DOI : 10.5958/0974-0112.2019.00024.0

Indian J. Hort. 76(1), March 2019: 168-175

Physico-chemical attributes and shelf life of aonla as influenced by packing materials and storage conditions

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ABSTRACT

The present investigation aimed at comparing the efficacy of two packing materials (LDPE and CFB boxes) and two storage conditions (cold storage and ambient conditions) in retaining the quality of stored aonla fruits. Under cold storage the fruits were subjected to different temperatures *viz* 6°C, 9°C and 12°C with 90-95% RH, whereas for ambient conditions the fruits were kept at room temperature (18±1°C). Periodically a representative sample of the stored fruits was taken out and analyzed for changes in physico-chemical attributes. The results revealed that LDPE bags significantly retained the quality of stored fruits in terms of PLW, spoilage, ascorbic acid and total phenols. LDPE packed fruits stored at 9°C registered minimum PLW followed by CFB boxes and it increased concomitantly with the storage interval. Total phenols and TSS registered an increasing trend initially but gradually declined thereafter. In general the aonla fruits showed increased PLW and decreased firmness, TSS, acidity and ascorbic acid as the storage interval was increased. Chilling injury was observed in fruits stored at 6°C only. The storage temperature, packing material and storage interval had significant influence on ascorbic acid and of the fruits. The present study implies that the aonla fruits can be efficiently stored in LDPE packaging at temperature of 9°C for 21 days.

Key words: *Emblica officinalis*, storage interval, temperature, CFB, LDPE.

INTRODUCTION

Aonla (*Emblica officinalis* L), the Indian Gooseberry, is an important indigenous fruit belonging to family Euphorbiaceae. It is a quite hardy deciduous fruit crop with a wide range of adaptability to different climates and soils including marginal and neglected lands. That is why extensive cultivation is being done in salt affected districts of many states namely, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu. Aonla has huge processing potential and can be processed into many products like pickles, preserves, jellies and powders, that are in great demand throughout the year. The fruits are highly perishable in nature with limited storage period due to rapid physical and physiological changes in the fruit.

The increased respiration rate and high perishability renders it unsuitable for consumption and transport to distant markets to get good price especially when there is glut in the market. The fruits show bruises, injuries and lose their attractive appearance with deterioration in quality, if not handled, packed and stored properly. Inappropriate storage atmosphere may result in accumulation of fermentative metabolites inside the fruit resulting in development of off flavors, rendering it unacceptable for the consumers (Kudachikar *et al.,* 6). The optimum temperature and packaging material play a vital role in enhancing the shelf life and maintain quality of aonla fruits. Management of storage temperature is one of the most critical factors for extending shelf life and marketable quality as temperature controls the factors like rate of respiration, ethylene production, low temperature injury and activity of microorganisms. The packing materials influence the rate of ripening, firmness, rate of respiration and nutritional quality (Kumar *et al.,* 7). These have different capacity to absorb the moisture and gases and also act as protective barrier during transit. Choosing the right packaging is therefore an important market consideration which affects the shelf life as well as presentation/ appeal of the produce. Effect of different storage temperatures as well as packing materials have been studied by the investigators for enhancing the shelf life and fruit quality of aonla however not much conclusive results have been obtained.

The present investigations were therefore conducted to increase the economic shelf life and quality of aonla fruits by packaging in LDPE polythene bags and CFB boxes and storage at 6°C, 9°C, 12°C and ambient temperatures respectively. The PLW, spoilage and chilling injury were taken into account along with other quality parameters and marketability.

