5.21	7.71
Oregon Spur	6.56	7.98	8.06	8.93	10.00	8.20	7.14	5.68	8.00
Rich-A-Red	5.11	5.12	5.88	6.85	7.46	10.20	6.17	7.69	7.05
Red Delicious	6.05	6.23	7.57	7.57	8.47	9.09	6.17	5.88	7.28
Mean	6.25	6.83	7.65	8.40	9.18	9.44	7.54	7.02	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.10			0.11		0.33	
Total sugars (%)									
Golden Delicious	7.05	7.23	8.85	9.76	9.76	9.89	9.97	12.50	9.71
Skyline Supreme	6.93	7.12	8.38	10.38	10.93	11.11	9.75	9.00	9.52
Red Chief	7.12	8.23	9.19	10.53	11.69	12.97	10.81	10.69	10.59
Bright-N-Early	7.69	8.12	9.17	10.05	10.47	10.90	9.22	9.16	9.58
Top Red	7.12	7.95	8.94	11.51	12.12	12.92	8.43	7.52	9.91
Starkrimson	7.05	8.33	9.16	9.19	12.27	10.12	9.11	8.17	9.48
Red Spur	7.23	8.26	9.95	11.76	12.34	9.57	8.76	7.14	9.68
Oregon Spur	7.26	8.10	8.35	10.63	11.86	9.27	8.61	7.04	9.12
Rich-A-Red	7.23	6.95	6.64	7.55	9.95	11.87	7.69	8.55	8.46
Red Delicious	6.98	7.25	8.16	8.90	9.85	10.40	7.93	7.36	8.55
Mean	7.17	7.75	8.68	10.03	11.12	10.90	9.03	8.71	
			Storage period (S)			Cultivar (C)		S×C	
C.D. 0.05			0.13			0.15		0.42	

Table 5. Changes in non-reducing sugars and organoleptic score in apple cultivars at ambient storage conditions (pooled mean).

Cultivars	Storage period (days)								
	0	7	14	21	28	35	42	49	Mean
Non-reducing sugars (%)									
Golden Delicious	1.00	0.95	1.99	1.08	0.94	0.95	0.59	2.26	1.25
Skyline Supreme	0.83	0.95	0.98	1.48	1.25	1.24	2.28	1.80	1.43
Red Chief	0.85	1.39	0.44	1.21	1.61	2.42	2.03	2.50	1.66
Bright-N-Early	0.70	0.67	0.92	1.67	2.01	2.31	0.57	1.33	1.35
Top Red	0.63	0.80	0.58	2.89	1.41	1.72	2.00	2.25	1.66
Starkrimson	0.22	0.44	1.05	0.65	2.70	0.66	1.00	0.57	1.01
Red Spur	0.93	1.08	2.26	2.98	3.09	0.76	1.13	1.84	1.88
Oregon Spur	0.66	0.11	0.28	1.62	1.77	1.02	1.40	1.29	1.07
Rich-A-Red	2.01	1.74	0.72	0.67	2.37	1.59	1.44	0.82	1.33
Red Delicious	0.88	0.97	0.56	1.95	1.31	1.24	1.67	1.41	1.30
Mean	0.87	0.91	0.98	1.62	1.84	1.39	1.41	1.61	
			Storage period (S)			Cultivar (C)			S×C
C.D. 0.05			0.17			0.19			0.53
Organoleptic score (1-9)									
Golden Delicious	7.33	8.00	4.67	4.67	4.67	5.33	5.33	4.00	5.24
Skyline Supreme	8.00	8.33	6.67	7.33	8.00	7.33	6.67	6.00	7.19
Red Chief	5.67	5.33	6.00	6.67	6.00	5.33	4.67	4.00	5.43
Bright-N-Early	6.67	7.33	6.00	5.33	6.00	6.00	6.00	4.00	5.81
Top Red	6.67	7.00	6.67	4.67	7.33	6.00	4.67	4.67	5.86
Starkrimson	6.67	7.33	7.33	6.00	4.67	6.00	6.00	6.00	6.19
Red Spur	8.00	8.67	7.67	6.67	7.33	6.67	6.00	6.00	7.00
Oregon Spur	6.33	7.33	6.67	6.00	5.33	4.00	4.00	4.00	5.33
Rich-A-Red	6.00	6.67	4.00	5.33	7.33	6.00	4.67	4.67	5.52
Red Delicious	6.33	6.67	6.00	7.33	6.00	6.00	4.67	4.00	5.81
Mean	6.77	7.27	6.17	6.00	6.27	5.87	5.27	4.73	
			Storage period (S)			Cultivar (C)			S×C
C.D. 0.05			0.46			0.52			1.47

of the cultivars. The highest mean reducing sugars and total sugars was found in Red Chief (8.89% and 10.59%), while lowest in cv. Rich-A-Red (7.05% and 8.46%) during storage, respectively. However, the highest mean non-reducing sugars were found in Red Spur (1.88%), while lowest in cv. Starkrimson (1.01%) during storage. The increase in sugars during storage may possibly be due to breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars. On complete hydrolysis of starch no further increase in sugars occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al*., 17). Wang *et al*. (16) also reported similar results as ascorbic acid, titratable acidity and sugars in apple fruits stored at room temperature.

The organoleptic score decreased gradually in all the cultivars with the advancement of storage period (Table 5). The mean organoleptic score was found highest in cv. Skyline Supreme (7.19) followed by Red Spur (7.00) and Starkrimson (6.19). On the other hand, the cv. Golden Delicious (5.24), Oregon Spur (5.33) and Red Chief (5.43) recorded the lowest score. Initially, most of the cultivars recorded the highest organoleptic score up to 7 days of storage showing acceptability but thereafter sudden decline in sensory quality was noticed. The organoleptic score of the cultivars revealed that cultivars having medium to high TSS and total sugars scored higher

values while lower values for any of these character resulted in lower score. The results obtained in the present investigation are found to be close conformity with the studies of Pandey *et al*. (9) and Issar *et al*. (5). Hence, on the basis of investigation, it was concluded that Skyline Supreme, Red Chief and Bright-N-Early have better shelf-life than other apple cultivars under ambient storage conditions.

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