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N Umme Seema
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

MD. Jameel Jhalegar
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

SL Jagadeesh
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

G Bhuvaneshwari
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Mallikarjun G Await
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Tanveer Ahmed
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Corresponding Author:
N Umme Seema
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Effect of packaging material on shelf life and quality of sapota cv. Cricket ball

N Umme Seema, Jameel Jhalegar, SL Jagadeesh, G Bhuvaneshwari, Mallikarjun G Await and Tanveer Ahmed

Abstract
The sapota fruit is very perishable due to its rapid metabolic activities. The main objective of this study is to increase the shelf life and maintain the quality of sapota fruit during storage. Fruits were packed in different packaging materials such as corrugated fiber board (CFB) box, Bamboo basket, Nylon bags and control (gunny bag) and then stored at ambient condition (28 °C and 85-90%). The fruits were examined for PLW, fruit firmness and fruit decay with respect to physiological parameters. While, chemical parameters *viz.*, TSS and total sugar were examined on every 2 days interval during storage. The result revealed that a fruit packed in CFB box was found to be more beneficial in reducing physiological loss in weight and fruit decay with minimum changes in chemical constituents than other packaging materials.

Keywords: *Manilkara achras*, shelf life, storage condition, corrugated fiber board, packaging materials fruit firmness

1. Introduction
Sapota (*Manilkara achras* (Mill.) Fosberg) is one of the prominent fruits in India and belongs to family Sapotaceae. It is a native of Mexico and Central America, and now widely cultivated throughout tropics. In India, its cultivation was first reported in Maharashtra in 1898 (Cheema *et al.*, 1954) [6]. Sapota fruit is a good source of digestible sugar, which ranging from 12 to 20 per cent and minerals such as iron and calcium (Bose and Mitra, 1990) [5]. The fruits have an appreciable amount of protein, fat, fibre, calcium, phosphorus, iron, carotene and vitamin C (Shanmugavelu and Srinivasan, 1973) [24]. Further it is also rich in bio-iron required for the formation of haemoglobin (Hiremath and Rokhade, 2012) [11]. It is also rich in phenolics, *viz.*, Gallic acid, catechin, chlorogenic acid, leucodelphinidin, leucocyanidin and leucopelargonidin (Anand *et al.*, 2007) [1].
Although, research efforts have succeeded in boosting the production of sapota crop, but the purpose of obtaining maximum profit will not be served unless an increased production is supplemented with similar efforts to minimize the post harvest losses. Hence, there is a need to regulate ripening so as to improve its shelf life. Extension of shelf life can be made possible by reducing the rate of transpiration, respiration, ethylene evolution, which may be achieved by proper storage methods like evaporative cooling, controlled or modified atmosphere storage and by post harvest practice, treatments like best packing material selected according to the produce suitability, skin coating and treatment with novel chemicals
Packaging of fresh fruit has a great significance in reducing the wastage. Packaging provides protection from mechanical damage, undesirable physiological changes and pathological deterioration during storage. A wide variety of containers such as corrugated fiber board (CFB) boxes, wooden boxes, bamboo baskets are the important packages form used in the transportation and storage of fruits. The CFB box has many advantages as light in weight, causes less damage, easy to handle and print improve the product image, reduce the fright cost and can be prepared form cheaper wood and other plant cellulose waste and retains their attractiveness. Sapota fruits are highly perishable and are normally packed in gunny bags for storage. Therefore, an experiment was planned to study the effect of packaging on quality of sapota fruits.

2. Materials and Methods
2.1 Materials and treatments
The present investigation was undertaken in the Dept of Post-Harvest Technology, University

of Horticultural Sciences, Bagalkot, India during the year 2016-17. Sapota fruits (cv. Cricket ball) of large sized and round shape, free from any visible damage, scratches and decay were selectively harvested manually from Kaladagi, a place known for production of sapota, near Bagalkot at right maturity stage that is when skin colour of the fruits changed from light brown to dark brown (Potato like colour) and brown scale like structure on the surface of fruit was disappeared and brought to the laboratory in plastic crates. Then, the plastic crates containing fruits were placed in the cold room for pre-cooling by room cooling method at 12ºC for 10 hours. Then fruits were packed in four different packaging materials like CFB boxes, bamboo baskets, nylon bags and gunny bags were used in the experiments. Then fruits were packed in those bags. Each pack of fruits was kept undisturbed until the scheduled date of observation. Thus, there were so many numbers of packs under each treatment as the number of times the fruits were observed at scheduled interval. There were 5 packs each containing 5 to 6 fruits for each treatment. All the fruit-packs removed from storage condition on scheduled day of observation were used to record different observations. Thus, each pack in the storage condition passed through the storage time undisturbed until it was finally taken out to observe for different parameters

