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Effect of Different Packaging Materials on Post-Harvest Quality Parameters of Pear under Zero Energy Chamber Storage Condition

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A B S T R A C T

Post-harvest biochemical changes occurring in fruits of three commercial varieties of pear (Patharnakh, Kashmirinakh and Baggugosha) stored under zero energy cool chamber (ZECC) (23.2±3°C and RH 90-95%) and at normal room temperature (32±4°C and RH 70-75%) conditions were assessed in the post-harvest Laboratory of the Department of Horticulture at CCS HAU, Hisar. Quality of fruits packed in polyethylene (PE 0.01 and 0.05 mm thickness) bags of individual fruit packing (IFP) and 1.0 kg capacity and corrugated fiber board (CFB) boxes was examined on alternate day basis up to 10th day of storage. Irrespective of packaging treatments, a continuous decrease in acidity and ascorbic acid contents of fruits was noticed with the passage of storage time, whereas TSS and sugar contents rose gradually with the advancement of storage period. Lower TSS (11.6%) was recorded in Patharnakh fruits packed in PE 0.05 mm of IFP at zero energy chamber (ZEC) storage and maximum (13.9%) was showed by Kashmirinakh under control condition. Maximum titrable acidity (0.46%) measured in Patharnakh stored at ZEC and having individual fruit packs in PE 0.01mm was at par with PE 0.05mm of IFP, while fruits of Kashmirinakh under control treatment showed lowest acidity (0.25%). The non-reducing, reducing and total sugar contents of fruits were not affected by packaging treatments. Conclusively, the fruits of all three varieties of pear packed in PE 0.05 or 0.01mm of individual fruit packing and stored at ZEC effectively maintained quality parameters, hence were marked best treatments. However, maximum degradation of fruits was observed in corrugated fiber board boxes stored at the room temperature.

Introduction

Pear fruits, commonly used for table purpose and bearing few small stone cells, are now becoming popular with the consumers for their unique and desirable qualities like fragrance, subtle aroma, appearance, sweetness, crispness and the delicious taste. Pear fruits are good source of sugars, minerals, various bioactive compounds like vitamin C and natural antioxidants. These chemicals having valuable role in maintaining fruit quality cannot be overlooked.

Some low chilling pear varieties with suitable adaptation to subtropical conditions of northern plains are gaining popularity in India. Such varieties ripen from last week of July to end of August. During these months, due to prevalence of high temperature at harvest, fruits get spoiled rapidly and reduce their shelf life greatly. Short shelf life of pear fruits limits their transportation to far off places whereby a glut like situation created in local markets deprives remunerative prices of

their produce to the growers, hence warrants a great need to enhance shelf life of pear fruits through simple and suitable means. Fruits stored in zero energy cool chambers get their shelf life enhanced by restricting the respiration and transpiration (Singh *et al.*, 2010).Besides, the storage of fruits in polyethylene films can result in a commodity generated modified atmosphere that diminishes dehydration and preserves freshness (Ben-Yehoshua *et al.*, 1994). Several researchers have investigated the effect of packaging and storage environment on post-harvest storage life and quality of different fruits (Kudachikar *et al.*, 2007).On farm storage plays a vital role in maintaining quality soon after harvest. However, no such systematic work has been done in pear to enhance shelf life by zero energy chamber and different types of packaging materials like modified atmosphere packaging (MAP). Hence, present study was carried out to evaluate the effect of various packaging materials and storage condition on fruit quality of three pear cultivars Patharnakh, Kashmirinakh and Baggugoshaunder zero energy cool chambers.

Materials and Methods

The experiment was conducted in Post-Harvest Laboratory and the ZECC of Department of Horticulture, CCS HAU, Hisar. Fruits of optimum maturity from the similar aged healthy trees of three pear varieties *viz.*, Patharnakh, Kashmirinakh and Baggugosha maintained under uniform cultural practices and harvested with the help of secateurs retaining small intact pedicel, were procured from experimental orchard of College of Agriculture, Kaul (Kaithal), CCS HAU, Hisar. The healthy, uniform sized and disease, injury or bruise free fruits selected for storage were wiped down with muslin cloth to remove dust particles. Two types of packaging material (A) corrugated fiber board (CFB) boxes of two kg capacity where fruits of all three varieties were packed using newspapers as cushioning material and taken as control treatment, and (B) polyethylene of 0.01 and 0.05mm thickness, measured by Lever Type Dial Thickness Guage, United Engineering Corporation, New Delhi, both for the bags of (a) individual fruit packing (IFP) and (b) one kg fruit packing of all the three varieties was used.