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MATERIALS AND METHODS

The present investigations were carried out during the year 2016 and repeated during 2017. The uniform and healthy fruits of aonla cv. *Neelum* were harvested from fifteen years old healthy trees of uniform vigour growing at PAU, Ludhiana. The fruits of uniform shape, size and colour, free from injuries and bruises were harvested manually in the end of November, handled gently and transported to laboratory for post-harvest treatments. The fruits were kept at 6°C, 9°C, 12°C and ambient temperatures (18±1°C) and 90-95 % RH with sample size of 2 kg fruits for each sampling date per replication, in two types of packaging for each temperature, viz., Corrugated Fibre Board (CFB) boxes and LDPE polyethylene bags (5% perforation). The experimental material was subjected to completely randomized factorial design with four replications and 32 treatments.

The physiological loss in weight (PLW), rotting as well as chilling injury of fruits was recorded at 7 days interval. The loss in weight was calculated by subtracting the fruit weight at 7 days interval from the initial fruit weight and expressed as weight loss percentage in reference to the initial fruit weight. The spoilage of fruit was due to chilling injury and/or blue mould and *Aspergillus* which was identified on the basis of characteristic visual symptoms and the spoilage percentage was calculated by counting the number of fruits showing chilling injury (CI) and spoilage incidence in each packaging and expressed as per cent spoilage to the initial spoilage. The chilling index was determined by visual assessment of the severity of the chilling symptoms using a 4 stage scale (Ding *et al.,* 2). The severity of symptoms was evaluated as 0 = no symptoms; 1 = few scattered discoloured and brown spots; 2= discolouration and browning covering up to 5% of the fruit surface; 3= discolouration and browning covering 5 to 25% of the fruit surface, and 4= discolouration and browning covering more than 25% of the fruit surface. The chilling injury index was determined by multiplying the number of fruits in each category with their chilling injury score and then dividing by the total number of fruits in a replication. As a parameter for economic shelf life, minimum 5 per cent PLW was taken into account as per the reports of Mahajan *et al.* (8). The spoilage and chilling injury were recorded as compared to the initially stored fruits and were expressed in percentage.

The firmness of the fruit was measured with hand held penetrometer (Model FT-327, USA) using stainless steel probe. A peel of 1 cm^2 was removed from the shoulder of the fruit and firmness of pulp was recorded and expressed in terms of Newton. Soluble solids content (SSC) was determined with digital refractometer (ATAGO, PAL-1, Model 3810, Japan) at room temperature by making subsequent corrections at 20°C. Ttitratable acidity (TA) in terms of malic acid and ascorbic acid were determined by AOAC (1).

The experimental results thus obtained were pooled for both the years and were subjected to the statistical analysis of variance by SAS package (V 9.3, SAS Institute Inc., USA). The interactions where found significant were subjected to mean separation using LSD ($p \le 0.05$).

RESULTS AND DISCUSSION

The fruits are the living biological entities until they are attached to the growing parent plants. But even after harvest, the produce is still living as it continues to perform most of the metabolic reactions and maintain the physiological systems that were present when it was attached to the plant. These systems are kept running at the cost of physical health of the fruit and thus there is degradation of the fruits which results in deterioration of the physiological characteristics of the fruit as is evident from the experimental results pertaining to the physiological loss in weight (PLW) presented in Fig. 1. The fruits kept in CFB boxes had high PLW than those packed in LDPE bags in all the treatments. The fruits kept in CFB boxes showed 50.60 per cent PLW at ambient temperature after 28 days of storage as compared to 19.46 per cent in LDPE bags when subjected to the similar conditions. The higher PLW in CFB boxes can be attributed to the fact that there was uncontrolled respiration in the fruits kept in CFB boxes which resulted in higher transpiration losses. The lower weight loss with LDPE can be attributed to the slow rate of respiration than CFB, eventually preventing excessive moisture losses (Kaur *et al.*, 3). The mean PLW was minimum (7.11%) in the fruits kept at 9°C followed by the fruits kept at 6°C (8.68%). The studies revealed that LDPE packing can minimize the PLW and prolong the shelf life of aonla fruits as is evident from the results viz., only 3.52 per cent PLW after 21 days of storage at 9°C and 8.75 per cent after 28 days. The interactions between storage temperature and packaging material were also found to be significant. PLW at 9°C in LDPE bags for 21 days is considered the best as it falls within the permissible limit of weight loss which is less than 5 per cent after which the fruit starts showing shrivelling and becomes unmarketable (Mahajan *et al.,* 8).

