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Effect of surface coatings and packaging materials on ascorbic acid and sugars of apple ber (*Zizyphus mauritiana*) at different storage conditions

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Abstract
Apple ber (*Zizyphus mauritiana*) is a Thailand variety ber belongs to the family Rhamnaceae. Apple ber is developed by grafting Thailand green apple with Thai local ber. In the studies conducted on the effect of surface coatings and packaging materials on quality of Apple ber (*Zizyphus mauritiana)* at different storage conditions at College of Horticulture- Rajendranagar, SKLTSHU, Rajendranagar. The experiment was conducted in two factor completely randomized design with three replications in which factor one includes nine treatments of surface coatings and packaging materials along with control (without any surface coating and packaging)**.** Factor two includes two storage condition S_1-cold storage (10±2ºC) and S_2-room temperature (22±2ºC) and observations were recorded at 3 days interval upto end of shelf life of fruits. Highest ascorbic acid content (61.20) and total sugars (14.40) was recorded by P_4S_1. Among the treatments Chitosan 1% + HDPE (High Density Polyethylene) is best followed by Chitosan 1% + PP (Polypropylene). Among both storage conditions fruits stored in cold storage (10±2ºC) gave better results. In interaction effects Chitosan 1% + HDPE (High Density Polyethylene) + cold storage (10±2ºC) is best of all the treatments followed by Chitosan 1% + PP (Polypropylene) + cold storage.

Keywords: Apple ber, surface coatings, packaging materials, storage conditions, quality, chitosan

1. Introduction
Apple ber (*Zizyphus mauritiana*) is a hardy minor tropical fruit, belongs to the family Rhamnaceae. This fruit resembles a green apple in its appearance and tastes like ber, hence the name Apple ber. It is also called as Apple plum or Jujube berry. It is also popularly known as "Telangana Apple" in Telangana state. The genus *Ziziphus* comprises about 40 species distributed throughout the tropical and subtropical regions of the world. Among various species, *mauritiana* is commercially cultivated for its nutritive and edible fruits. It is popularly known as the poor man's fruit of the tropics.

In India apple ber cultivation first started in Maharashtra, later extended to other states like Gujarat and Telangana. In Telangana it is cultivated commercially in Hyderabad, Mahbubnagar, Medak, Warangal and Khammam districts. It is also popularly known as "Telangana Apple" in Telangana state. The heaviness of each fruit is 60-150g. It is very attractive, sweet, crispy and juicy. In current years farmers are showing interest in cultivation of apple ber when compared to ber due to its unique traits like thorn less nature, high yielding, early crop, ease of cultivation in terms of harvesting and wider adaptability to grow in any type of soil with less consumption of water. It has the ability to withstand extreme summer, heavy rains, heavy winds and extreme winter. It starts yielding in nine months. Fruits are produced mainly from November to March with nominal first crop of 20-25 kg per tree and second crop will be around 50 kg per tree and third year onwards yield will be 100 kg to 200 kg per tree.

The edible or surface coatings are defined as a thin layer of material that covers the surface of the fruit and can be eaten as part of the whole product. Surface coatings when applied to fruits help in extending their shelf life by acting as a barrier between the atmosphere and fruit surface. Among this most commonly and widely used surface coatings are aloe vera and Chitosan [1]. Aloe vera is a well-known plant for its marvellous medicinal properties. It prolongs the conservation of fresh fruits. This natural product is a safe and environmentally Friendly.

Aloe vera gel forms a protective layer against the oxygen and moisture of the air and inhibits the action of micro-organisms that causes food borne illnesses through its various antibacterial and antifungal compounds, it also prevents loss of moisture, retains firmness, controls respiratory rate and maturation [2].

Chitosan is a natural polymer obtained by deacetylation of chitin shells of shrimp and other crustaceans. Chitosan has several advantages such as bio-compatibility, bio-degradability and no toxicity over other polysaccharides [3]. Although this surface coating has many advantages in preservation of postharvest fruits and vegetables, simple coating sometimes limits inhibition to microorganism that leads fruits to decay due to lack of permeability of carbon dioxide and oxygen [4]. To effectively apply the surface coatings, it should be combined with other substances through physical methods viz. short heating (or) short gas fumigation (or) packaging [5].

