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EFFECT OF SURFACE COATINGS AND PACKAGING MATERIALS ON SHELF LIFE ATTRIBUTES OF APPLE BER (*ZIZYPHUS MAURITIANA*)

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Abstract

Apple ber (*Zizyphus mauritiana*) is a Thailand variety ber, developed by grafting Thailand green apple with Thai local ber. In the studies conducted on the effect of surface coatings and packaging materials on shelf life of Apple ber (*Zizyphus mauritiana)* at different storage conditions S_1-cold storage (10±2ºC) and S_2-room temperature (22±2ºC) reported that Chitosan 1% + HDPE (High Density Polyethylene) is best treatment followed by Chitosan 1% + PP (Polypropylene). Among both storage conditions fruits stored in cold storage (10±2ºC) gave better results with an increase of shelf life to 21 days. In interaction effects Chitosan 1% + HDPE (High Density Polyethylene) + cold storage (10±2ºC) is best of all the treatments with a shelf life of 21 days followed by Chitosan 1% + PP (Polypropylene) + cold storage 20 days.

Key words : Apple ber, surface coatings, packaging materials, storage conditions, shelf life, chitosan, cold storage.

Introduction

Apple ber (*Zizyphus mauritiana*) is a hardy minor tropical fruit, belongs to the family Rhamnaceae**.** The taste of this Apple Ber is Sweet, Crispy & Juicy. It appears to be like green Apple. That is the reason it is named as Apple Plum or Jujube berry or Apple Ber. It is a new variety in the present market and it is attractive too. In all the urban habitations and metro cities in India these fruits can be sold. Apple ber is gradually gaining popularity among medium farmers, particularly of the semi-arid regions of Telangana. Its drought-resistant properties and distinctive flavour skin to apple and jujube earned it the nickname 'Telangana Apple' among the growers. 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 poor man's fruit of 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, Mahabubnagar, Medak, Warangal and Khammam districts. The weight of each fruit is around 150-200 gm. 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 ability to withstand extreme summer, heavy rains, heavy winds and extreme winter. This plant starts giving fruits after 6-8 months of plantation. Generally the height of the plant would be ranging between 10-15ft. About 450 to 500 plants can be accommodated in an Acre. Fruits are produced mainly from November to March. The tree gives 20-30 kg fruits during first year and in the second year it will be around 45-50 kg fruits and third year onwards yield will be 100 kg to 200 kg fruits per tree.

The edible or surface coatings are defined as thin layer of material that covers the surface of the fruit and can be eaten as part of the whole product. Surface

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coatings when applied to fruits help in extending their shelf life by acting as a barrier between atmosphere and fruit surface. Among this most commonly and widely used surface coatings are aloe vera and Chitosan (Milena *et al*., 2014).

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 (Jawadul *et al.*, 2014).

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. 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. 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 (Padmaja and Bosco, 2014; Milena *et al*., 2014; Adetunji *et al*., 2014; Duan and Zhang, 2013).

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. 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 (Sharma *et al*., 2013; Manpreet *et al*., 2009). 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 (Lal *et al*., 2002).

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 factor completely randomized design with three replications. Factor one includes nine treatments P_1 – Aloe vera gel (1:3) + HDPE (High Density Polyethylene), P2 – 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)a nd factor two includes two storage condition S_1-cold storage (10±2ºC) and S_2-room temperature (22±2ºC).

Methodology

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 colourless hydro parenchyma was grinded in a blender and strained through muslin cloth to remove thick particles. Take 1% of pectin with 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.

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 minutesin 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. 5 fruits in each treatment were undisturbed for evaluation of physiological loss in weight, spoilage, browning and shelf life. The remaining was used for analyzing firmness of fruits.

Results and Discussion

Physiological loss in weight (%)

The effect of surface coatings and packaging material on physiological loss in weight of apple ber stored at both

Table 1 : Effect of surface coatings and packaging materials at different storage conditions on physiological loss in weight (%) of apple ber (*Zizyphus mauritiana*).

