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Effect of different packaging materials on shelf-life and quality of apple during storage

R.R. Sharma* and Dinesh Singh**
Central Institute of Post-harvest Engineering and Technology, Abohar 152 116, Punjab

ABSTRACT

Studies were conducted to assess the effect of different containers and liners on post-harvest losses and quality parameters of apple during storage at room temperature (22–28°C) and walk-in chambers (5 ± 2°C). For this, apples were packed in CFB boxes, wooden boxes, plastic crates and gunny bags and lined either with polyethylene sheet or newspaper cuttings. Observation on PLW (%), decay loss (%), fruit firmness (N), juice recovery (%), and quality parameters (TSS, acidity, total sugars and ascorbic acid content) were recorded at different intervals. Our results indicated that PLW and decay loss of apples increased significantly with increase in storage period both at ambient conditions and cold storage, and this increase was much more drastic in control than in different containers. Among different containers, PLW (5.60%) and decay loss (8.0%) were lesser in CFB boxes, followed by wooden boxes. Similarly, containers lined with polyethylene sheet had lesser PLW and higher decay loss than those lined with newspaper cuttings. Fruits remained firmer with higher juice recovery in CFB or wooden containers than other containers or control. Among different quality parameters, total soluble contents, total sugars of apples increased and ascorbic acid content, and acidity decreased with the increase in storage period at ambient conditions up to 30 days, which declined afterwards. Under cold storage conditions, these parameters showed the similar trend up to five months of storage. This increase or decrease in different quality attributes was faster in control fruits than those kept in different containers. Fruits in CFB or wooden boxes had better quality attributes than those in other containers or control. Thus, CFB or wooden boxes were found better in controlling post-harvest losses in apples during storage than other containers. Similarly, fruits lined or wrapped with polyethylene sheet were better in all aspects than those wrapped in newspaper cuttings.

Key words: Apple storage, post-harvest losses, packaging containers, liners, quality parameters.

INTRODUCTION

Apple (*Malus* x *domestica*) is considered as the most important temperate fruit of the world. In India, it occupies a place of eminence among temperate fruits, as it is cultivated on the largest area (2.76 thousand hectares) with highest production (1,842 thousand metric tonnes) (Anon, 2). At present, it is mainly grown in the hilly states like H.P., J&K, Uttrakhand and to some extent in north-eastern states, and transported to different markets. Before transportation, apples are sorted, graded and then packed in different containers and transported on trucks (Maini *et al.,* 6, 7). For effective packing, different cushioning material *i.e.,* liners or wrappers, newspaper cuttings, paddy straw or standardized cushions are used. After transportation, these are either stalked in cold storage or sent to retail marketing. During storage, huge losses occur, which include loss in weight, firmness, decay loss or loss in quality parameters (Lal and Anand, 4; Maini and Anand, 5). Thus, different packing containers or liners/ cushioning material may have great impact on post-harvest life of apples. Thus, systemic studies on this aspect of apples was undertaken to assess the losses occurring during storage of apples in different containers.

MATERIALS AND METHODS

These studies were conducted at CIPHET, Abohar (Punjab) in collaboration with Regional Horticultural Research Station, Seobagh, Kullu (HP). Fully mature Royal Delicious apples were harvested from a private orchard (near Regional Hort. Research Station, Seobagh) in Kullu district of Himachal Pradesh. After sorting and grading, apples were packed in CFB boxes (20 kg), wooden boxes (20 kg), plastic crates (20 kg) and gunny bags (20 kg), which were lined/wrapped either with polyethylene sheet (P) (100 gauge) or newspaper (NP) cuttings. The packed fruits were loaded on a truck and then transported to Abohar (Punjab). Each treatment consisted of 10 boxes, and single box/container was considered as one replication. Initial records of firmness (N), weight (g), juice (%), TSS (%), acidity (%), total sugars (%) and ascorbic acid content (mg/100 g pulp) *etc.*, were recorded before packaging or transportation at Regional Horticulture Research Station, Seobagh, Kullu (H.P.), and all these

*Corresponding author's present address: Division of Post Harvest Technology, IARI, New Delhi - 110 012; E-mail: rrs_fht@rediffmail.com
**Division of Plant Pathology, IARI, New Delhi

parameters were again recorded after transportation to CIPHET, Abohar. In addition, observations were also recorded on weight loss (%), bruising injury (%) and decay loss (%). After sorting the bruised and decayed fruits, the healthy fruits were again re-packed in different containers and stored at room temperature (22-28°C) and cool chambers (5 ± 2°C) for further observations on PLW (%), fruit decay (%), firmness (N), juice (%), and quality parameters for 40 days (room temperature) and 6 months (walk-in-chambers), respectively. The fruits in control treatment were kept in trays both at ambient and cold storage conditions without wrapping either in newspaper cuttings or polyethylene sheets.