The mouth of polyethylene bags after filling with measured quantity of fruits was tied up. Thereafter half of the packed fruit material was stored at post-harvest laboratory (32±4°C and RH 70-75%) and remaining half packaged material was kept at zero energy cool chambers (23.2±3°C and RH 90-95%) prepared on farm outside of the laboratory. All treatments were replicated four times, taking each box as one replication. Three fruits were taken randomly from 4^{th} replication on every alternate day for analysis of quality parameters. On observations recording dates, i.e. 2^{nd}, 4^{th}, 6^{th}, 8^{th} and 10^{th} day of storage, the mouth of bags was kept open for ten minutes to remove excess gases and moisture sticking the inner side of bags. The TSS of pear fruits with hand refractometer; the acidity and ascorbic as per the method suggested by AOAC (1990) and sugars following the potassium ferricyanide method of Hulme and Narain (1931) was determined.

Results and Discussion

TSS content (%)

Irrespective of packaging treatments, the TSS content of fruits in all the three varieties increased with increasing period of storage (Table 1). The TSS content of 10.2 % recorded in variety *Patharnakh* at the beginning stage of storage increased progressively reaching maximum of 13.7% on 10^{th} day of storage. Considering TSS on mean basis, irrespective of storage period, the fruits stored in different types of polyethylene

showed lower TSS (11.6-12.0%) as compared to CFB boxes both at room temperature and zero energy chamber storage condition that had maximum TSS content (12.3%). Similarly, an increasing trend of TSS was seen from beginning (11.8%) to the end of storage period (15.0%) in Kashmirinakh. Irrespective of storage period, the TSS was recorded minimum in fruits stored in individual fruit packing with PE 0.01 mm stored at zero energy cool chambers (13.2%), which was found statistically at par with another polyethylene type. Whereas, the TSS in fruits stored in CFB boxes was found maximum (13.9 and 13.7%) at room temperature and zero energy chamber storages, respectively. The effect of packaging materials, irrespective of storage, on variety Baggugosha and overall effect on all three varieties was not-significant. At room temperature storage conditions TSS content increased gradually in all the three varieties irrespective of the treatments.

However, on 10th day of storage minimum TSS was recorded in Patharnakh (13.8%) and maximum in Baggugosha (15.7%). Similar trend was also observed for zero energy chamber storage. Comparing TSS on overall storage mean basis, irrespective of the varieties and packaging treatments, maximum TSS of 14.8% was observed on 10th day of storage. Comparing all three varieties irrespective of storage and packaging treatments, the TSS was found minimum in Patharnakh (11.9%) while maximum in cv. Baggugosha (14.1%). Except the storage x variety, the various interactions were not significant. However, among varieties Patharnakh and Baggugosha had minimum TSS content in different types of polyethylene and maximum in CFB boxes stored both at room temperature and zero energy cool chambers. The increasing trend consolidates the previous findings of Nath *et al.,* (2012) and Kaur *et al.,* (2013) in pear. The rise of TSS during storage might be associated with transformation of pectic substances and starch hydrolysis yielding mono and disaccharides and also with dehydration of fruits (Mahajan *et al.,* 2004). Lower TSS content in different polyethylene packaging treatments can be attributed to minimized weight loss, retard ripening and senescence processes which simultaneously slow down conversion of starch into sugars. The pattern of these results resembles with the findings of Rana *et al.,* (2015) in guava. And higher TSS in control treatment of fruits might be associated with more transpirational and respirational losses.

Acidity content (%)

The overall mean data for storage indicated that acidity content decreased continuously irrespective of varieties and packaging treatments and minimum (0.29%) was recorded on 10th day of storage (Table 2). Based on observations for varieties, irrespective of the storage and packaging treatments, the titerable acidity was found maximum in variety Patharnakh (0.44%)followed by Baggugosha (0.28%) and Kashmirinakh (0.26%).Interactions among variety x storage and variety x packaging were found significant, but non-significant among storage x packaging and storage x variety x packaging. However, maximum acidity content was observed on 10th day of storage in fruits of variety Patharnakh stored in PE 0.01 and 0.05mm of individual fruit packing at ZEC. Most of polyethylene bags retained higher acidity content of fruits as compared to control, the reason might be the development of modified atmosphere around fruits in PE bags that slowed down various metabolic processes resulting in lower utilization of acids and decreased activity of invertage enzyme resulting in slow conversion of acids into sugars (Wavlah and Athale, 1988). This decrease in acidity can be attributed to conversion of acids into sugars (Sandhu *et al.,* 1989) and utilization of acids during respiration (Waskar *et al.,* 1999).