PLW%																			
	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	0.08	1.34	**0.71**	0.13	1.39	**0.76**	0.31	3.94	**2.12**	0.43	9.38	**4.90**	0.61	12.43	**9.02**	1.23	*	2.79	*
P_2	0.51	1.07	**0.79**	0.20	1.92	**1.06**	0.29	4.01	**2.15**	0.40	7.44	**3.92**	0.58	9.58	**5.08**	1.40	*	2.84	*
P_3	0.17	4.69	**2.43**	0.23	6.88	**3.55**	0.33	8.67	**4.50**	0.46	12.64	**6.55**	0.72	*	**-**	1.41	*	*	*
P_4	0.04	0.42	**0.23**	0.09	0.89	**0.49**	0.17	2.91	**1.54**	0.25	4.36	**2.30**	0.38	9.28	**4.83**	1.02	*	2.48	*
P_5	0.05	0.71	**0.38**	0.12	1.53	**0.82**	0.19	3.93	**2.06**	0.28	5.85	**2.91**	0.44	9.51	**4.97**	1.10	*	2.61	*
P_6	0.15	3.42	**1.78**	0.21	5.51	**2.86**	0.35	8.22	**4.28**	0.53	14.44	**7.48**	0.84	*	**-**	1.82	*	*	*
P_7	0.25	5.74	**2.99**	0.30	8.99	**4.64**	0.43	10.91	**5.67**	0.57	*	**-**	1.04	*	**-**	1.98	*	*	*
P_8	0.26	4.93	**2.59**	0.31	7.59	**3.95**	0.36	10.39	**5.37**	0.59	*	**-**	1.12	*	**-**	2.45	*	*	*
P_9	0.31	8.00	**4.15**	0.37	11.11	**5.74**	0.57	*	**-**	0.74	*	**-**	1.51	*	**-**	2.56	*	*	*
Mean	**0.20**	**3.62**		**0.21**	**5.09**		**0.33**	**6.56**		**0.47**	**8.85**		**0.80**	**11.45**		**1.66**	**-**	**2.68**	**-**

	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	0.24	0.71	0.33	0.96	0.68	1.96	0.52	1.51	0.29	0.83	0.09	0.27	0.02	0.08
S	0.11	0.33	0.15	0.45	0.32	0.92	0.54	0.71	0.13	0.39	0.04	0.12	0.01	0.03
PXS	0.35	1.01	0.47	1.36	0.96	2.77	0.74	2.13	0.41	1.18	0.13	0.38	0.03	0.11

*** - end of shelf life; 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.

cold storage and room temperature at different intervals is presented in the table 1 and fig. 1.

The percent PLW values showed an increasing trend from 3rd day to 21st day in both the storage conditions. From 3rd day to 21st day except on 18th and 21st day where all treatments in room temperature showed end of shelf life.

There was a significant difference observed among all the treatments at different storage conditions. Interaction effect between treatments and storage conditions was also significant.

With respect to the storage conditions, lowest PLW of (0.20), (0.21), (0.33), (0.47) and (0.80) on 3rd, 6th, 9th, 12th and 15th day was recorded in S_1-cold storage conditions while highest PLW was noticed in S_2-room temperature condition with (3.62), (5.09), (6.56), (8.85) and (11.45) on 3rd, 6th, 9th, 12th and 15th day, respectively.

Among interactions, P_4S_1-chitosan (1%) + HDPE packing + cold storage recorded significantly least PLW (0.04), (0.17), (0.17), (0.25) and (0.38) on 3rd, 6th, 9th, 12th and 15th days respectively followed by P_5S_1-chitosan (1%) + PP packing + cold storage.

Among all the treatments, P_4-fruits treated with chitosan (1%) and packed in 100 gauge HDPE showed minimum loss of physiological weight in fruits during storage compared to other treatments, as chitosan coating and HDPE packing reduces the water loss and respiration rate of fruits during storage by acting as a protective layer between fruit surface and atmosphere. Though, the chitosan coating and packaging in HDPE and PP show better results in room temperature, combination of cold storage (10±2°C) with chitosan and HDPE packing show least PLW in apple ber fruits with slow increase in loss of weight during storage period compared to room temperature. The results obtained in the present investigation are in close conformity with those results of Manpreet *et al.* (2009), which reveals that ber fruits packed in polymeric film and stored in refrigerator condition reduces moistures loss and extended the shelf life. Singh *et al.* (2013) was also found that physiological loss in weight was maximum in control ber fruits after storage while lowest was in packed polybags.