Packing fresh fruits and vegetables is one of the most important steps in the long and complicated journey from grower to consumer. A package provides protection, tampers resistance and improves the shelf life and quality of fruits [6]. Generally ber fruits are packed in CFB (Corrugated fiber board) boxes or HDPE (High density polyethylene) or in PP (Polypropylene) which reduces moisture loss from fruits during storage [7]. Since past two years, Apple ber fruits are rushing into markets resulting in glut, hence there is a need for proper packaging and storage of fruits for further supply [8].

2. Materials and Methods

The experiment was conducted at College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad and MFPI-Quality Control Laboratory, PJTSAU, Rajendrana during the year 2016-2017. Apple ber fruits used for research were procured from the orchard in Medak district, Hyderabad.

The experiment was conducted in two factors completely randomized design with three replications. Factor one includes nine treatments P_1 – Aloe vera gel (1:3) + HDPE (High Density Polyethylene), P_2 – Aloe vera gel (1:3) + PP (Polypropylene), P_3 – Aloe vera gel (1:3) + CFB (Corrugated Fiberboard), P_4–Chitosan 1% + HDPE (High Density Polyethylene), P_5 – Chitosan 1% + PP (Polypropylene), P_6 – Chitosan 1% + CFB (Corrugated Fiberboard), P_7 – Aloe vera gel (1:3), P_8 – Chitosan 1%, P_9 – Control(without any surface coating and packaging) and factor two includes two storage condition S_1-cold storage (10±2ºC) and S_2-room temperature (22±2ºC).

Methodology

Preparation of treatment solutions

2.1 Preparation of Aloe Vera gel

Fresh aloe Vera leaves collected from Medicinal and Aromatic Plants Research Station were washed to remove the dust, aloe vera gel matrix was separated from the outer cortex of leaves using knife and then the colorless hydro parenchyma was grinded in a blender and strained through muslin cloth to remove thick particles. Take 1% of pectin with the amount of water which is going to mix with aloe vera gel and heat to the required temperature. Mix both water and aloe vera gel in the ratio of 1:3 for treatment of fruits.

2.2 Preparation of chitosan solution

1% chitosan solution was prepared by dissolving 10g of chitosan powder in 1000ml of distilled water.

Mature green stage fruits of apple ber were selected and the fruits were Washed thoroughly under running tap water to remove the adherent dirt material. Fruits were treated with 1:3 aloe vera gel for 10 minutes and then allowed to air dry for 20-30 minutes in shade, similarly fruits were dipped in 1% chitosan solution for 10 minutes and air dried before packing in 100 gauge High Density Polyethylene (HDPE), Polypropylene (PP) bags and CFB (Corrugated Fiberboard) boxes. 10 fruits were packed for each treatment and kept in both ambient conditions in a room at 22±2ºC and in cool chamber (10±1ºC) according to treatments. The analysis of the fruits was done after removal from the package at every 3 days intervals for Total soluble sugars, titable acidity, brix acid ratio, ascorbic acid content, total sugars, reducing sugars, non-reducing sugars and organoleptic evaluation.

2.3 Ascorbic acid (mg/100g)

Ascorbic acid was estimated by Indophenol method [9].

2.4 Total sugars and Reducing sugars (%)

Total sugars and Reducing sugars were determined by the method of Lane and Eyon [10].

2.5 Non- reducing sugars (%)

Non-reducing sugars in a sample is obtained by subtracting reducing sugars from total sugars. Non-reducing sugars (%) = Total sugars - Reducing sugars

3. Results and Discussion

3.1 Ascorbic acid content (mg/100g)

Results of ascorbic acid content of apple ber influenced by surface coatings, packaging materials and different storage conditions is presented in the Table.1. and Fig.1.