Fruit firmness was recorded with texture analyzer and force required to puncture fruit was expressed as N (Newton). Pulp TSS (%) was recorded with hand refractometer. Acidity as malic acid was recorded by titrating known amount of fruit juice with 0.1N NaOH solution. Total sugars and ascorbic acid were determined by following standard procedures (AOAC, 1). For recording all these parameters, five fruits were randomly selected from a single lot and replicated five times. Sensory evaluation of stored apples was conducted by a panel of five experts, and represented on hedonic scale (0-9). Data obtained from different parameters were subjected to factorial RBD (Gomez and Gomez, 3)

RESULTS AND DISCUSSION

The study indicated that PLW (%) increased significantly with increase in storage period from 10th (3.61%) to 40th day (11.8%) at room temperature (22-28°C), and the increase was much more drastic in apples kept in control than those in different containers (Table 1). Among different containers, PLW (%) was much less in CFB boxes, followed by wooden boxes. Further, fruits lined with polyethylene sheet had lesser PLW than those lined with newspaper cuttings. There was a consistent difference in PLW (%) in fruits in control and those kept in CFB and wooden boxes at 10th, 20th, and 30th day of storage. At the end of 40th day, PLW was highest in control (9.62%) and lowest in CFB boxes lined with polyethylene sheet (5.60%) (Table 1). Irrespective of packaging containers, PLW (%) of apples increased significantly with increase in storage period from 1st month of cold storage (3.41%) to 6th month (10.2%). This increase in PLW (%) was much more drastic in control than those in different containers. Among different containers, PLW (%) was much lesser in CFB boxes (»5.0%), followed by wooden boxes (»5.0%). Similarly, containers lined with polyethylene sheet had lesser PLW than those lined with newspaper cuttings. Further, PLW was all time high in control than fruits stored in different containers at different intervals of observations, and at the end of 6th month storage, PLW was highest in control (11.4%) and lowest in CFB boxes lined with polyethylene (5.1%) (Table 2). Increase in PLW with the storage period may be due to loss of moisture from the fruits by way of transpiration or evaporation. Since fruits in control were kept in open, hence there must be higher rate of evaporation from them those kept in closed containers (Maini *et al*., 6,7). Pandey *et al*. (8) have also reported

Table 1. PLW (%) and decay loss (%) in apples kept in different packaging containers and liners under ambient conditions.

Packing material	Days after storage									
	PLW (%)					Decay loss (%)				
	10	20	30	40	Mean	10	20	30	40	Mean
Control	5.22	7.30	11.62	14.40	9.62	3.2	8.3	12.5	42.5	16.6
Gunny bag (NP)	4.12	6.32	10.20	13.22	8.53	3.0	8.3	10.5	32.5	13.6
Gunny bag (P)	4.10	5.73	10.0	12.80	8.16	3.6	8.2	10.4	35.3	14.4
Plastic crate (NP)	4.10	6.36	9.92	12.69	8.34	2.5	4.5	6.9	17.5	7.9
Plastic crate (P)	3.92	5.20	8.33	11.72	7.32	2.8	4.2	6.3	18.6	8.0
CFB box (NP)	3.20	4.52	8.30	10.52	6.69	1.2	4.5	9.3	22.6	9.4
CFB box (P)	2.22	3.62	7.25	9.32	5.60	1.5	4.6	9.2	24.6	10.0
Wooden box (NP)	3.33	4.62	8.32	11.52	6.95	2.3	5.6	9.4	21.6	9.7
Wooden box (P)	2.29	3.49	7.36	9.92	5.77	2.5	6.0	9.2	22.0	9.9
Mean	3.61	5.20	9.0	11.8		2.5	6.0	9.3	26.4	
$CD_{0.05}$	Container (C) = 0.14					Container (C) = 0.16				
	Days (D) = 0.10					Days (D) = 0.12				
	C × D = 0.13					C × D = 0.22				

Table 2. Effect of packing containers and liners on PLW and decay loss in apple under cold storage conditions.