The impact of the chilling injury was observed only at 6°C temperature. The injury was consistently recorded in CFB and LDPE packed fruits after 7,

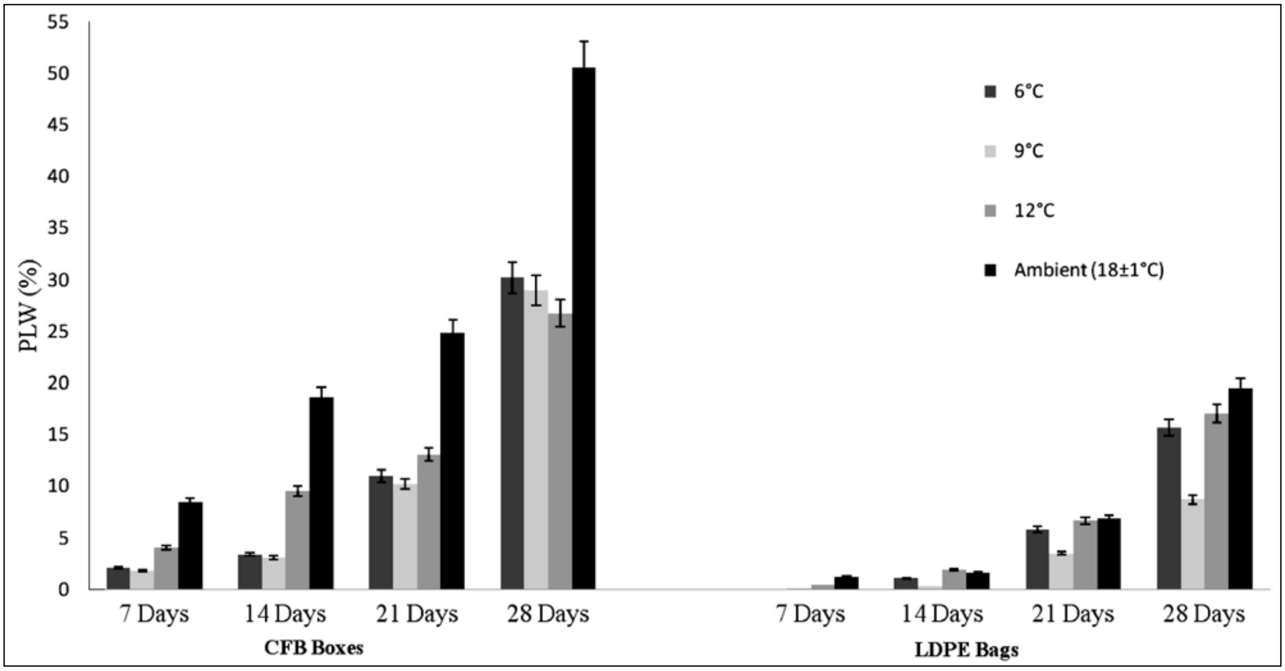

Fig. 1. Effect of storage temperature and packing material on PLW (%) of aonla cv. *Neelum*. The vertical lines represent SE mean of three replicates (n=25). Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.

14, 21 and 28 days of storage. In CFB, the injury was observed in all storage intervals (1.13, 4.56, 6.35 and 8.49 per cent, respectively). In LDPE at 6°C, the chilling injury was 1.22 per cent after 21 days and 3.84 per cent after 28 days of storage. No injury due to chilling was observed at 9°C, 12°C or ambient temperatures. The development of chilling injury symptoms have been observed in aonla which may be attributed to breakdown of mesocarp cells, increase in peroxidase and breakdown of unsaturated fatty acids in membrane lipids (Pareek and Kitinoja, 11).