On 21st day P3, P6, P7, P8 and P9 shown end of shelf life in S2-room temperature and among the remaining treatments highest ascorbic acid content was seen in P_4S_1- chitosan (1%) + HDPE + cold storage (61.20) and lowest was seen in P_2S_1-aloe vera gel (1:3) + PP + cold storage (57.14). With respect to interactions maximum ascorbic acid content was recorded by P_4S_1 - chitosan (1%) + HDPE + cold storage (87.48), (81.00), (78.20), (73.78) and (67.12) on 3rd, 6th, 9th, 12th and 15th days respectively.

Among storage conditions S_1-cold storage recorded significantly highest ascorbic acid content with (84.99), (79.36), (76.25), (70.73) and (65.13) on 3rd, 6th, 9th,12th and 15th day respectively and lowest was in S_2-room temperature with (83.77), (77.89), (69.93), (61.16) and (56.30) on 3rd, 6th, 9th,12th and 15th day respectively.

P_4S_1-chitosan (1%) + HDPE + cold storage recorded highest ascorbic acid content followed by P_5S_1-chitosan (1%) + PP + cold storage. The decrease trend of ascorbic acid is less in surface coated, packed and low temperature stored fruits compared to control where there is a rapid decrease of ascorbic acid. This may be due to increase in total soluble sugars increases in the fruits [11].

3.2 Total sugars (%)

The synergistic effect of surface coatings and packaging at different storage conditions of apple ber on total sugars was presented in the Table.2. And Fig.2.

Initially total sugars increases along with storage period up to 9th day in S_2 – room temperature and later it reduces till the end of shelf life, but in S_1-cold storage it increases up to 18th day and later started decreasing.

With respect to interactions maximum total sugars content was recorded in P_4S_1 – chitosan (1%) + HDPE + cold storage (11.36), (12.03), (13.15) and (3.54) on 3rd, 6th, 9th and 12th days respectively except on 15th day P_5S_1 – chitosan (1%) + PP + cold storage recorded maximum total sugars (14.76).

Among two storage conditions S_1-cold storage recorded highest total sugars of (10.72), (11.49), (12.49), (12.90) and (13.81) on 3rd, 6th, 9th, 12th and 15th day respectively and S_2-room temperature recorded lowest total sugars of (10.46), (11.17), (11.98), (11.74) and (11.65) on 3rd, 6th, 9th, 12th and 15th day respectively.

P_4S_1 – chitosan (1%) + HDPE + cold storage was the best treatment with maximum total sugars during storage period. The total and reducing sugars were increased up to ripening there after showed a decline at the end of shelf life in all treatments. The initial raise in sugars may be due to conversion of starch into sugars, while later the decrease was due to consumption of sugars for respiration during storage [12].

3.3 Reducing sugars (%)

Results on the effect of surface coatings and packaging at different storage conditions of apple ber on reducing sugars were presented in the Table.3. And Fig.3. Total sugars increases along with storage period until the fruit ripens i.e. 9th day in S_2 and later it reduces till the end of shelf life, but in S_1 it increases up to 18th day and later started decreasing.

With respect to interactions maximum total sugars content was recorded in P_4S_1 – chitosan (1%) + HDPE + cold storage (4.71), (5.24), (6.50) and (7.84) on 3rd, 6th, 9th and 12th days respectively except on 15th day P_5S_1 – chitosan (1%) + PP + cold storage recorded maximum total sugars (8.56).

Among two storage conditions S_1-cold storage recorded highest reducing sugars of (4.20), (4.63), (5.69), (6.66) and (7.54) on 3rd, 6th, 9th, 12th and 15th day respectively and S_2-room temperature recorded lowest reducing sugars of (3.83), (4.32), (5.27), (4.39) and (3.59) on 3rd, 6th, 9th, 12th and 15th day respectively.

3.4 Non-reducing sugars (%)

Results on the effect of surface coatings and packaging at different storage conditions of apple ber on non-reducing sugars was presented in the Table.4 Initially non-reducing sugars increases along with storage period and later it starts decreasing till the end of shelf life.

Non-reducing sugars on 21st day was highest in P_5S_1-chitosan (1%) + PP + cold storage (7.05) which was on par with P_4S_1 (7.04) and lowest was in P_1S_1-aloe vera gel (1:3) + HDPE + cold storage (6.08).