Table 2 : Effect of surface coatings and packaging materials at different storage conditions on firmness (kg/cm²) of apple ber (*Zizyphus mauritiana*).

	Firmness (kg/cm²)																		
	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	12.23	12.00	**12.11**	12.13	11.10	**11.61**	11.30	10.20	**10.75**	11.00	9.73	**10.36**	10.23	8.83	**9.53**	10.00	*	9.33	*
P_2	11.50	11.30	**11.40**	11.13	10.80	**10.96**	10.81	9.96	**10.38**	10.16	8.76	**9.46**	9.96	8.03	**8.99**	9.03	*	8.60	*
P_3	12.63	11.93	**12.28**	12.33	10.60	**11.46**	11.62	9.76	**10.69**	10.10	8.93	**9.51**	9.63	*	**-**	8.90	*	*	*
P_4	12.70	12.56	**12.63**	12.36	12.26	**12.31**	11.53	11.03	**11.28**	11.16	10.03	**10.59**	10.96	8.73	**9.80**	10.03	*	9.93	*
P_5	12.30	12.06	**12.18**	11.96	11.83	**11.89**	11.63	11.30	**11.46**	11.23	10.73	**10.98**	11.00	9.80	**10.40**	10.66	*	10.03	*
P_6	12.36	11.43	**11.89**	11.93	10.23	**11.08**	11.26	9.60	**10.43**	10.16	8.06	**9.11**	9.40	*	**-**	8.83	*	*	*
P_7	11.93	11.46	**11.69**	12.50	10.72	**11.61**	11.46	9.56	**10.51**	10.60	*	**-**	9.66	*	**-**	8.76	*	*	*
P_8	11.76	11.25	**11.50**	11.33	10.54	**10.93**	10.78	9.53	**10.15**	9.73	*	**-**	8.70	*	**-**	8.00	*	*	*
P_9	11.86	10.11	**10.98**	11.53	8.34	**9.93**	10.66	*	**-**	10.13	*	**-**	8.30	*	**-**	7.53	*	*	*
Mean	**12.14**	**11.56**		**11.91**	**10.71**		**11.23**	**10.11**		**10.47**	**9.37**		**9.75**	**8.84**		**9.08**	**-**	**9.47**	**-**

	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	0.22	0.65	0.23	0.67	0.25	0.72	0.22	0.63	0.14	0.40	0.08	0.23	0.04	0.13
S	0.10	0.30	0.11	0.33	0.11	0.34	0.10	0.29	0.06	0.19	0.03	0.10	0.02	0.06
PXS	0.32	0.95	0.33	1.00	0.35	1.02	0.31	0.89	0.20	0.57	0.11	0.32	0.06	0.18

*** - end of shelf life.** Firmness of apple ber on 0th day – 12.86 kg/cm². **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.

Firmness (kg/cm²)

Results on firmness of apple ber stored at both cold storage and room temperature affected by surface coatings and packaging material was presented in the table 2 and fig. 2. Firmness of apple ber fruits showed decreasing tendency with increase in storage period.

Among the storage conditions S_1-cold storage condition recorded highest firmness of 11.12, 10.47 and 9.75 on 9th, 12th and 15th day respectively and lowest was in S_2-room temperature condition with (11.87), (11.33), (10.98), (10.20) and (9.29) on 3rd, 6th, 9th, 12th and 15th day, respectively.

With respect to interactions highest firmness was recorded by P_4S_1-chitosan (1%) + HDPE packing + cold storage (12.70) and (12.36) on 3rd and 6th days respectively while P_5S_1-chitosan (1%) + PP packing + cold storage recorded highest firmness on (11.63), (11.23) and (11.00) on 9th, 12th and 15th days, respectively.