Close scrutiny of data pertaining to spoilage presented in Table 1 revealed that the per cent spoilage increased with storage period. At 9°C and 12°C, there was no spoilage for 14 days and it started with the progression of storage period. The spoilage was minimum at 9°C (1.40 %), while maximum value (2.60%) was obtained at 6°C which was statistically at par with ambient temperature (2.56 %). At 6°C, chilling injury also contributed to the spoilage. The overall spoilage percentage in LDPE (1.62 %) was significantly less than CFB (2.51 %) as the fruits stored in LDPE packaging had more firmness. The firmer the fruit, the lesser it will be prone to rotting or spoilage. All interactions between storage temperature, interval, packing material were found to be significant.

The changes in fruit firmness over storage time with varying storage temperature and packaging material are depicted in the Table 2. The general trend of the data revealed that the fruit firmness showed progressive decline as the storage time is enhanced as it decreased from 120.30 N at harvest to 100.29 N after 28 days of storage. This decrease in fruit firmness with prolonged storage can be attributed to disintegration of primary cell wall and middle lamella structures due to loss of water (Wei *et al.,* 15). This decrease in fruit firmness was non-significant among treatments with varying temperature. The interactions among the type of packaging, storage interval and the storage temperature were found to be non significant. However, the interaction among storage interval and packaging material was observed to be significant with maximum firmness being shown after 7 days of storage in CFB boxes.

The data presented in Table 3 revealed that the storage temperature and time had direct influence on the TSS percentage of the stored fruits. Up to 7-14 days of storage, the maximum mean TSS (%) was recorded at ambient temperature and 6°C but as the storage time was prolonged the maximum expression of TSS was shown by fruits stored at 9°C (21 and 28 days of storage). The fruits stored in CFB boxes had significantly higher (7.75%) TSS than those stored in LDPE bags (7.42%) as the

Table 1. Effect of different packing materials and storage conditions on spoilage (%) of aonla cv. *Neelum.*

Storage Interval	7 Days			14 Days			21 Days			28 Days			Mean Temp (A)	Mean Packaging (A×C)	
Packing / Temperature*	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)		CFB	LDPE
6°C	1.90 (1.38)	0.00 (0.00)	**0.69^{l}**	7.34 (2.70)	0.47 (0.69)	**1.69^{i}**	17.90 (4.23)	12.30 (3.51)	**3.87^{d}**	19.55 (4.42)	15.00 (3.87)	**4.14^{c}**	2.60^{a}	3.18^{b}	2.01^{c}
9°C	0.00 (0.00)	0.00 (0.00)	**0.00^{m}**	0.00 (0.00)	0.00 (0.00)	**0.00^{m}**	9.51 (3.08)	3.37 (1.84)	**2.46^{g}**	11.00 (3.32)	9.00 (3.00)	**3.16^{f}**	1.40^{d}	1.60^{e}	1.21^{g}
12°C	0.00 (0.00)	0.00 (0.00)	**0.00^{m}**	0.00 (0.00)	0.00 (0.00)	**0.00^{m}**	8.84 (2.97)	3.20 (1.79)	**2.38^{h}**	25.03 (5.00)	15.40 (3.92)	**4.46^{b}**	1.71^{c}	1.99^{c}	1.42^{f}
Ambient 18±1°C	2.90 (1.70)	0.00 (0.00)	**0.85^{k}**	5.13 (2.26)	0.00 (0.00)	**1.13^{j}**	17.60 (4.19)	5.62 (2.37)	**3.28^{e}**	24.70 (4.97)	25.00 (5.00)	**4.98^{a}**	2.56^{a}	3.28^{a}	1.84^{d}
Mean (B×C)	**0.77^{f}**	**0.00^{h}**		1.24^{e}	0.17^{g}		3.62^{c}	2.37^{d}		4.43^{a}	3.95^{b}		Spoilage at Harvest : 0.00		
Mean (Storage Interval; B)		0.38^{d}			0.70^{c}			3.00^{b}			4.19^{a}				

Mean (Packing material; C) CFB : 2.51^{a} LDPE: 1.62^{b}

LSD (0.05) Storage Temp (A) : 0.03 Storage Interval (B) : 0.03 Packing material (C) : 0.02 A × B : 0.03 B × C : 0.02 A × C : 0.02 A x B × C : 0.05

Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.
*Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.
Figures in the parenthesis are square root transformations. Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.