With respect to interactions maximum non-reducing sugars content was recorded in P_3S_1 – chitosan (1%) + CFB + cold storage (7.36), (7.68) and (7.98) on 3rd, 6th and 9th days respectively except on 12th day P_3S_2 – chitosan (1%) + CFB + room temperature recorded maximum non-reducing sugars (7.70) and P_4S_2-chitosan (1%) + HDPE + room temperature recorded maximum non-reducing sugars (8.45) on 15th day.

Among two storage conditions values of non-reducing sugars are statistically on par on 3rd, 6th and 9th day of storage. Highest non-reducing sugars (7.33) and (8.05) were recorded by S_2-room temperature and less non-reducing sugars% (6.24) and (6.26) was recorded by S_1-cold storage on 12th and 15th day respectively.

Treated fruits show slow build-up of sugars compared to control due to exposure of fruit to atmosphere without any treatment and increase in respiration. But in treated fruits slow build-up of the sugars occurs. There was a gradual increase in total sugars and reducing sugars which reached maximum at ripe stage and there after decreasing gradually.

4. Conclusion

Ascorbic acid decreases as the storage period increases but in case on total sugars it increases as the storage period increases. According to vitamin-C content and sugars P_4S_1-Chitosan 1% + HDPE (High Density Polyethylene) + cold storage was best of all the treatments with a shelf life of 21 followed by P_5S_1- Chitosan 1% + PP (Polypropylene) + cold storage with shelf life of 20.33 days.

Table 1: Effect of surface coatings and packaging materials at different storage conditions on ascorbic acid content (mg/100g) of Apple ber (*Zizyphus mauritiana).*

Ascorbic acid content (mg/100g)																			
	3rd Day			6th Day			9th Day			12th Day			15th Day			18th Day		21st Day	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	S_1	S_2
P_1	84.64	83.98	84.31	78.94	78.93	78.93	76.77	71.41	74.09	71.23	62.00	66.61	63.83	56.74	60.28	61.83	*	57.88	*
P_2	85.41	83.01	84.21	78.00	78.99	78.49	76.75	71.41	74.08	71.98	61.50	66.74	64.80	55.89	60.34	62.21	*	57.14	*
P_3	85.41	82.84	84.12	78.76	78.48	78.62	76.34	70.67	73.50	71.31	60.00	65.65	65.49	*	-	59.72	*	*	*
P_4	87.48	87.12	87.30	81.00	79.05	80.02	78.2	72.33	75.26	73.78	62.13	67.95	67.12	56.51	61.81	63.50	*	61.20	*
P_5	86.06	84.25	85.15	80.36	77.94	79.15	77.00	71.66	74.33	71.33	61.83	66.58	67.00	56.08	61.54	63.05	*	59.45	*
P_6	84.63	84.68	84.65	79.44	77.20	78.32	76.35	71.00	73.67	70.59	59.50	65.04	65.42	*	-	60.07	*	*	*
P_7	83.09	81.97	82.53	79.23	77.50	78.36	75.14	66.66	70.90	68.47	*	-	66.00	*	-	59.89	*	*	*
P_8	85.47	85.08	85.27	79.53	77.00	78.26	75.17	64.33	69.75	69.66	*	-	63.45	*	-	59.08	*	*	*
P_9	82.78	81.08	81.93	79.00	77.05	78.00	74.58	*	-	68.30	*	-	63.09	*	-	58.57	*	*	*
Mean	84.99	83.77		79.36	77.89		76.25	69.93		70.73	61.16		65.13	56.30		60.88	-	58.91	-

	3rd Day		6th Days		9th Day		12th Day		15th Day		18th Day		21st Day	
	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
P	0.15	0.46	0.62	1.86	0.48	1.39	0.51	1.47	0.51	1.46	0.19	0.56	0.14	0.41
S	0.54	1.55	0.24	0.72	0.22	0.65	0.24	0.69	0.24	0.69	0.09	0.26	0.06	0.19
PXS	0.69	2.01	0.94	2.58	0.68	1.96	0.72	2.09	0.72	2.07	0.27	0.79	0.20	0.58

* - end of shelf life. Ascorbic acid content on 0th day – 92.27mg/100g.