Packing material	Storage period (month)									
	1	3	5	6	Mean	1	3	5	6	Mean
	PLW (%)					Decay loss (%)				
Control	4.3	9.3	13.6	18.4	11.4	1.2	3.3	12.5	15.2	8.1
Gunny bag (NP)	4.1	8.2	10.2	15.2	9.4	2.0	3.3	10.5	12.5	7.1
Gunny bag (P)	3.0	6.8	10.0	14.8	8.9	3.6	4.2	10.4	15.3	8.4
Plastic crate (NP)	4.1	8.4	9.9	14.7	9.3	2.5	3.0	6.9	10.5	5.7
Plastic crate (P)	3.9	7.2	8.5	13.6	8.3	2.8	4.2	6.3	16.6	7.5
CFB box (NP)	2.2	3.5	6.3	9.3	5.3	1.3	2.5	9.0	9.6	4.7
CFB box (P)	2.0	3.3	6.2	9.0	5.1	1.5	2.8	9.5	10.6	6.1
Wooden box (NP)	3.3	4.3	6.7	10.2	6.1	2.5	3.6	10.5	12.5	7.3
Wooden box (P)	3.2	4.2	6.4	9.9	5.9	2.5	3.6	10.5	12.7	7.3
Mean	3.4	6.1	8.6	10.2		2.2	3.4	9.6	12.8	
$CD_{0.05}$	Container (C) = 0.12					Container (C) = 0.14				
	Months (M) = 0.09					Months (M) = 0.10				
	C × M = 0.11					C × M = 0.32				

increase in PLW in apple following storage either at room temperature or at cold storage.

Decay loss also showed significantly increasing trend with the increase in storage period from 10th (2.5%) to 40th day (26.4%) in apples at room temperature. Decay loss was very high in control (16.6%) and significantly very low in plastic crates lined either with polyethylene sheet (7.9%) or newspaper cuttings (8.0%) (Table 1). Further, fruits lined with polyethylene sheet had higher decay loss than those lined with newspaper cuttings. There was consistent difference in decay loss (%) in fruits in control and those kept in CFB and wooden boxes at 10th, 20th, and 30th day of storage. At the end of 40th day, as high as 42.5% apples got decayed in control as compared to only about 18.0% in plastic crates (Table 1). Decay loss (%) in apples also showed significantly increasing trend with the increase in cold storage period from 1st (2.2%) to 6th month (12.8%). Irrespective of storage period, decay loss was very high in gunny bags (8.4%), non-significantly followed by control (8.1%) and significantly very low in CFB boxes (4.7%) (Table 2). This loss was all time higher in fruits under control than containers at different intervals of observations, and at the end of 6th month, nearly 15.0% apples were lost due to decay in control and those packed in gunny bags. Similarly, fruits in open may have higher chances of infection by microbes than those in containers; hence they decayed at a higher rate (Maini *et al.,* 6,7). Many researchers have demonstrated in different fruits that fruits in open have higher PLW and they decay at a higher rate than those kept in closed space or containers. Loss of water from apples kept in closed containers (CFB or wooden boxes) was lesser and hence they have less PLW and decay loss. Pandey *et al*. (8) have also reported increase in decay following storage of apples at ambient conditions.

There was drastic decline in fruit firmness of apples from 10th day (68.1 N) to 40th day (50.8 N) of storage at room temperature. This decline in fruit firmness was much higher in fruits under control than those kept in different containers (Table 3). Similarly, containers lined with polyethylene sheet had better texture that those lined with newspaper cuttings. However, fruits kept in CFB and wooden boxes were firmer than those kept either gunny bags or plastic crates. There was high difference in the firmness of fruits in control and those kept in CFB and wooden boxes at various intervals of observations. At the end of 40th day, fruits in control had least firmness (48.3 N) and those lined with polyethylene sheet and kept in CFB boxes had the highest firmness (63.9 N) (Table 3). Further, there was increasing decline in fruit firmness of apples from 1st (69.6 N) to 6th (58.9 N) month of storage in walk-in-chamber. This decline in fruit firmness was much higher in fruits under control (60.6 N) than those kept in different containers (Table 4). However, fruits kept in CFB (»67.0%) and wooden boxes were firmer than those kept either in gunny bags (»64.0%) or plastic crates (»65.0%). Similarly, containers lined with polyethylene sheet had better texture that those lined with newspaper cuttings (Table 4). This decline in fruit firmness was much higher in fruits under control than those kept in different containers. However, fruits kept

Table 3. Fruit firmness and juice recovery in apple as affected by packaging container and liner under ambient conditions.