2.2 Physiological loss in weight (%)
To determine the physiological loss in weight (PLW), sapota fruits from each replication were weighed at beginning of storage which was recorded as initial weight. On subsequent dates of observation during storage, the fruits were reweighed and recorded as final weight on every 2 days intervals. PLW was calculated by using following formula and expressed in percentage.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight (g)} - \text{Final weight(g)}}{\text{Initial weight (g)}} \times 100$$

2.3 Fruit decay (%)
At regular intervals the number of rotten (spoiled) fruits were counted in each replication and the decay was expressed in per cent. Extent of decay was determined by number of rotten/spoiled fruits at each interval of observation and percentage was calculated on the basis of total number of fruits stored in each treatment.

$$\text{Fruit decay (\%)} = \frac{\text{Number of rotten/spoiled fruits}}{\text{Total number of fruits}} \times 100$$

2.4 Fruit firmness (Newtons)
Fruit firmness was determined using texture analyzer using shear test. The sapota fruit were cut using a cutting/shear probe by programmed setting.

Mode	:	measure shear force
Pre speed	:	5.0 mm/s
Test speed	:	5.0 mm/s
Post test speed	:	10.0 mm/s
Distance	:	38 mm

Firmness was defined as maximum force (kgf) required during the cut, which was expressed in Newtons (N)

2.5 Respiration rate (ml CO_2 $kg^{-1}h^{-1}$)
Respiration rate was measured by using auto gas analyzer (Model: Checkmate 9900 O 2 /CO 2, PBI Dan sensor, Denmark) and expressed as ml CO2 kg-1 h -1. For this, two kiwifruits were trapped in 500 ml airtight containers having twist-top lid fitted with a silicone rubber septum at the center of the lid. The containers were kept at 250C for 1h for accumulation of respiratory gases at the headspace. After specified time, the head space gas was sucked to the sensor of the analyzer through the hypodermic hollow needle and the displayed value of evolution rate of CO 2 concentration (%) was recorded. Rate of respiration was calculated on the basis of rate of evolution of CO 2 from the sample per unit weight per unit time using the following formula. CO2 (%) x Head space Respiration rate (ml CO2 kg-1 h -1) = 100 x Weight (kg) x Time (h)

$$\text{Rate of respiration (ml CO2/kg/h)} = \frac{\text{CO2 (\%)} \times \text{Head space}}{100 \times \text{weight of fruit (kg)} \times \text{Time (hr)}}$$

2.6 Polygalactouronase (PG) activity
Polygalactouronase (PG) activity in sapota was measured following the method of Lazan *et al*. (1989) with minor modifications.

2.6.1 Reagents
a. Sodium acetate buffer 0.2M pH (6.0)
b. 0.4% sodium acetate buffer (pH 3.8)
c. 5% phenol solution
d. PG enzyme assay mixture: For the preparation of enzyme assay mixture, 0.45 g of pectin and 0.1g casein were dissolved in 0.4% sodium acetate buffer (pH 3.8) and then the solution was diluted to 100 ml with 0.4% sodium acetate buffer (pH 3.8) Preparation of enzyme extract One gram of sapota pulp was weighed and homogenized in 10 ml sodium acetate buffer (0.2 M; pH 6.0) with a pinch of $Na_2S_2O_4$ and polyvinylpyrrolidine in chilled mortar. The homogenate was centrifuged at 15000 ´ g for 20 min at 4°C and supernatant was used for the assay of Polygalactouronase (PG) activity.

2.6.2 PG enzyme assay
For measuring the PG enzyme activity, 0.2ml of enzyme extract was added to 2ml of assay mixture and incubated at 37°C for 2 h. From this incubated mixture, 0.05 ml was added to 1ml 5% phenol; followed by 5 ml of 96% H_2SO_4 was poured over a mixture and allowed to react for 15 min. the content was diluted with 5 ml distilled water, thoroughly mixed and cooled to room temperature. The absorbance was recorded at 490nm in spectrophotometer (Double beam UV-VIS spectrophotometer UV5704SS). Blank was prepared by adding distilled water instead of enzyme extract in the assay mixture.