Table 2. Effect of different packing materials and storage conditions on firmness (N) of aonla cv. *Neelum.*

Storage Interval	7 Days			14 Days			21 Days			28 Days			Mean Temp (A)	Mean packaging (A×C)	
Packing / Temperature*	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)		CFB	LDPE
6°C	119.90	120.10	**120.00**	115.13	115.55	**115.34**	108.13	109.25	**108.69**	100.20	102.40	**101.30**	111.33	110.84	111.83
9°C	119.10	119.85	**119.48**	114.50	115.00	**114.75**	108.50	108.92	**108.71**	100.00	101.35	**100.67**	110.90	110.52	111.28
12°C	119.25	119.80	**119.53**	113.85	114.15	**114.00**	107.85	108.55	**108.20**	99.70	100.00	**99.85**	110.39	110.16	110.63
Ambient 18±1°C	119.15	119.90	**119.53**	113.38	113.97	**113.67**	107.16	107.90	**107.51**	99.13	99.58	**99.35**	110.02	109.69	110.34
Mean (B×C)	**119.35^{a}**	**119.91^{a}**		**114.21^{b}**	**114.67^{b}**		**107.90^{c}**	**108.66^{c}**		**99.76^{d}**	**100.83^{d}**		Firmness at harvest : 120.30		
Mean (Storage Interval; B)		119.63^{a}			114.44^{b}			108.28^{c}			100.29^{d}				

Mean (Packing material; C) CFB : 110.30 LDPE: 111.02

LSD (0.05) Storage Temp (A) :NS Storage Interval (B) : 1.66 Packing material (C) : NS A × B : NS B × C : 3.33 A × C : NS A × B × C : NS

*Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.
Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.

fruits in CFB boxes had more rate of respiration, accounting for more PLW and eventually more TSS than LDPE. The interactions between storage temperature, storage interval and packaging material by eliminating the effect of one of the factors was found to be significant. There was initial increase in TSS content of fruits with storage period up to 14 days. The TSS might have increased due to the increased activity of starch hydrolysing enzymes and thus there was hydrolysis of starch to sugars (Krishnamoorthy, 5). Similar results of enhancement in TSS with storage of aonla fruits have been reported earlier also (Kore *et al.*, 4). The TSS content consequently declined afterwards as on completion of hydrolysis of starch, the further increase in TSS did not occur. Hence decline in TSS concentration is predictable as these are the prime substrates for respiration of fruits.

The evaluation of titratable fruit acidity among bio-chemical traits is extremely vital as it signifies the characteristic tangy flavour of aonla fruit. The results pertaining to the effect of various storage treatments on titratable acidity of aonla cv. *Neelum* are shown in Fig. 2. The perusal of data shows that the critical difference was statistically significant with regard to packaging material with LDPE bags showing mean titratable acidity of 2.01 per cent and CFB boxes had value to the tune of 1.90 per cent. The titratable acidity showed linear decline as the storage interval and the storage temperature increased with maximum expression of acidity recorded from fruits after 7 days of storage (2.28 %) and at lowest storage temperature i.e. 6°C (2.03 %). The interaction between storage interval and packing material was significant with maximum expression of acidity shown by fruits stored in LDPE boxes after 14 days of storage. Likewise the interactions between storage interval and storage temperature and packing material and storage temperature were also observed to be significant. This decrease in acidity with increased storage time might be due to increase in membrane permeability of cells which allows the acids stored in the cells to be respired, formation of salts of malic acid due to movement of potassium into fruits (Patel and Sachan, 12). The higher titratable acidity at low temperature stored fruits might be due to reduction in metabolic changes of organic acid into carbon dioxide and water as reported by Marcilla *et al.* (9) in citrus.