From the results, it was observed that highest firmness was observed with fruits treated with P_5- chitosan (1%), packed in PP and kept in cold storage. The rate of decrease in firmness in treated fruits was slow when compared to control fruits which indicated the hinderance of ripening process. Highest firmness may be due to low rate of respiration in polythene bags and also by surface coatings. Low temperatures slow down the metabolic activity of fruits which may leads to high firmness in fruits stored in low temperature. Similar results were obtained by Sophia *et al.* (2015) were mango fruits stored at 13°C significantly reduced loss of fruit firmness.

Spoilage (%)

Spoilage per cent of apple ber fruits stored in both cold storage and room temperature packed in different packaging material and treated with surface coatings is presented in table 3 and fig. 3.

Spoilage percent increases throughout the storage period, significantly lowest spoilage was recorded in P_4-chitosan (1%), packed in 100 gauge HDPE treatment in both storage conditions followed by P_5-chitosan (1%), packed in 100 gauge in PP and highest spoilage was recorded in control till 6th day there after control fruits shown the end of shelf life.

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

	Spoilage%																
	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	S_1	S_2	
P_1	0	0	**0**	0	23.33	**11.66**	0	46.66	**23.33**	20.00	66.66	**43.33**	43.33	*	63.33	*	
P_2	0	0	**0**	0	30.33	**15.16**	0	43.33	**21.66**	20.00	63.33	**41.66**	40.00	*	66.66	*	
P_3	0	0	**0**	0	43.33	**21.66**	0	56.66	**28.33**	33.33	*	**-**	60.00	*	*	*	
P_4	0	0	**0**	0	16.66	**8.33**	0	36.66	**18.33**	13.33	56.66	**34.99**	30.00	*	53.33	*	
P_5	0	0	**0**	0	33.33	**16.66**	0	50.00	**25.00**	16.66	63.33	**39.99**	36.66	*	56.66	*	
P_6	0	0	**0**	0	40.00	**20.00**	0	53.33	**26.66**	40.00	*	**-**	66.66	*	*	*	
P_7	0	6.66	**3.33**	0	46.66	**23.33**	10.00	*	**-**	53.33	*	**-**	76.66	*	*	*	
P_8	0	6.66	**3.33**	0	50.00	**25.00**	10.00	*	**-**	43.33	*	**-**	73.33	*	*	*	
P_9	0	30.00	**15.00**	0	*	**-**	13.33	*	**-**	46.66	*	**-**	63.33	*	*	*	
Mean	**0**	**4.81**		**0**	**35.45**		**3.70**	**47.77**		**31.84**	**62.49**		**56.66**	**-**	**59.99**	**-**	

	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%
P	0.78	2.25	1.24	3.56	1.36	3.90	2.60	7.47	1.36	3.90	1.46	4.21
S	0.37	1.06	0.58	1.68	0.64	1.84	1.22	3.52	0.64	1.84	0.69	1.98
PXS	1.11	3.18	1.75	5.04	1.92	5.52	3.68	10.57	1.92	5.52	2.07	5.96

*** - end of shelf life,** **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.

Initially spoilage was started on 6^{th} day in fruits stored in S_2-room temperature with significantly lowest spoilage was recorded in P_7-aloe vera gel (1:3) + control and P_8-chitosan (1%) + control (3.33) and highest spoilage was recorded in P_9-control (15.00).

With respect to interactions least spoilage was recorded in P_4S_1- chitosan (1%) + HDPE packing + cold storage (16.66), (36.66) and (13.33) on 9^{th}, 12^{th} and 15^{th} days, respectively.

There was significant difference between two storage conditions with lowest spoilage in S_1 0, 0, (3.70) and (31.84) on 6^{th}, 9^{th}, 12^{th} and 15^{th} day respectively, highest spoilage% was seen in S_2 (4.81), (35.45), (47.77) and (62.49) on 6^{th}, 9^{th}, 12^{th} and 15^{th} day, respectively.