Packing material	Days after storage									
	Fruit firmness (N)					Juice recovery (%)				
	10	20	30	40	Mean	10	20	30	40	Mean
Control	63.5	58.5	51.6	48.3	55.5	62.3	55.4	47.5	38.6	57.0
Gunny bag (NP)	65.3	59.5	54.3	48.5	56.9	63.3	55.9	49.5	43.2	53.0
Gunny bag (P)	65.7	60.3	55.0	49.0	56.8	64.3	57.6	54.3	43.6	55.0
Plastic crate (NP)	66.9	61.2	56.3	51.6	59.0	63.3	54.9	49.5	45.3	53.5
Plastic crate (P)	68.3	61.2	58.4	52.3	60.1	65.4	60.4	53.2	48.5	56.9
CFB box (NP)	70.5	66.4	60.6	51.2	62.2	67.4	62.5	58.3	51.5	59.9
CFB box (P)	72.5	68.5	61.5	53.2	63.9	69.5	63.6	60.4	52.3	61.5
Wooden box (NP)	69.7	66.0	60.0	51.0	61.7	65.4	62.3	57.7	51.3	59.2
Wooden box (P)	70.6	66.9	61.3	52.4	62.8	66.4	62.6	57.6	52.0	59.7
Mean	68.1	63.2	57.7	50.8		65.2	59.5	54.2	48.4	
$CD_{0.05}$	Container (C) = 4.4					Container (C) = 3.8				
	Days (D) = 1.8					Days (D) = 1.3				
	C × D = 3.2					C × D = 3.9				

in CFB and wooden boxes were firmer and they contained higher juice (%) than those kept either in gunny bags or plastic crates. Similarly, fruits lined with polyethylene had better texture because of 1000 loss moisture than those lined with newspaper cuttings. Following storage, there is loss of moisture, as a results, fruits become softer and less firmer. Similarly due to moisture loss, there is decline in juice content as well (Maini *et al.,* 6,7). As the loss in moisture is lesser in CFB or wooden boxes, fruits in these containers have better texture and juice recovery as well.

The recovery of juice declined with the increase in storage period from 10th day (65.2%) to 40th day (48.4%) at room temperature, and this decline in juice was much higher in control than those kept in different containers (Table 3). Although, declining trend in juice recovery was observed in all the containers, but it was very less in apples kept either in wooden or CFB boxes and very high in those kept either in gunny bags or plastic crates. Further, fruits lined with polyethylene sheet were more juicy than those lined with newspaper cuttings. At the end of 40th day, fruits in control had only 38.6% juice recovery, whereas those kept in CFB boxes and lined with polyethylene sheet had as high as 52.3% juice recovery (Table 3). The recovery of juice in apple declined with the increase in storage period from 1st (67.7%) to 6th month (55.9%) of cold storage, and this decline in juice was higher in control than those kept in different containers (Table 4). Although, this declining trend in juice recovery was observed in all the containers, but it was less in wooden or CFB boxes, and higher in gunny bags or plastic crates. Further, fruits wrapped with polyethylene sheets were more juicy than those wrapped with newspaper cuttings. At the end of 6th month, fruits in control had nearly 56% juice recovery, whereas those kept in CFB boxes and lined with polyethylene sheet had as high as 62.0% juice recovery (Table 4). Reduction in juice recovery following storage has also been reported by Pandey *et al.* (8).