Aonla is one of the richest sources of vitamin C and is valued for in nutritional properties. It is the cheapest source of vitamin C and likewise other bio chemical constituents; vitamin C content is also directly influenced by storage conditions. The mean ascorbic acid content of the fruits stored in LDPE

Table 3. Effect of different packing materials and storage conditions on TSS (%) of aonla cv. *Neelum.*

Storage Interval	7 Days			14 Days			21 Days			28 Days			Mean Temp	Mean packaging (A×C)	
Packing	CFB	LDPE	Mean	CFB	LDPE	Mean	CFB	LDPE	Mean	CFB	LDPE	Mean	(A)	CFB	LDPE
Temperature*			(A×B)			(A×B)			(A×B)			(A×B)			
6°C	8.40	8.03	**8.21^{bc}**	8.50	8.23	**8.36^{a}**	7.53	7.33	**7.42^{h}**	5.20	4.07	**4.64^{l}**	7.16^{d}	7.41^{d}	6.91^{f}
9°C	8.13	8.03	**8.07^{d}**	8.33	8.13	**8.22^{b}**	7.83	8.03	**7.92^{e}**	7.13	7.53	**7.32^{i}**	7.89^{a}	7.85^{b}	7.92^{a}
12°C	8.23	8.03	**8.12^{cd}**	8.33	8.13	**8.22^{b}**	7.83	7.63	**7.72^{f}**	6.83	7.13	**6.97^{j}**	7.76^{b}	7.80^{c}	7.72^{c}
Ambient 18±1°C	8.60	7.83	**8.21^{bc}**	8.80	7.93	**8.36^{a}**	8.23	7.03	**7.62^{g}**	6.20	5.70	**5.95^{k}**	7.54^{c}	7.96^{a}	7.12^{e}
Mean (B×C)	**8.34^{b}**	**7.97^{d}**		8.49^{a}	8.10^{c}		7.85^{e}	7.50^{f}		6.34^{g}	6.11^{h}		TSS at harvest : 7.90%		
Mean (Storage Interval; B)		8.16^{b}			8.29^{a}			7.67^{c}			6.22^{d}				

Mean (Packing material; C) CFB : 7.75^{a} LDPE: 7.42^{b}

LSD (0.05) Storage Temp (A) : 0.04 Storage Interval (B) : 0.04 Packing material (C) : 0.03 A × B : 0.09 B × C : 0.06 A × C : 0.06 A × B × C : 0.13

*Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.
Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.