Among all the treatments, fruits treated with P_4-chitosan (1%) and packed in 100 gauge HDPE stored in cold storage show least spoilage in fruits during storage compared to other treatments, this may be due to low respiration rate and low ethylene synthesis in low temperature and HDPE and chitosan coating helps in forming a barrier between fruit surface and outer atmosphere. Present results are in close conformity with the results obtained by Pandey *et al.* (2012) in ber fruits were fruits stored in room temperature spoiled till 12 days where as refrigerated fruits were in good condition till 21 days.

Browning

The data pertaining to browning of apple ber fruits at both storage conditions influenced by surface coatings and different packaging materials is presented in table 4 and fig. 4.

Browning score was given according to a scale from 1-5. Browning increased significantly along with the storage period. Lowest browning was recorded in P_4-chitosan (1%), packed in 100 gauge HDPE treatment in both storage conditions followed by P_5-chitosan (1%), packed in 100 gauge in PP and highest browning was recorded in control till 6^{th} day there after shelf life of control fruits end.

Browning of fruits started on 6^{th} day in fruits stored in S_2-room temperature with significantly lowest was in P_7-aloe vera + control (0.33) and highest was in P_9-control. P_7S_2 –chitosan (1%) + room temperature (0.54) recorded least browning (0.66) among interactions.

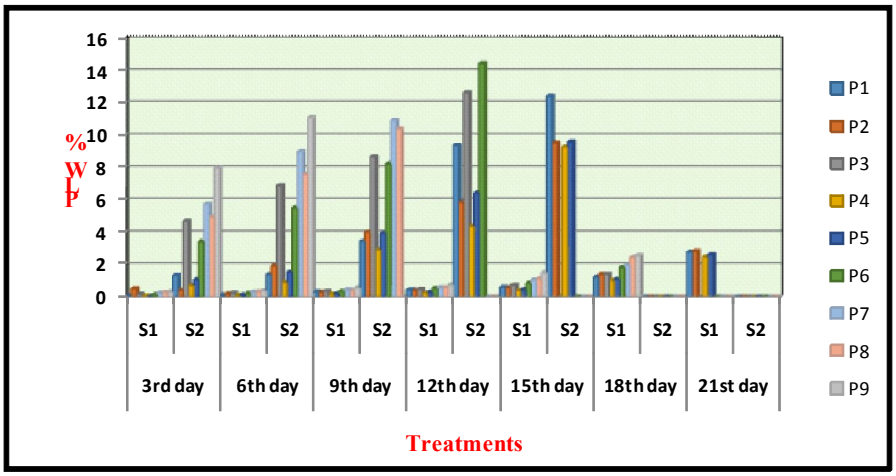
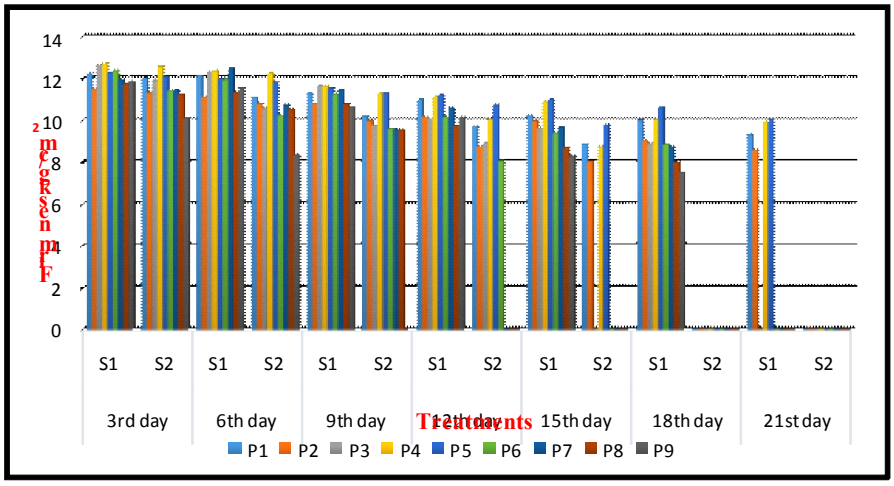


Fig. 1 : Effect of surface coatings and packaging materials at different storage conditions on physiological loss in weight (%) of apple ber (*Zizyphus mauritiana*).