Total soluble solids increased with the increase in storage period from 10th (10.7%) to 40th day (12.2%) of storage at room temperature (Fig. 1A). Initially, this increase in TSS content was faster in control fruits than those kept in different containers, but later it declined. Further, fruits wrapped/lined with polyethylene sheet had lesser TSS than those wrapped in newspaper cuttings (Fig. 1A). There was greater difference in TSS content of fruits in control and those kept in different containers at various intervals on observations, and at the end of 40th day, fruits in control had lowest TSS (11.8%) and those kept in wooden boxes had the highest (12.1%) (Fig. 1A). Total sugars content showed a trend similar to TSS content with regard to different containers and storage period *i.e.,* total sugars increased with the storage period from 10th (7.6%) to 40th day (9.0%) (Fig. 1B). Total sugar content were comparatively lower in fruits under control (8.4%) than different containers, although no definite trend was observed. Similarly, fruits lined with polyethylene sheets had higher total sugars than those lined with newspaper cuttings, but was non-significant (Fig. 1B). Titratable acidity showed declining trend with the storage period from 10th (1.18%) to 40th day (1.10%).

Table 4. Effect of packing containers and liners on fruit firmness and juice recovery in apple during cold storage.

Packing material	Storage period (Month)									
	Fruit firmness (N)					Juice recovery (%)				
	1	3	5	6	Mean	1	3	5	6	Mean
Control	68.5	62.5	58.5	52.8	60.6	66.3	60.2	54.2	42.6	55.8
Gunny bag (NP)	69.3	67.5	64.5	56.7	64.5	66.3	61.9	54.5	44.2	56.7
Gunny bag (P)	69.7	67.3	64.0	55.4	64.1	66.7	62.2	55.8	48.6	58.3
Plastic crate (NP)	68.4	67.2	65.4	60.3	65.3	67.3	62.9	55.5	49.5	58.8
Plastic crate (P)	68.8	67.0	66.3	60.6	65.7	67.8	60.4	56.2	52.5	59.2
CFB box (NP)	70.5	68.2	66.5	63.2	67.1	68.4	62.5	58.3	53.5	60.7
CFB box (P)	70.5	67.4	66.6	62.8	66.8	69.5	63.6	60.4	54.3	62.0
Wooden box (NP)	70.6	67.9	64.3	59.2	65.5	68.4	62.3	57.0	51.7	59.9
Wooden box (P)	69.7	66.0	60.0	59.0	63.7	68.8	62.6	57.9	52.0	60.3
Mean	69.6	66.8	64.0	58.9		67.7	62.1	56.6	55.9	
$CD_{0.05}$	Container (C) = 3.6					Container (C) = 3.6				
	Months (M) = 1.6					Months (M) = 1.6				
	C × M = 3.5					C × M = 3.5				

However, the decline was comparatively sharper in fruits under control than those stored in different containers. Among different containers, decline in acidity was lesser in CFB and wooden boxes than those kept in gunny bags or plastic crates (Fig. 1C). In general, fruits in control were less acidic than those kept in different containers. Ascorbic acid content decreased with the increase in storage period from 10th to 40th day of storage (Fig. 1C). This decrease in ascorbic content was lower in control fruits than those kept in different containers. Among different containers, ascorbic acid content were higher in fruits kept either in CFB or wooden boxes than those kept in gunny bags or plastic crates (Fig.1D). Such increase or decrease in TSS, acidity or other quality parameters following storage have also been reported by Maini *et al.* (6, 7) and Pandey *et al.* (8).