2.6.3 Calculation
PG activity was expressed as (288.07× OD) "µg galactouronic acid FW g^1 h^{-1}"

2.7 Electrolyte leakage (%)
Fifteen freshly cut fruit discs (0.5 cm^2 each) were rinsed 3 times (2-3 min) with demineralised water and subsequently floated on 10 mL of demineralised water. The electrolyte leakage in the solution was measured after 22 h of floating at room 33º C temperature using a conductimeter (Crison 522, Crison Instruments, S.A., Spain). Total conductivity was obtained after keeping the flasks in an oven (90 °C) for 2 h. Results were expressed as percentage of total conductivity.

2.8 Total soluble solids (°Brix)
The juice extracted by crushing the pulp of the sapota and

strained through muslin cloth was used for measuring total soluble solids. Total soluble solids were estimated using FISHER Hand Refractrometer (0 -50). The results were expressed as degree brix.

2.9 Total sugar (%)
Total sugars were determined following the method described by AOAC, 1980). Fifty ml lead free filtrate was taken in a 100 ml volumetric flask and to it 5 ml of concentrated HCl was added, mixed well and then kept for 24 hours at room temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein indicator till the pink colour persisted for at least few seconds. Then volume was made up to 100 ml. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator till brick red colour is formed and noted as an end point.

$$\text{Total sugar (\%)} = \frac{\text{Factor} \times \text{volume made up}}{\text{titre value} \times \text{weight of sample}} \times 100$$

2.10 Experimental design and data analysis
The experiment was carried out with 4 treatments and the experiment was repeated 5 times and pooled data was subjected to statistical analysis. Fruits were arranged in Complete Randomised Design. Randomly selected fruits were taken to analyse physiological loss in weight, respiration rate, Total Soluble Solids (TSS), total sugar, firmness, Polygalactouronase activity and Electrolyte leakage. Statistical analyses were performed using Web Agri Stat Package (WASP) Version 2. Significant differences among means at P = 0.05 were determined by post hoc tests using Duncan's multiple range test

3. Results and Discussion
3.1 Physiological loss in weight (PLW) (%)
The data pertaining to PLW of sapota fruits as influenced by packaging material under ambient storage are presented in Table 1. Irrespective of the treatments under ambient condition, there was a controlled increase in physiological loss in weight (PLW) with the increase in storage period from 2nd day (8.70%) to 5th day (25.00%). Similarly, PLW was the maximum in control fruits (22.90%) and minimum in fruits packed in CFB box (13.30%). Other packaging treatments showed intermediate results, which were significant over control. However, in general, PLW increased steadily in CFB box, bamboo and nylon packed fruits with the increase in the storage period, whereas, in gunny bags packed fruits the PLW showed a sharp increase. Further, gunny bag packed fruits showed quite higher PLW (23.60%) even on 4th day of storage; whereas fruits packed in CFB had less PLW (20.90%) even on 5th day of storage.

Irrespective of the treatments, there was an increase in PLW with the increase in storage period from 2nd day (8.70%) to 5th day (25.00%). In the present investigation, the increase in PLW with increased period of storage was obvious because fruits are living entities and various physiological activities such as transpiration and respiration during storage go on. These changes lead to reduction in water content, organic compounds, which are used as substrates in the process of respiration of produce. Increase in PLW with increased in storage was also reported by Fageria *et al*., 2007 and Yadav *et al*. 2005 in ber fruits. Among various treatments, minimum PLW was recorded in the fruits packed in CFB boxes, which may be attributed to less transpiration and respiration due to modified atmosphere created in CFB which also acts as a physical barrier for transpiration. As a result less amount of water transpired from the fruits. Similar findings were reported by Haard and Salunkhe, 1975 [10]; Yadav *et al*., 2010 [29] in mango, Ayar *et al*., 2011 [2] in jamun, Chaudhary and Kumbhare (1979) in sweet orange and Waskar *et al*. (1999) in sapota, Naik and Rokhade. (1997) [18] in ber and Kaur *et al*. (2013) [12] in pear. The higher PLW in case of gunny bag stored sapota fruits might be due to the detrimental effect of higher temperature and humidity can reduce the weight loss of fresh produce, leading to increased moisture loss. This can also be attributed to the increase in respiration and transpiration losses with increase in temperature Salisbury and Ross. (1992) [22]