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. 2 : Effect of surface coatings and packaging materials at different storage conditions on firmness (kg/cm^2) of apple ber (*Zizyphus mauritiana*).

There was significant difference between two storage conditions with lowest spoilage in S_1 0, 0, (1.45) and (2.86) on 6th, 9th, 12th and 15th day respectively, highest spoilage was seen in S_2 (0.27), (3.21), (3.60) and (4.37) on 6th, 9th, 12th and 15th day, respectively.

Fruits treated with P_4- chitosan (1%) and packed in 100 gauge HDPE stored in cold storage show least browning in fruits during storage compared to other treatments. Browning of fruits was little more in aloe vera gel coated fruits compared to chitosan, this may due to aloe vera gel becomes brown when kept exposed and even though pectin is added in aloe vera gel, it may limit browning only to some extent.

Shelf life (days)

Shelf life days of apple ber fruits treated with surface coatings, packed in different packaging materials and stored at different storage conditions was presented in the table 5 and fig. 5.

Highest shelf life was (16.50) recorded in P_4-chitosan (1%) + HDPE and lowest shelf life (11.83) of was recorded in P_9-control.

Apple ber fruits treated with chitosan (1%) and packed in 100 gauge HDPE stored in cold storage-P_4S_1 recorded significantly higher shelf life of (21.00) and least shelf life of was recorded in P_9S_2-control (7.66) fruits at room temperature.

Among both storage conditions significantly highest shelf life was recorded in S_1-cold storage of (18.10) and lowest shelf life was in S_2-room temperature with (10.88).

Table 4 : Effect of surface coatings and packaging materials at different storage conditions on browning of apple ber (*Zizyphus mauritiana*).

Browning																
	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	S_1	S_2
P_1	0	0	**0**	0	3.04	**1.52**	1.19	3.13	**2.16**	2.40	4.38	**4.26**	4.33	*	5.12	*
P_2	0	0	**0**	0	3.04	**1.52**	1.12	3.16	**2.14**	2.61	4.82	**3.71**	4.33	*	5.15	*
P_3	0	0	**0**	0	3.38	**1.69**	1.08	4.82	**2.95**	3.19	*	-	4.62	*	*	*
P_4	0	0	**0**	0	1.94	**0.97**	0.66	2.58	**1.62**	1.33	4.11	**2.72**	3.19	*	4.52	*
P_5	0	0	**0**	0	3.13	**1.56**	0.75	3.41	**2.08**	1.18	4.18	**2.68**	3.77	*	4.55	*
P_6	0	0	**0**	0	3.54	**1.77**	1.19	4.55	**2.87**	3.64	*	-	4.63	*	*	*
P_7	0	0.66	**0.33**	0	3.55	**1.77**	2.18	*	-	4.54	*	-	5.19	*	*	*
P_8	0	0.77	**0.38**	0	4.06	**2.03**	2.33	*	-	3.33	*	-	4.85	*	*	*
P_9	0	1.08	**0.54**	0	*	-	2.58	*	-	3.55	*	-	4.82	*	*	*
Mean	**0**	**0.27**		**0**	**3.21**		**1.45**	**3.60**		**2.86**	**4.37**		**4.41**	-	**4.83**	-

	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 %
P	0.06	0.17	0.10	0.28	0.13	0.38	0.09	0.28	0.05	0.14	0.07	0.20
S	0.02	0.08	0.04	0.14	0.06	0.18	0.04	0.13	0.02	0.06	0.03	0.09
PXS	0.08	0.24	0.14	0.40	0.19	0.55	0.14	0.40	0.07	0.20	0.10	0.29