Total soluble contents increased with the increase in storage period from 1st (10.7%) to 6th month (12.1%) of cold storage (Fig. 2A). This increase in TSS content was faster initially in control fruits than those kept in different containers, but later it declined. Although, fruits in control had sweeter taste (TSS = 11.5%) than those in different containers, but TSS content were not significantly higher than those kept in any of the containers (Fig. 2A). Other containers have not much effect on TSS content. Although, fruits wrapped in polyethylene sheets have high TSS, but was not significantly higher than those wrapped in newspaper cuttings (Fig. 2A). Total sugars content showed a trend similar to TSS content with regard to different containers and storage period *i.e.,* total sugars increased with the storage period from 1st (7.6%) to 6th month (9.0%) (Fig. 2B). Total sugars contents were higher in fruits under control (8.6%) than those in different containers. Among different containers, there was not much significant difference in TSS content, however, total sugars were better in CFB boxes. Although, fruits wrapped in polyethylene sheets have better sugars, but not significantly superior to those wrapped in newspaper cuttings (Fig. 2B). Titratable acidity showed declining with the storage period from 1st month (1.17%) to 6th month of cold storage (1.10%). However, the decline was comparatively sharper in fruits under control than those stored in different containers (Fig. 2C). Among different containers, decline in acidity was lesser in CFB and wooden boxes than those kept in gunny bags or plastic crates. In general, fruits in control were less acidic than those kept in different containers. Ascorbic acid content decreased with the increase in storage period from 1st month to 6th month of cold storage. This decrease in ascorbic content was lower in control fruits than those kept in different containers. Among different containers, ascorbic acid content were higher in fruits kept either in CFB or wooden boxes than those kept in gunny bags or plastic crates (Fig. 2D). Although, fruits wrapped in polyethylene sheets have high ascorbic acid content, but were not significantly higher than those wrapped in newspaper cuttings (Fig. 2D). Total soluble solids contents, total sugars of apples increased and ascorbic acid content, and acidity decreased with the increase in storage either under ambient or cold storage conditions. This increase or decrease in different quality attributes was faster in control fruits than those kept in different containers. Fruit quality attributes were better

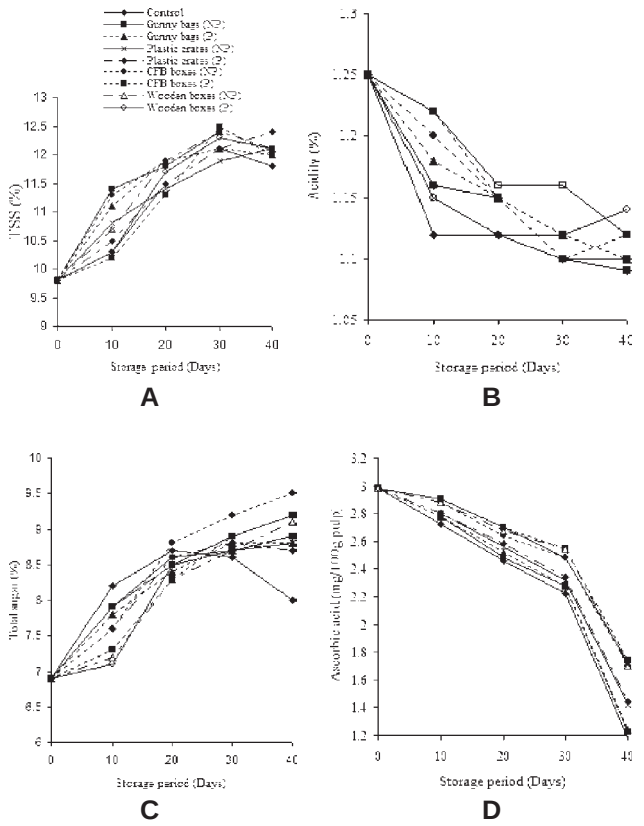

Fig. 1. Effect of packaging containers and liners on quality parameters (A) TSS, (B) total sugars, (C) acidity and (D) ascorbic acid of apple stored under ambient temperature (22-28°C).