Table.1 Effect of packaging materials on TSS (^{0} brix) during storage of pear at room temperature and zero energy chamber

Treatments	Varieties																				
	Patharnakh							Kashmirinakh							Baggugosha							
	Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	Grand Mean
	0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
CFB boxes Room (Control)	10.2	10.9	11.7	13.1	13.8	14.2	**12.3**	11.8	13.1	13.7	14.5	14.9	15.3	**13.9**	12.5	13.6	14.3	14.9	15.5	16.0	**14.5**	**13.5**
CFB at ZEC	10.2	10.8	11.5	13.0	13.6	14.1	**12.2**	11.8	13.0	13.5	14.2	14.6	15.1	**13.7**	12.5	13.4	14.1	14.8	15.2	15.8	**14.3**	**13.4**
PE 0.01 mm (IFP) Room	10.2	10.6	11.5	12.0	13.3	13.9	**11.9**	11.8	12.2	13.1	14.0	14.5	14.9	**13.4**	12.5	13.3	14.0	14.6	15.0	15.7	**14.2**	**13.2**
PE 0.01 mm(IFP) ZEC	10.2	10.5	11.4	11.8	13.0	13.7	**11.8**	11.8	12.0	12.9	13.7	14.1	14.7	**13.2**	12.5	13.3	13.8	14.3	14.8	15.4	**14.0**	**13.0**
PE 0.05 mm (IFP) Room	10.2	10.7	11.6	12.1	12.6	13.0	**11.7**	11.8	12.4	13.6	14.4	14.8	15.1	**13.7**	12.5	13.4	14.1	14.8	15.5	15.8	**14.4**	**13.2**
PE 0.05 mm (IFP) ZEC	10.2	10.6	11.5	11.9	12.4	12.9	**11.6**	11.8	12.3	13.3	14.1	14.6	15.0	**13.5**	12.5	13.0	13.8	14.3	14.9	15.5	**14.0**	**13.0**
PE 0.01 mm (1 kg bag) Room	10.2	10.5	11.6	12.3	13.0	14.1	**12.0**	11.8	12.5	13.5	14.2	14.7	15.0	**13.6**	12.5	12.9	14.2	14.7	14.8	15.7	**14.1**	**13.2**
PE 0.01 mm (1 kg bag) ZEC	10.2	10.5	11.4	12.0	12.7	13.8	**11.8**	11.8	12.4	13.2	14.0	14.6	14.9	**13.5**	12.5	12.9	13.9	14.5	14.7	15.6	**14.0**	**13.1**
PE 0.05mm (1 kg bag) Room	10.2	10.6	11.5	12.4	13.1	14.0	**12.0**	11.8	12.4	13.2	13.9	14.6	15.0	**13.5**	12.5	12.9	13.8	14.6	15.2	15.5	**14.1**	**13.2**
PE 0.05 mm (1kg bag) ZEC	10.2	10.4	11.6	12.2	12.9	13.7	**11.8**	11.8	12.3	13.0	13.8	14.4	14.8	**13.4**	12.5	12.8	13.6	14.4	15.1	15.3	**14.0**	**13.0**
Mean storage	**10.2**	**10.6**	**11.5**	**12.3**	**13.0**	**13.7**		**11.8**	**12.5**	**13.3**	**14.1**	**14.6**	**15.0**		**12.5**	**13.2**	**14.0**	**14.6**	**15.1**	**15.6**		
Mean Room	10.2	10.7	11.6	12.4	13.2	13.8		11.8	12.5	13.4	14.2	14.7	15.1		12.5	13.2	14.1	14.7	15.2	15.7		
Mean ZEC	10.2	10.6	11.5	12.2	12.9	13.6		11.8	12.4	13.2	14.0	14.5	14.9		12.5	13.1	13.8	14.5	14.9	15.5		
Storage	11.5	12.1	12.9	13.6	14.2	14.8																
Variety	11.9	13.5	14.1																			
CD at 5%																						
Storage	0.18		S x P		NS			CFB	Corrugated fiber board boxes					CD at 5% for Packaging								
Variety	0.13		S x V		0.31			IFP	Individual fruit packing					Patharnakh	0.44							
Packaging	NS		V x P		NS			ZEC	Zero energy chamber					Kashmirinakh	0.37							
Room	0.5		S x V x P		NS			PE	Polyethylene					Baggugosha	NS							
ZEC	0.3							Room	Room temperature													

Table.2 Effect of packaging materials on acidity (%) during storage of pear at room temperature and zero energy chamber