P1 – *Aloe vera* gel+HDPE, P2 – *Aloe vera* gel+PP, P3 – *Aloe vera* gel+CFB, P4 – Chitosan+HDPE, P5 – Chitosan+PP, P6 – Chitosan+CFB, P7 – *Aloe vera* gel, P8 – Chitosan, P9 – Control.

S1 – cold storage, S2 – room temperature**.**

Table 2: Effect of surface coatings and packaging materials at different storage conditions on total sugars (%) of Apple ber (*Zizyphus mauritiana*).

Total sugars (%)																			
	3rd Day			6th Day			9th Day			12th Day			15th Day			18th Day		21st Day	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	S_1	S_2
P_1	10.86	9.74	10.30	11.91	11.00	11.45	12.95	11.98	12.46	13.25	11.65	12.45	14.13	11.22	12.67	15.30	*	13.21	*
P_2	10.68	10.50	10.59	11.45	11.35	11.40	11.87	11.87	11.87	12.28	11.54	11.91	13.68	11.35	12.51	14.96	*	13.13	*
P_3	11.34	10.48	10.91	12.03	11.43	11.73	12.98	11.83	12.40	13.05	11.47	12.26	14.06	*	-	15.86	*	*	*
P_4	11.36	11.15	11.25	11.82	11.54	11.68	13.15	12.45	12.80	13.54	12.30	12.92	14.30	12.17	13.23	15.86	*	14.40	*
P_5	10.86	10.87	10.86	11.99	11.00	11.49	13.01	12.10	12.55	13.42	12.00	12.71	14.76	11.86	13.31	15.92	*	14.25	*
P_6	10.95	9.96	10.45	11.15	11.39	11.27	11.96	11.74	11.85	12.32	11.48	11.90	13.63	*	-	14.93	*	*	*
P_7	9.99	10.95	10.47	10.99	11.55	11.27	12.42	12.06	12.24	12.86	*	-	13.10	*	-	14.63	*	*	*
P_8	10.32	10.53	10.42	11.00	11.05	11.02	12.20	11.82	12.01	12.74	*	-	13.40	*	-	14.60	*	*	*
P_9	10.19	9.96	10.07	11.15	10.22	10.68	11.95	*	-	12.69	*	-	13.23	*	-	14.80	*	*	*
Mean	10.72	10.46		11.49	11.17		12.49	11.98125		12.90	11.74		13.81	11.65		15.20	-	13.74	

	3rd Day		6th Day		9th Day		12th Day		15th Day		18th Day		21st Day	
	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
P	0.080	0.250	0.060	0.190	0.040	0.130	0.040	0.120	0.040	0.110	0.012	0.030	0.003	0.008
S	0.040	0.180	0.030	0.090	0.020	0.060	0.020	0.050	0.010	0.050	0.005	0.010	0.001	0.004
PXS	0.120	0.350	0.090	0.270	0.060	0.180	0.060	0.170	0.050	0.160	0.017	0.050	0.004	0.120

* - end of shelf life. Total sugars% of apple ber on 0th day – 9.75%.

P1 – *Aloe vera* gel+HDPE, P2 – *Aloe vera* gel+PP, P3 – *Aloe vera* gel+CFB, P4 – Chitosan+HDPE, P5 – Chitosan+PP, P6 – Chitosan+CFB, P7 – *Aloe vera* gel,

P8 – Chitosan, P9 – Control.

S1 – cold storage, S2 – room temperature**.**

Table 3: Effect of surface coatings and packaging materials at different storage conditions on reducing sugars (%) of Apple ber (*Zizyphus mauritiana*).