3.2 Fruit decay
Interestingly neither fruit packed in CFB box nor gunny bags (control) fruits showed any symptom of fruit decay up to 4th day of storage. However, irrespective of storage period, fruit decay was significantly higher in the gunny bags packed fruits (7.42%), than the CFB packed fruits. Among different packaging materials, CFB box packed fruits showed significantly least fruit decay (4.78%) followed by fruits packed in bamboo baskets (6.25%) and nylon bags (7.42%). Similarly, fruit decay increased with increase in storage period from 4th day (4.90%) to 5th day of storage (12.30%). The interaction effect of treatment (T) x storage period (D) was also significant

Minimum decay percentage was recorded in T1 (7.79%) and T2 (9.68%) which may be due to limited exposure of fruits to the micro flora and atmospheric oxygen and also due to less mechanical damage occurred in CFB boxes due adequate and proper ventilation. Present results confirm with those of Kurubar *et al.* (2011) [13] who reported reduced fruit decay in poona fig packed in CFB boxes. Similar findings were also obtained by Ayar *et al.*, 2011 [2] in jamun. However, the control fruits showed higher decay percentage which may be ascribed to skin injury or cracking caused degradation of cell wall as well as it increases the ethylene production and respiration rate which results in decaying and rotting of fruits and consequently occurrence of the pathogen. These are in conformity with results of Masalkar and Garande. (2005) [16] and Chouksey *et al*. (2013) [7] in custard apple. Similar findings were also made by Kadu and Gajipara. (2009) in sapota and Narsaiah *et al*. (2015) [19] in papaya.

3.3 Fruit firmness
Irrespective of storage period, fruits packed CFB box had better firmness than control fruits (37.10N). Among different packaging materials fruits packed in CFB box (63.50 N) had the best firmness significantly followed by bamboo baskets (54.43 N) and nylon bags (49.88 N) packed fruits. Similarly, fruit firmness decreased sharply with the increase in storage period from 2nd day (67.07 N) to the 5th day of storage (30.67N). Interestingly control fruits showed very less firmness (17.09 N) even on 5 th day of storage, whereas the fruits packed in CFB box (44.18N) packed fruits were still firmer even on 5th day of storage. The interaction effect of treatment (T) x storage period (D) were also significant

The fruits were quite firm on 3rd day of storage. A sudden decrease in fruit firmness was noticed on 4th day of storage in control, whereas, the fruits packed in CFB box (63.50 N) showed significantly higher firmness. The acceptable limit of firmness for sapota fruits lies between 38.06 N to 45.55N. The minimum fruit firmness (35.52N) was recorded in control fruits. The minimum loss in firmness of flesh during storage could be due lesser degradation of soluble pectin by least activity of endopolygalacturonase enzyme in fruits. The results are in agreement with Mann *et al.* (1990) [15] who reported a decrease in fruit firmness with the advancement in storage period. Decrease in fruit firmness during storage is presumably due to change in cell wall polysaccharides. Similar results were obtained by Singh and Narayana (1999) [25] in mango.

3.4 Respiration rate (ml CO_2 /kg/hr)

Respiration determines the rate of metabolic processes which in turn have a direct impact on quality characteristics such as firmness, sugar content and overall flavor. Commodities with high rate of respiration possess short storage life in comparison to commodities with low rate of respiration which are usually having relatively long storage life.

Respiration rate increased significantly with the increase in the storage period, from the 2nd day (67.14 ml CO_2 kg^{-1} h $-^{1}$) to 4th day of storage (74.62 ml CO_2 kg^{-1} h $-^{1}$) under ambient conditions and then declined. Similarly, fruits packed in CFB box showed lesser respiration rate (51.59 ml CO_2 kg^{-1} h $-^{1}$) than gunny bag fruits (control) (57.76 ml CO_2 kg^{-1} h $-^{1}$), significantly followed by bamboo baskets (55.01 ml CO_2 kg^{-1} h $-^{1}$) and nylon bags (55.78 ml CO_2 kg^{-1} h $-^{1}$). Further, gunny bag fruits showed increasing trend in respiration rate from 2rd day (67.14 ml CO_2 kg^{-1} h $-^{1}$) of storage to 4th day (74.62 ml CO_2 kg^{-1} h $-^{1}$), but then respiration rate declined thereafter. However, fruits packed in CFB box, bamboo baskets and nylon bags showed significantly increasing trend, but at slower rate with the increase in storage period and declined thereafter, although fruits packed in CFB box was being the most effective in doing so. The interaction effect of treatment (T) x storage period (D) was also significant