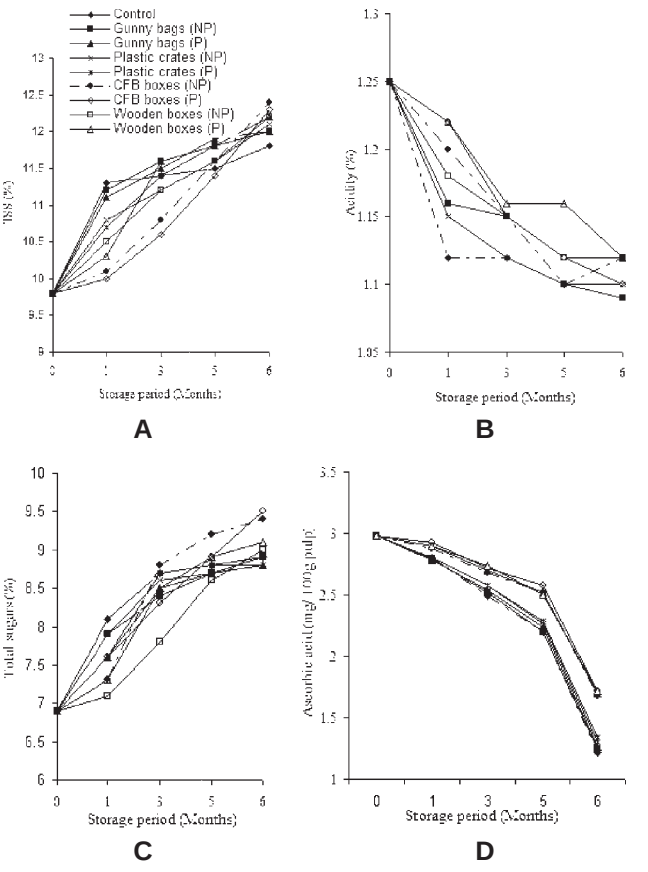

Fig. 2. Effect of packaging containers and liners on quality parameters (A) TSS, (B) total sugars, (C) acidity and (D) ascorbic acid of apple under cold store (5 ± 2°C).

in fruits packed in wooden or CFB boxes. It may primarily be due to the fact that with the increase in storage period, there is increase in PLW, and loss in water, as a result, TSS, total sugars or ascorbic acid content increases. Due to inverse relation between acidity and sugars, it decreases, as the sugars or TSS increases.

On the basis of sensory evaluation, it appears that apples in control were inferior in taste (5.1), colour (5.4), appearance (4.2) and over all acceptability than those packed in different containers (Table 5). Irrespective of duration of storage, apples kept either in CFB or wooden boxes scored significantly higher for taste, colour, appearance and overall acceptability than other containers. Similarly, irrespective of packaging containers, apples had better score for taste, colour, appearance and overall acceptability on 10th day of storage at room temperature than 40th day of storage. In general, irrespective of containers, apples were overall acceptable only up to 20th day of storage. However, apples were acceptable up to 30th day in wooden as well as CFB boxes, but not in other containers. In general, fruits lined with polyethylene sheet had better score than those lined with newspaper cuttings (Table 5). Apples in control were inferior in taste (6.6), colour (8.2), appearance (6.3) and in over all acceptability (7.7) than those packed in different containers (Table 6). Irrespective of duration of storage, apples kept either in CFB or wooden boxes scored significantly higher for taste, colour, appearance and overall acceptability than other containers. Similarly, irrespective of packaging containers, apples had better score for taste, colour, appearance and overall acceptability after 1st month of cold storage than 6th month of cold storage. In general, irrespective of containers, apples were overall acceptable up to 5th month of cold storage. However, apples were acceptable up to even 6th month of cold storage in wooden as well as CFB boxes, but not in other containers (Table 6). Over all, apples kept either in CFB or wooden boxes have significantly higher overall acceptability score primarily because they have higher juice content, better colour, taste and quality attributes and than those kept in other containers or control.

Table 5. Sensory evaluation of apple packed in different containers and liners under ambient conditions.

Packing material	Days after storage																			
	Taste					Colour					Appearance					Overall acceptability				
	10	20	30	40	Mean	10	20	30	40	Mean	10	20	30	40	Mean	10	20	30	40	Mean
Control	7.2	6.3	4.8	2.2	5.1	7.5	6.5	4.9	2.5	5.4	6.3	5.2	4.3	1.0	4.2	6.5	5.8	4.2	3.2	4.2
Gunny bag (NP)	7.2	6.4	4.8	2.8	5.3	7.6	6.6	4.9	2.9	5.5	6.4	5.2	4.4	1.2	4.3	6.6	5.8	4.2	3.4	4.3
Gunny bag (P)	7.3	6.3	4.9	2.6	5.3	7.7	6.8	5.1	3.0	5.7	6.3	5.3	4.5	1.6	4.4	6.8	5.9	4.3	3.6	4.5
Plastic crate (NP)	7.3	6.4	5.0	3.0	5.4	7.7	6.8	5.3	3.3	5.8	6.3	5.4	5.0	2.0	4.7	7.0	6.0	5.0	3.8	4.8
Plastic crate (P)	7.4	6.4	5.0	3.1	5.5	7.8	6.9	5.4	3.4	5.9	6.4	5.4	5.0	2.1	4.7	7.4	6.4	5.0	4.1	5.0
CFB box (NP)	8.3	7.6	6.2	5.2	6.8	8.8	7.4	6.8	5.6	7.2	7.3	6.2	5.2	4.8	5.9	8.2	6.8	6.2	5.0	5.7
CFB box (P)	8.4	7.7	6.3	5.2	6.9	8.9	7.7	6.8	5.7	7.3	7.4	6.5	5.3	5.2	6.1	8.4	6.8	6.3	5.2	5.8
Wooden box (NP)	8.2	7.5	6.2	4.8	6.7	8.2	7.7	6.6	5.2	6.9	7.0	6.6	5.3	4.7	5.9	8.2	7.5	6.2	4.8	5.6
Wooden box (P)	8.3	7.6	6.3	5.0	6.8	8.4	7.6	6.7	5.3	7.0	7.2	6.6	5.2	4.4	5.8	8.3	7.6	6.3	4.0	5.7
Mean	7.7	6.9	5.5	3.5		6.1	6.4	5.8	4.0		6.7	5. 4	4.9	3.0		7.2	5.7	4.8	2.7	
$CD_{0.05}$	Container (C) = 0.10 Days (D) = 0.03 C × D = 0.12					Container (C) = 0.16 Days (D) = 0.09 C × D = 0.10					Container (C) = 0.12 Days (D) = 0.09 C × D = 0.10					Container (C) = 0.14 Days (D) = 0.09 C × D = 0.11				