Reducing sugars (%)																			
	3rd Day			6th Day			9th Day			12th Day			15th Day			18th Day		21st Day	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	S_1	S_2
P_1	4.63	4.01	4.32	5.02	4.56	4.79	7.08	5.30	6.19	7.75	4.52	6.13	8.25	3.55	5.90	8.86	*	7.13	*
P_2	4.13	3.83	3.98	4.49	4.36	4.42	5.43	5.32	5.37	6.25	4.65	5.45	7.38	3.48	5.43	7.91	*	6.45	*
P_3	3.98	3.68	3.83	4.35	4.10	4.22	5.00	4.84	4.92	5.94	3.77	4.85	6.66	*	-	7.31	*	*	*
P_4	4.71	4.18	4.44	5.24	4.77	5.00	6.50	5.93	6.21	7.84	4.89	6.36	8.54	3.72	6.13	8.92	*	7.36	*
P_5	4.58	4.17	4.37	5.20	4.77	4.98	6.30	5.74	6.02	7.62	4.71	6.16	8.56	3.64	6.10	8.89	*	7.20	*
P_6	3.95	3.70	3.82	4.32	4.12	4.22	5.21	4.81	5.01	6.38	3.85	5.11	7.46	*	-	8.00	*	*	*
P_7	4.37	3.82	4.09	4.73	4.36	4.54	5.62	5.28	5.45	6.20	*	-	7.32	*	-	8.21	*	*	*
P_8	3.68	3.63	3.65	4.09	4.06	4.07	5.15	4.67	4.91	6.08	*	-	7.00	*	-	7.75	*	*	*
P_9	3.81	3.46	3.63	4.25	3.86	4.05	4.95	*	-	5.88	*	-	6.75	*	-	7.32	*	*	*
Mean	4.20	3.83		4.63	4.32		5.69	5.27		6.66	4.39		7.54	3.59		8.13		7.03	

	3rd Day		6th Day		9th Day		12th Day		15th Day		18th Day			21st Day
	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
P	0.130	0.380	0.040	0.140	0.040	0.120	0.040	0.130	0.030	0.090	0.030	0.100	0.006	0.018
S	0.060	0.270	0.020	0.060	0.020	0.060	0.020	0.060	0.010	0.040	0.010	0.040	0.003	0.008
PXS	0.180	0.650	0.070	0.200	0.060	0.180	0.060	0.090	0.040	0.130	0.050	0.140	0.006	0.026

* - end of shelf life. Reducing sugars% of apple ber on 0th day – 2.56%.

P1 – *Aloe vera* gel+HDPE, P2 – *Aloe vera* gel+PP, P3 – *Aloe vera* gel+CFB, P4 – Chitosan+HDPE, P5 – Chitosan+PP, P6 Chitosan+CFB,P7 – *Aloe vera* gel,

P8 – Chitosan, P9 – Control,

S1 – cold storage, S2 – room temperature.

Table 4: Effect of surface coatings and packaging materials at different storage conditions on non-reducing sugars (%) of Apple ber (*Zizyphus mauritiana*).

Non-reducing sugars (%)																			
	3rd Day			6th Day			9th Day			12th Day			15th Day			18th Day		21st Day	
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	S_1	S_2
P_1	5.56	5.95	5.75	6.89	6.44	6.66	5.87	6.68	6.27	5.50	7.13	6.31	5.88	7.67	6.77	6.44	*	6.08	*
P_2	6.55	6.67	6.61	6.96	6.99	6.97	6.44	6.55	6.49	6.03	6.86	6.44	6.30	7.87	7.08	7.05	*	6.68	*
P_3	7.36	6.80	7.08	7.68	7.33	7.50	7.98	6.99	7.48	7.11	7.70	7.40	7.40	*	-	8.55	*	*	*
P_4	6.65	6.97	6.81	6.58	7.13	6.85	6.65	6.52	6.58	5.70	7.41	6.55	5.76	8.45	7.10	6.94	*	7.04	*
P_5	6.28	6.700	6.49	6.79	6.77	6.78	6.71	6.36	6.53	5.80	7.29	6.54	6.20	8.22	7.21	7.03	*	0.15	*
P_6	7.00	6.26	6.63	6.83	7.27	7.05	6.75	6.93	6.84	5.94	7.63	6.78	6.17	*	-	6.93	*	*	*
P_7	5.62	7.13	6.37	6.26	7.19	6.72	6.80	6.78	6.79	6.66	*	-	5.78	*	-	6.42	*	*	*
P_8	6.64	6.90	6.77	6.75	6.99	6.87	7.05	7.15	7.10	6.66	*	-	6.40	*	-	6.85	*	*	*