*** - end of shelf life, 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.

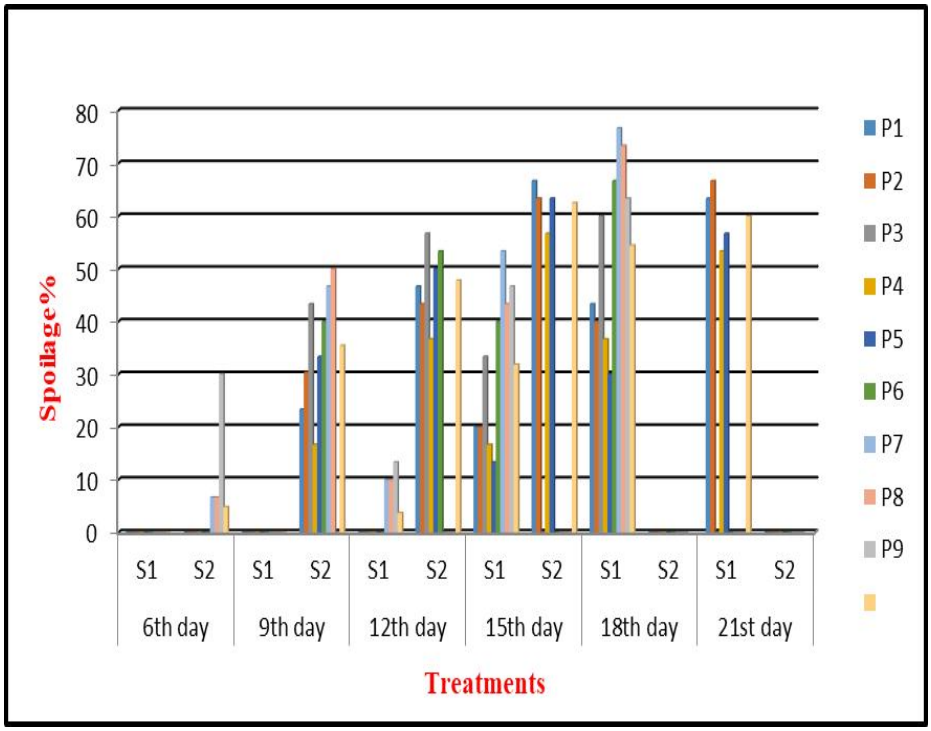
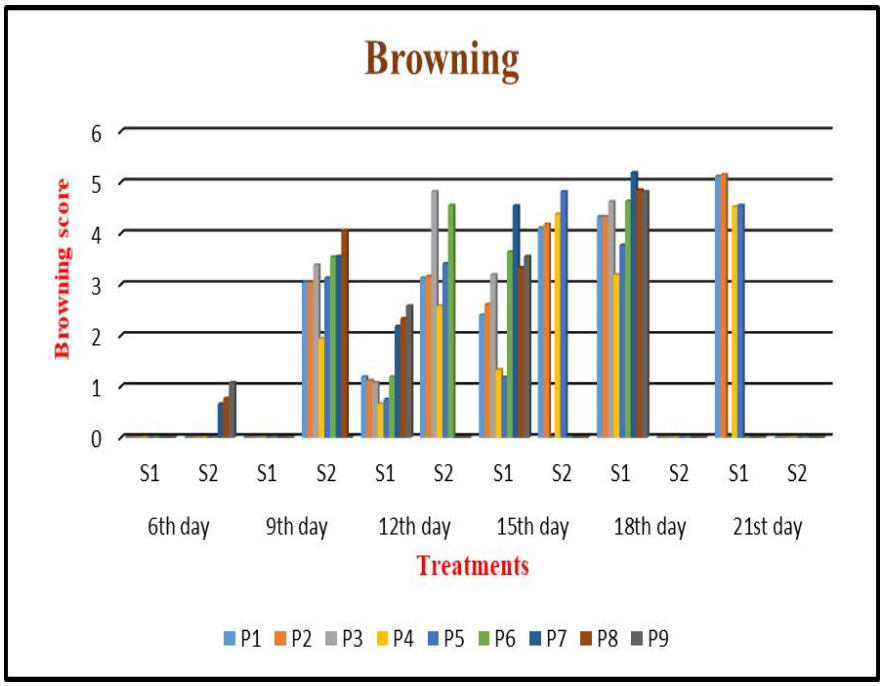


Fig. 3. Effect of surface coatings and packaging materials at different storage conditions on spoilage (%) of apple ber (*Z. mauritiana*).



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. 4 : Effect of surface coatings and packaging materials at different storage conditions on browning of apple ber (*Zizyphus mauritiana*).