Irrespective of packaging materials, respiration rate increased significantly with the increase in the storage period, from the 2nd day (67.14 ml CO2 kg^{-1} h $-^{1}$) to 4 th day of storage (74.78 ml CO2 kg^{-1} h $-^{1}$) under ambient conditions. Respiration rate of the sapota fruits was observed to decrease gradually with a progress in storage duration. The lowest respiration rate was recorded in case of fruits packed in CFB boxes whereas the control fruits exhibited higher respiration rates throughout storage. Lower rate of respiration in fruits packed in CFB boxes in comparison to other packaging material could be attributed to CFB provides appropriate environment, ventilation and maintained high humidity inside the pack by accumulation of CO_2 and depletion of O_2. This helped to maintain turgidity, higher firmness and freshness and retained the respiratory subtrates (carbohydrates, proteins, and fats) from getting broken down into simple end products during storage. The results of the study are in comfirmity with the findings of Srivastava and Dwivedi. (2000) [27] and Raorane *et al.* (2012) [21] in banana and kokum, respectively.

3.5 Polygalactouranase (PG) activity

PG is an important enzyme responsible for fruit softening. With decreased PG activity, fruit softening is delayed, which helps in increasing the shelf or storage life of fruits. Irrespective of any treatment, PG activity increased significantly from 2nd day (26.55 µg-galatouronic acid-FW g^{-1} h $^{-1}$) to 4th day of storage (71.18 µg-galatouronic acid-FW g^{-1} h $^{-1}$) and then declined sharply on 5th day of storage, whereas fruits packed in CFB box also showed the similar trend but at a significantly slower rate with the increase in storage period. Further, irrespective of storage period, PG activity was significantly higher in the gunny bag fruits (88.72 µg-galatouronic acid-FW g^{-1} h $^{-1}$) than the CFB box on 4th day storage. Among different packaging materials, fruits packed in CFB box showed least PG activity (55.40 µg-galatouronic acid-FW g^{-1} h $^{-1}$), significantly followed by bamboo baskets (61.95 µg-galatouronic acid-FW g^{-1} h $^{-1}$) and nylon bags (89.06 µg-galatouronic acid-FW g^{-1} h $^{-1}$). The interaction effect of treatment (T) x storage period (D) was also significant

The present study indicated that untreated (gunny bag) fruits exhibited very high PG activity than the treated fruits. Irrespective of any treatment, PG activity increased significantly from 2nd day (27.25 µg-galatouronic acid-FW g^{-1} h $^{-1}$) to 4th day of storage (80.23 µg-galatouronic acid-FW g^{-1} h $^{-1}$) and then declined sharply on 5 th day of storage, whereas fruits packed in CFB box also showed an increasing trend but significantly at a slower rate. Such effects of packaging materials on PG activity can be explained on the basis of the role of packaging in increasing fruit firmness by regulating the hydrolytic cleavage of a-(1-4)-galacturonan linkage involved in PG activity Fischer and Bennett. (1991) [9] and is responsible for pectin disassembly during fruit ripening Sitrit and Bennett (1998) [26].

3.6 Electrolyte leakage

Electrolyte leakage increased significantly with the increase in the storage period, from the 2nd day (4.34%) to 5th day of storage (10.42%) under ambient conditions. Similarly, fruits packed in CFB box showed lesser electrolyte leakage than gunny bag fruits (control) (10.64%), among different packaging materials fruits packed in CFB box showed the least electrolyte leakage (4.43%) significantly followed by bamboo baskets (5.88%) and nylon bags (7.78%). Further, gunny bag fruits showed increasing trend in electrolyte leakage from 2nd day (6.84%) of storage to 5th day (14.61%). However, fruits packed in CFB box, bamboo baskets and nylon bags showed significantly increasing trend, but at slower rate with the increase in storage period. The interaction effect of treatment (T) x storage period (D) was also significant.