P_9	7.05	6.28	6.66	6.66	6.36	6.51	7.00	*	-	6.81	*	-	6.48	*	-	7.48	*	*	*
Mean	6.52	6.62		6.82	6.94		6.80	6.74		6.24	7.33		6.26	8.05		7.07		4.98	-

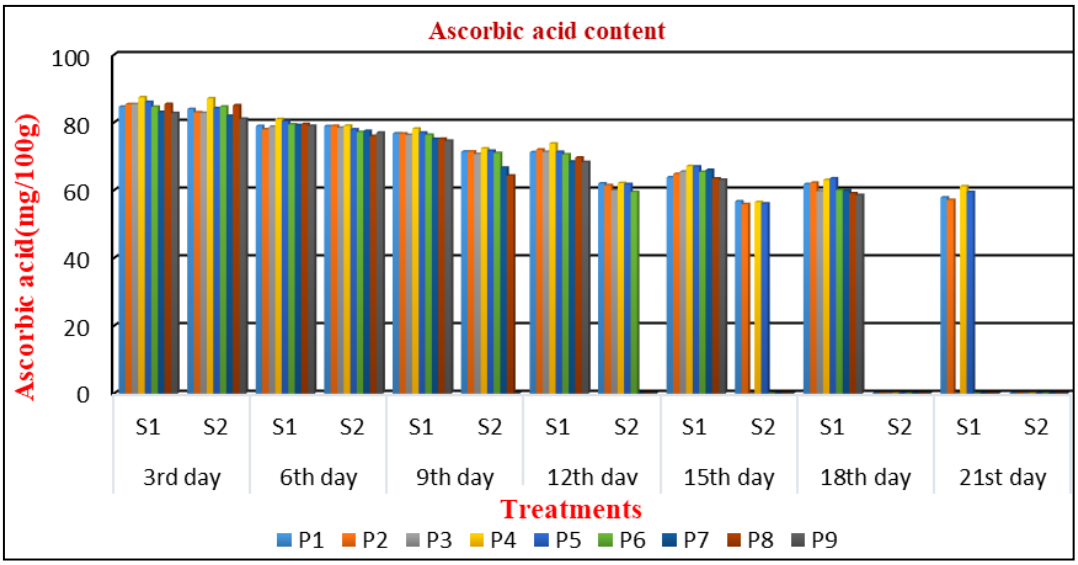
	3rd Day		6th Day		9th Day		12th Day		15th Day		18th Day		21st Day	
	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%	S.Em±	CD at 5%
P	0.100	0.280	0.090	0.270	0.060	0.180	0.050	0.160	0.040	0.110	0.030	0.180	0.008	0.025
S	0.040	0.130	0.040	0.120	0.030	0.080	0.020	0.070	0.010	0.050	0.160	0.480	0.004	0.011
PXS	0.140	0.400	0.130	0.390	0.090	0.260	0.080	0.230	0.050	0.160	0.050	0.140	0.012	0.036

* - end of shelf life. Non-reducing sugars% of apple ber on 0th day – 5.62%.

P1 – *Aloe vera* gel+HDPE, P2 – *Aloe vera* gel+PP, P3 – *Aloe vera* gel+CFB, P4 – Chitosan+HDPE, P5 – Chitosan+PP, P6 –Chitosan+CFB, P7 – *Aloe vera* gel,

P8 – Chitosan, P9 – Control.

S1 – cold storage, S2 – room temperature



P1 – Aloe vera gel+HDPE, P2 – Aloe vera gel+PP, P3 – Aloe vera gel+CFB, P4 -Chitosan+HDPE,
P5 – Chitosan+PP, P6 – Chitosan+CFB, P7 – Aloe vera gel, P8 – Chitosan, P9 – Control.
S1 – cold storage, S2 – room temperature.

Fig 1: Effect of surface coatings and packaging materials at different storage conditions on ascorbic acid content (mg/100g) of apple ber (*Zizyphus mauritiana*).