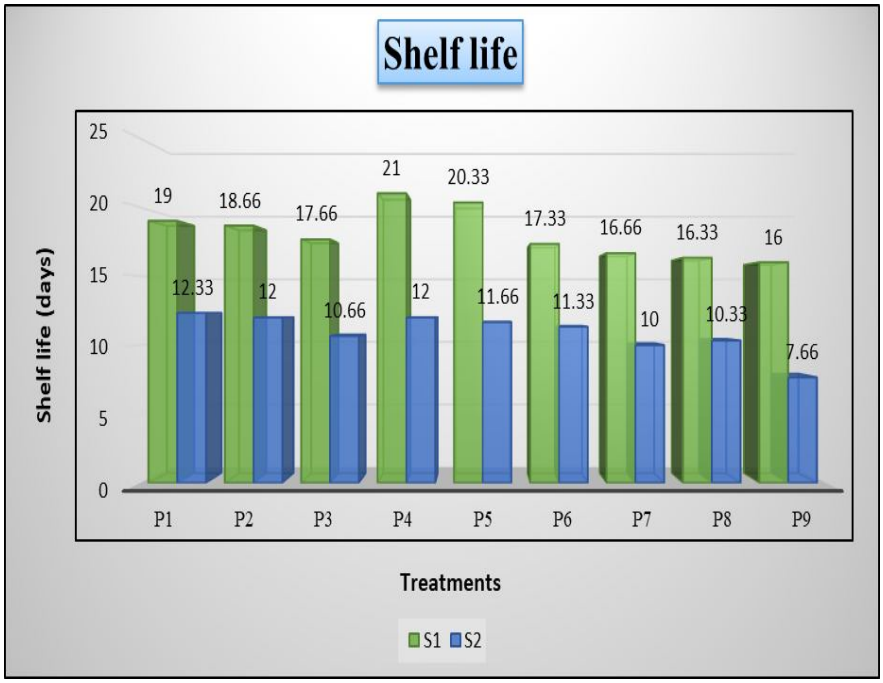


Fig. 5 : Effect of surface coatings and packaging materials at different storage conditions on shelf life (days) of apple ber (*Zizyphus mauritiana*).

Chitosan (1%) coating plus polythene packing (HDPE, PP) scored well and found satisfactory in maintaining high shelf life. Chitosan coating reduces shrinkage by reducing loss of moisture and their by retains freshness of fruits. HDPE and PP packing helps in reducing transpiration there by reduces respiration losses (Hening, 1975). Low temperature of 10±2^{0}C is very much favourable for apple ber fruits to extend its shelf life as it reduces ethylene synthesis; if temperature is reduced further there may be a problem of chilling injury. Sandeep

Table 5 : Effect of surface coatings and packaging materials at different storage conditions on shelf life (days) of Apple ber (*Zizyphus mauritiana*).

Shelf life (days)			
	S_1	S_2	Mean
P_1	19.00	12.33	**15.66**
P_2	18.66	12.00	**15.33**
P_3	17.66	10.66	**14.16**
P_4	21.00	12.00	**16.50**
P_5	20.33	11.66	**15.99**
P_6	17.33	11.33	**14.33**
P_7	16.66	10.00	**13.33**
P_8	16.33	10.33	**13.33**
P_9	16.00	7.66	**11.83**
Mean	**18.10**	**10.88**	

Factor	S.Em±	CD at 5%
P	0.22	0.69
S	0.17	0.54
P X S	0.39	1.23

P_1 – *Aloe vera*gel+HDPE,
P_2 – *Aloe vera*gel+PP,
P_3 – *Aloe vera*gel+CFB,
P_4 – Chitosan+HDPE,
P_5 – Chitosan+PP,
P_6 – Chitosan+CFB,
P_7 – *Aloe vera* gel,
P_8 – Chitosan,
P_9 – Control.

S_1 – cold storage,
S_2 – room temperature.

and Bal (2003) also reported that ber fruits can be stored economically for 6 days in ambient conditions and 24 days in cold storage when packed in polyethylene bags.

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