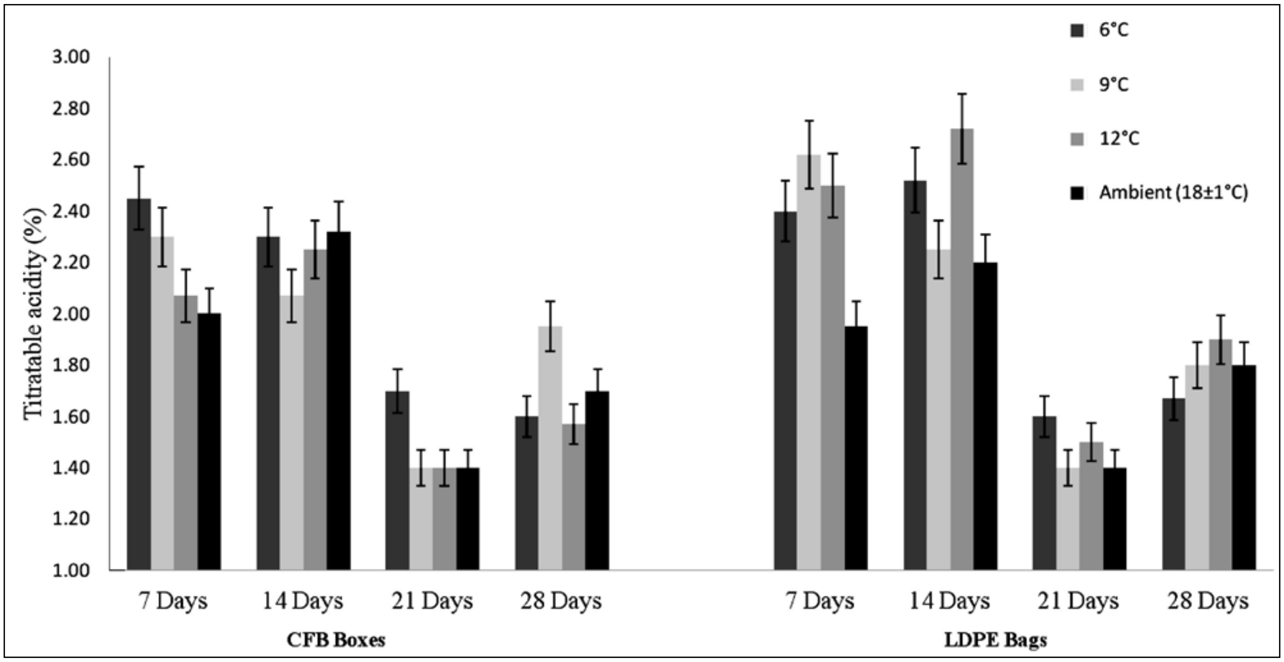

Fig. 2. Effect of storage temperature and material on Titratable acidity (%) of aonla cv. *Neelum*. The vertical lines represent SE mean of three replicates (n=25). Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.

bags was significantly higher (461.70 mg $100g^{-1}$) as compared to those in CFB boxes (453.36 mg $100g^{-1}$). The ascorbic acid content showed linear progressive decline from 7 days of storage (481.47 mg $100g^{-1}$) to 28 days (431.20 mg $100g^{-1}$) as is evident from the results presented in Table 4. However, the storage temperature had no evident relationship with the ascorbic acid content of the fruits. The interactions between all the storage components investigated in the study were significant. The declining ascorbic acid content with increased storage time is in concurrence with the findings of Upadhyay and Dixit (14). The ascorbic acid content of fruits decreased with increase in storage period due to its oxidation to dehydoascorbic acid by the action of ascorbic acid oxidase (Singh *et al.*, 13).

The maximum mean total phenolic content (2.38 mg/100g pulp) was recorded from the fruits after 21 days of storage (Table 5) followed by those with 14 days (2.32 mg/100g pulp). The fruits stored in LDPE bags showed higher expression of total phenols (2.36 mg/100g pulp) which was significantly better than the fruits stored in CFB boxes (2.28 mg/100g pulp). The fruits stored at 9°C were having total phenol content of 2.34 mg/100g pulp which was statistically at par with the fruits stored at 12°C (2.33 mg/100g pulp). Thus the general trend of the results implicated that the total phenols showed a tendency to increase during initial storage up to 21 days and at lower temperature thereafter it started the upward trend. Some others workers have also previously observed this phenomenon and reported a possible increment of polyphenolic compounds associated to the microbial growth or to reactions between oxidized polyphenols and formation of new compounds of antioxidant character during the storage of fruits (Martinez-Flores *et al.,* 10).