Electrolyte leakage showed an exponential increasing behavior as storage period prolonged. Irrespective of packaging materials, electrolyte leakage increased significantly with the increase in the storage period, from the 2nd day (4.34%) to 5th day of storage (10.42%) under ambient conditions. Similarly, fruits packed in CFB box showed lesser electrolyte leakage than gunny bag fruits (control) (10.64%), Biswas *et al*. (2010) [4] suggested that inhibition of lipid peroxidation may be one of the mechanisms responsible for the anti-senescence effects of the CFB.

3.7 Total soluble solid

Interestingly, gunny (control) fruits showed high TSS from 2nd day itself and they increased till 4 th day but thereafter, it declined, whereas, in CFB box, bamboo baskets and nylon bags packed fruits it went on increasing up till 5th day of storage but at slower rate. However, irrespective of storage period, TSS was significantly higher in the gunny bags (21.43 °B), than the CFB boxes. Among different packaging materials, fruits packed in CFB boxes showed least TSS (19.72 °B), significantly followed by bamboo baskets (20.33

°B) and nylon bags (20.68 °B). Similarly, irrespective of packaging materials, TSS increased with increase in storage period from 2nd day (18.67 °B) to 5th day of storage (21.92 °B). The interaction effect of treatment (T) x storage period (D) was also significant.

The minimum TSS at all the days of storage was observed in the CFB boxes, and bamboo basket when compared to all other treatments this might be due might be attributed to conversion of starch and other polysaccharides into soluble forms of sugar. In general, the increase in TSS during the storage period may be due to the numerous catabolic processes taking place in the fruits, preparing it for senescence. The reason for the increase in TSS could be attributed to the water loss and hydrolysis of starch and other polysaccharides to soluble form of sugar. Wills *et al* (1989) [28] have also reported that starch gets hydrolyzed into mono and disaccharides, which in turn may lead to an increase in TSS. Similar findings of increase in TSS of peach fruits during storage have also been reported by Ochel *et al.* (1993) [20] Salunkhe and Desai. (1995) [23].

3.8 Total sugar

Interestingly, fruits packed in gunny bags (control) showed high total sugars from 2nd day itself (14.64%), which increased till 4th day (19.54%) of storage but thereafter, total sugars declined, whereas, in CFB box, bamboo baskets and nylon bags packed fruits total sugars showed increasing trend till 5th day of storage but at slower rate. However, irrespective of storage period, total sugars were significantly higher in the gunny bag fruits (16.69%), than the CFB box, bamboo baskets and nylon bags. Among different packaging materials fruits packed in CFB box showed least total sugars (13.59%), significantly followed bamboo baskets (13.88%) and nylon bags (14.42%). Similarly, irrespective of packaging material, total sugars increased with increase in storage period from 2nd day (10.21%) to 5th day of storage (18.2%). The interaction effect of treatment (T) x storage period (D) was also significant.

The increase in total sugars during storage may possibly be due to breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars. The decline in the sugar content at the later stages of storage may be attributed to the fact that after the completion of 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.* (1989) [28]. The delayed increase in the sugar content under CFB packaging may be attributed to the inherent property of package in delaying the metabolic activities of fruits during storage due to delay in ethylene production and respiration rate. Increase in total and reducing sugars with the advancement of storage interval in fruits as a result of different packaging materials have also been reported by Banik *et al.* (1988) [3] in sapota. Further, the results obtained in the present studies are in agreement with the earlier findings of Kaur *et al.* (2013) [12] who reported similar trends in the total sugar content of mango fruits packed in perforated polythene bags and that of Mohla *et al.* (2005) [17] in sand pear.