Table 6. Effect of packing containers and liners on sensory score of apple during cold storage.

Packing material	Taste					Colour					Appearance					Overall acceptability				
	Storage period (months)																			
	1	3	5	6	Mean	1	3	5	6	Mean	1	3	5	6	Mean	1	3	5	6	Mean
Control	6.2	5.3	4.6	2.1	4.6	7.5	6.5	4.9	2.5	5.4	6.3	5.2	4.3	1.0	4.2	6.5	5.8	4.2	3.2	4.9
Gunny bag (NP)	6.3	5.4	4.5	2.4	4.7	7.6	6.6	4.9	2.9	5.5	6.4	5.2	4.4	1.2	4.3	6.6	5.8	4.2	3.4	5.0
Gunny bag (P)	6.3	5.3	4.5	2.6	4.7	7.7	6.8	5.1	3.0	5.7	6.3	5.3	4.5	1.6	4.4	6.8	5.9	4.3	3.6	5.2
Plastic crate (NP)	6.3	6.4	5.0	2.8	5.1	7.7	6.8	5.3	3.3	5.8	6.3	5.4	5.0	2.0	4.7	7.0	6.0	5.0	3.8	5.5
Plastic crate (P)	6.4	5.4	5.2	3.0	5.0	7.8	6.9	5.4	3.4	5.9	6.4	5.4	5.0	2.1	4.7	7.4	6.4	5.0	4.1	5.7
CFB box (NP)	7.3	6.6	5.2	4.2	5.8	8.8	7.4	6.8	5.6	7.2	7.3	6.2	5.2	4.8	5.9	8.2	6.8	6.2	5.0	6.6
CFB box (P)	7.5	7.7	5.3	5.2	6.4	8.9	7.7	6.8	5.7	7.3	7.4	6.5	5.3	5.2	6.1	8.4	6.8	6.3	5.2	6.7
Wooden box (NP)	6.2	6.5	5.6	4.8	5.8	8.2	7.7	6.6	5.2	6.9	7.0	6.6	5.3	4.7	5.9	8.2	7.5	6.2	4.8	6.7
Wooden box (P)	7.3	6.8	5.6	5.0	6.2	8.4	7.6	6.7	5.3	7.0	7.2	6.5	5.2	4.4	5.8	8.3	7.6	6.3	5.0	6.7
Mean	6.6	5.9	5.1	3.6		8.2	6.3	5.7	3.9		6.7	5.8	4.9	3.0		7.3	6.5	5.3	4.2	
$CD_{0.05}$	Container (C) = 0.09 Month (M) = 0.06 C × D = 1.29					Container (C) = 0.04 Month (M) = 0.03 C × D = 1.62					Container (C) = 0.09 Month (M) = 0.05 C × D = 1.36					Container (C) = 0.07 Month (M) = 0.13 C × D = 1.39				

Similarly, lining with polyethylene sheet was better from sensory evaluation point of view. Thakur and Lal (9) have also reported that CFB boxes are better for apples.

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