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Table 4. Effect of different packing materials and storage conditions on ascorbic acid (mg/100g) of aonla cv. *Neelum.*

Storage Interval	7 Days			14 Days			21 Days			28 Days			Mean Temp (A)	Mean packaging (A×C)	
Packing / Temperature*	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)		CFB	LDPE
6°C	467.25	492.80	480.02^{ab}	449.10	483.00	**466.05^{cde}**	437.58	471.07	**454.32^{fg}**	428.15	455.55	**441.85^{hi}**	460.56^{a}	445.52^{d}	475.61^{a}
9°C	484.45	478.00	481.22^{ab}	472.65	464.77	**468.71^{cd}**	448.63	445.00	**446.81^{gh}**	420.25	422.70	**421.48^{k}**	454.56^{b}	456.49^{b}	452.62^{bcd}
12°C	481.67	499.05	490.36^{a}	464.15	477.75	**470.95^{bcd}**	450.10	461.45	**455.77^{efg}**	423.95	445.98	**434.96^{ij}**	463.01^{a}	454.97^{bc}	471.06^{a}
Ambient 18±1°C	475.30	473.23	474.26^{bc}	463.18	457.92	**460.55^{def}**	451.07	442.30	**446.69^{gh}**	436.33	416.70	**426.51^{jk}**	452.00^{b}	456.47^{b}	447.54^{cd}
Mean (B×C)	**477.17^{b}**	**485.77^{a}**		462.27^{c}	470.86^{b}		446.84^{d}	454.96^{c}		427.17^{f}	435.23^{e}		Ascorbic acid at harvest: 509.20 mg/100 g		
Mean (Storage Interval; B)		481.47^{a}			466.57^{b}			450.90^{c}			431.20^{d}				

Mean (Packing material; C) CFB : 453.36^{b} LDPE: 461.70^{a}

LSD (0.05) Storage Temp (A) : 5.50 Storage Interval (B) : 5.50 Packing material (C) : 3.89 A × B : 11.01 B × C : 7.78 A × C : 7.78 A × B × C : 15.57

*Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.
Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.

Table 5. Effect of different packing materials and storage conditions on total phenols (mg/100g) of aonla cv. *Neelum.*

Storage Interval	7 Days			14 Days			21 Days			28 Days			Mean Temp (A)	Mean packaging (A×C)	
Packing / Temperature*	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)	CFB	LDPE	Mean (A×B)		CFB	LDPE
6°C	2.19	2.28	**2.23^{i}**	2.26	2.34	**2.30^{ef}**	2.33	2.40	**2.36^{c}**	2.30	2.34	**2.32^{de}**	2.30^{c}	2.27^{d}	2.34^{b}
9°C	2.24	2.30	**2.27^{gh}**	2.30	2.38	**2.34^{cd}**	2.38	2.48	**2.43^{a}**	2.33	2.32	**2.32^{de}**	2.34^{a}	2.31^{c}	2.37^{a}
12°C	2.28	2.36	**2.32^{de}**	2.33	2.35	**2.34^{cd}**	2.40	2.39	**2.39^{b}**	2.24	2.27	**2.25^{hi}**	2.33^{b}	2.31^{c}	2.34^{b}
Ambient 18±1°C	2.14	2.40	**2.27^{gh}**	2.21	2.43	**2.32^{de}**	2.27	2.39	**2.33^{d}**	2.25	2.32	**2.28^{fg}**	2.30^{c}	2.22^{e}	2.38^{a}
Mean (B×C)	2.21^{f}	2.33^{c}		2.27^{e}	2.37^{b}		2.34^{c}	2.41^{a}		2.28^{e}	2.31^{d}		Total phenols at harvest : 1.98 mg/100g		
Mean (Storage Interval; B)		2.27^{d}			2.32^{b}			2.38^{a}			2.29^{c}				

Mean (Packing material; C) CFB : 2.28^{b} LDPE: 2.36^{a}

LSD (0.05) Storage Temp (A) : 0.01 Storage Interval (B) : 0.01 Packing material (C) : 0.01 A × B: 0.02 B × C : 0.01 A × C : 0.01

*Under cold storage 90-95 % RH was maintained, whereas for ambient storage RH was not regulated.
Means with same letter are not significantly different (at p≤0.05). Each value represents the pooled mean of 2 years.

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Received : April, 2018; Revised : February, 2019; Accepted : February, 2019