Table 1: Effect of packaging material on physiological loss in weight (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Packaging material	PLW (%)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	6.7	12.4	20.9	13.30
T_2	7.5	13.4	22.1	14.30
T_3	8.4	15.5	24.1	16.00
T_4	12.4	23.6	32.7	22.90
Mean	8.70	16.2	25.0	
S. Em±	0.047	0.056	0.122	
C.D. at 1%	0.194	0.231	0.503	

T_1- Fruits packed in CFB box
T_2- Fruits packed in Bamboo basket
T_3- Fruits packed in Nylon bags
T_4- Fruits packed in Gunny bags

Table 2: Effect of packaging material on fruit decay (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Packaging material	Fruit decay (%)		
	4 DAS	5 DAS	Mean
T_1	1.76	7.79	4.78
T_2	2.82	9.68	6.25
T_3	3.92	10.91	7.42
T_4	11.09	20.81	15.95
Mean	4.90	12.30	
S. Em±	0.03	0.06	
C.D. at 1%	0.13	0.27	

Table 3: Effect of packaging material on fruit firmness (N) of sapota cv. Cricket ball during storage at ambient condition

Packaging material	Firmness (N)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	77.57	68.76	44.18	63.50
T_2	69.27	61.75	32.28	54.43
T_3	64.65	56.85	28.13	49.88
T_4	56.81	37.41	17.90	37.10
Mean	67.07	56.94	30.67	
Initial	82.32			
S. Em±	0.10	0.08	0.18	
C.D. at 1%	0.41	0.35	0.54	

Table 4: Influence of packaging material on respiration rate (ml CO_2 / kg / h) of sapota cv. Cricket ball during storage at ambient condition during storage

Packaging material	Respiration rate (ml CO_2 / kg / h)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	56.58	64.23	36.46	51.59
T_2	67.07	73.34	30.52	55.01
T_3	68.22	76.44	29.36	55.78
T_4	76.69	84.47	20.78	57.76
Mean	67.14	74.62	29.28	
Initial	49.10			
S. Em±	0.13	0.05	0.07	
C.D. at 1%	0.55	0.24	0.30	

Table 5: Effect of packaging material on Polygalactouronase enzyme activity (µg-galatouronic acid-FW g^{-1} h^{-1}) of sapota cv. Cricket ball during storage at ambient condition

Packaging material	Polygalactouranase enzyme activity (µg-galatouronic acid-FW g^{-1} h^{-1})			
	2 DAS	4 DAS	5 DAS	Mean
T_1	23.41	57.24	72.04	50.89
T_2	25.01	62.58	78.62	55.40
T_3	28.12	76.18	81.55	61.95
T_4	29.67	88.72	23.01	47.13
Mean	26.55	71.18	63.80	
Initial	22.15			
S. Em±	0.11	0.05	0.08	
C.D. at 1%	0.45	0.22	0.35	

Table 6: Effect of packaging material on electrolyte leakage (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Packaging material	Electrolyte leakage (%)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	2.45	4.25	6.59	4.43
T_2	3.51	5.39	8.72	5.88
T_3	4.75	6.83	11.76	7.78
T_4	6.84	10.47	14.61	10.64
Mean	4.34	6.74	10.42	
Initial	1.61			
S. Em±	0.05	0.03	0.09	
C.D. at 1%	0.22	0.12	0.34	

Table 7: Effect of packaging TSS (°B) of sapota fruit cv. Cricket ball during storage at ambient conditions

Packaging material	TSS (°B)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	16.36	18.96	23.84	19.72
T_2	17.98	20.018	22.98	20.33
T_3	18.89	21.18	21.98	20.68
T_4	21.43	23.98	18.89	21.43
Mean	18.67	21.03	21.92	
Initial	16.02			
S. Em±	0.08	0.11	0.08	
C.D. at 1%	0.34	0.45	0.34	

Table 8: Effect of packaging Total sugar (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Packaging material	Total sugar (%)			
	2 DAS	4 DAS	5 DAS	Mean
T_1	7.9	12.89	19.99	13.59
T_2	8.76	13.98	18.92	13.88
T_3	9.54	15.73	17.99	14.40
T_4	14.64	19.54	15.9	16.69
Mean	10.21	15.53	18.2	
Intial	6.45			
S. Em±	0.03	0.12	0.07	
C.D. at 1%	0.15	0.57	0.36	

4. Conclusion
In case of packaging materials, out of four levels (i.e. corrugated fibre board boxes, bamboo baskets, nylon bags and gunny bag) the corrugated fibre board boxes was found to be more beneficial followed by bamboo baskets as compared to gunny bag.

Packaging is a vital component of post-harvest management to assemble the produce into convenient units and to protect it from deterioration during handling and marketing. Adequate packaging protects the fruits from physiological, pathological and physical deterioration in marketing channels and retains their attractiveness.

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