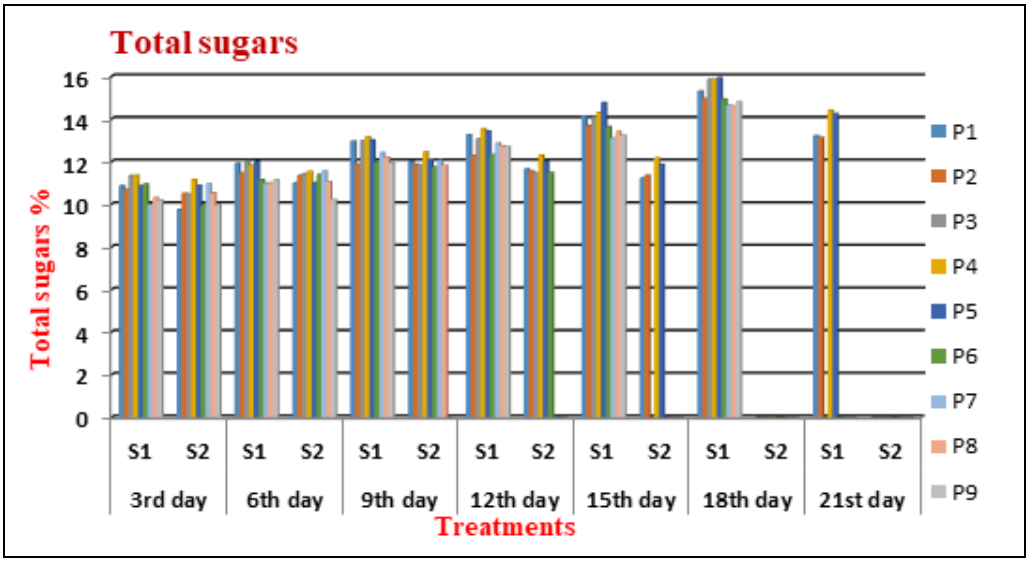
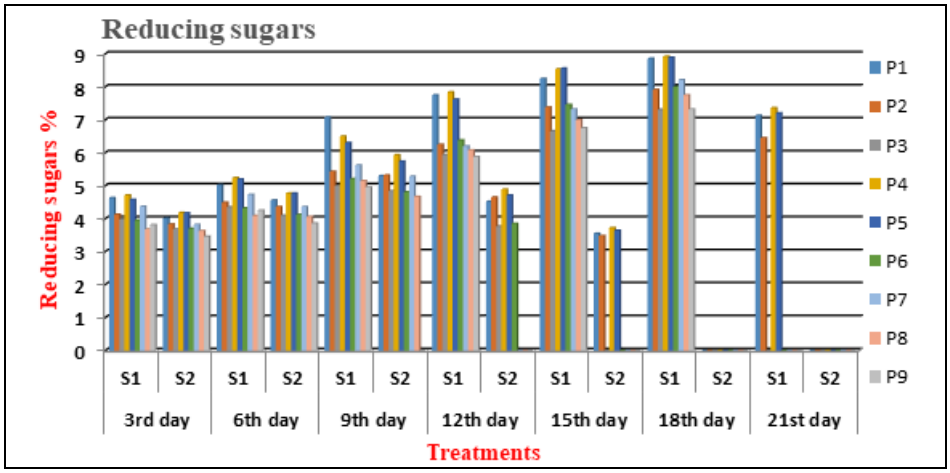


Fig 2: Effect of surface coatings and packaging materials at different storage conditions on total sugars (%) of apple ber (*Zizyphus mauritiana).*



P1 – Aloe vera gel+HDPE, P2 – Aloe vera gel+PP, P3 – Aloe vera gel+CFB, P4 -Chitosan+HDPE, P5 – Chitosan+PP, P6 – Chitosan+CFB, P7 – Aloe vera gel, P8 – Chitosan, P9 – Control.
S1 – cold storage, S2 – room temperature.

Fig 3: Effect of surface coatings and packaging materials at different storage conditions on reducing sugars (%) of apple ber (*Zizyphus mauritiana).*

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