Sr. No.	Treatments	Varieties																						Over all Mean
		Patharnakh							Kashmirinakh							Baggugosha								
		Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	
		0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
1.	CFB boxes Room (Control)	0.48	0.45	0.43	0.42	0.40	0.38	0.43	0.30	0.27	0.25	0.23	0.22	0.20	0.25	0.32	0.28	0.25	0.24	0.23	0.21	0.26	0.31
2.	CFB ZEC	0.48	0.46	0.45	0.43	0.41	0.39	0.44	0.30	0.28	0.27	0.25	0.23	0.21	0.26	0.32	0.29	0.27	0.26	0.24	0.23	0.27	0.32
3.	PE 0.01 mm (IFP) Room	0.48	0.47	0.46	0.44	0.43	0.42	0.45	0.30	0.29	0.28	0.24	0.24	0.23	0.26	0.32	0.32	0.30	0.27	0.26	0.25	0.29	0.33
4.	PE 0.01 mm(IFP) ZEC	0.48	0.48	0.47	0.45	0.44	0.43	0.46	0.30	0.28	0.26	0.23	0.23	0.23	0.26	0.32	0.32	0.31	0.28	0.27	0.26	0.29	0.34
5.	PE 0.05 mm (IFP) Room	0.48	0.47	0.46	0.44	0.43	0.39	0.45	0.30	0.29	0.28	0.25	0.25	0.24	0.27	0.32	0.28	0.25	0.25	0.24	0.23	0.26	0.33
6.	PE 0.05 mm (IFP) ZEC	0.48	0.48	0.46	0.46	0.43	0.42	0.46	0.30	0.30	0.27	0.26	0.26	0.25	0.27	0.32	0.30	0.27	0.26	0.26	0.24	0.28	0.33
7.	PE 0.01 mm (1 kg bag) Room	0.48	0.46	0.44	0.43	0.42	0.41	0.44	0.30	0.28	0.28	0.25	0.25	0.23	0.27	0.32	0.31	0.28	0.25	0.24	0.24	0.27	0.33
8.	PE 0.01 mm (1 kg bag) ZEC	0.48	0.47	0.46	0.43	0.42	0.42	0.45	0.30	0.29	0.28	0.25	0.25	0.24	0.27	0.32	0.31	0.29	0.27	0.26	0.25	0.28	0.33
9.	PE 0.05mm (1 kg bag) Room	0.48	0.46	0.44	0.42	0.40	0.39	0.43	0.30	0.27	0.25	0.23	0.23	0.22	0.25	0.32	0.30	0.28	0.27	0.26	0.24	0.28	0.32
10.	PE 0.05 mm (1kg bag) ZEC	0.48	0.46	0.45	0.43	0.40	0.40	0.44	0.30	0.28	0.26	0.24	0.24	0.23	0.26	0.32	0.31	0.29	0.28	0.28	0.26	0.29	0.33
Overall mean for		0.48	0.47	0.45	0.43	0.42	0.40		0.30	0.28	0.27	0.24	0.24	0.23		0.32	0.30	0.28	0.26	0.25	0.24		
	Room	0.48	0.46	0.45	0.43	0.42	0.40		0.30	0.28	0.27	0.24	0.24	0.22		0.32	0.30	0.27	0.26	0.25	0.23		
	ZEC	0.48.	0.47	0.46	0.44	0.42	0.41		0.30	0.29	0.27	0.25	0.24	0.23		0.32	0.31	0.29	0.27	0.26	0.25		
	Storage	0.37	0.35	0.33	0.32	0.30	0.29																
	Variety	0.44	0.26	0.28																			
	CD at 5%														CD at 5% for Packaging								
	Storage	0.005		S x P		NS			CFB	Corrugated fibre board boxes					Patharnakh	0.01							
	Variety	0.004		S x V		0.009			IFP	Individual fruit packing					Kashmirinakh	0.01							
	Packaging	NS		V x P		0.01			ZEC	Zero energy chamber					Baggugosha	0.01							
				S x V x P		NS			PE	Polyethylene													
	Room	0.01							Room	Room temperature													
	ZEC	0.01																					

Table.3 Effect of packaging materials on ascorbic acid (mg/100 g fruit pulp) during storage of pear at Room temperature and zero energy chamber

Sr. No.	Treatments	Varieties																			Over all Mean
		Patharnakh							Kashmirinakh							Baggugosha							
		Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	
		0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
1.	CFB boxes Room (Control)	3.00	2.73	2.65	2.61	2.57	2.54	2.68	4.00	3.70	3.66	3.64	3.58	3.51	3.68	3.25	3.03	2.95	2.90	2.86	2.83	2.97	3.11
2.	CFB ZEC	3.00	2.78	2.72	2.66	2.62	2.58	2.73	4.00	3.77	3.76	3.63	3.60	3.58	3.72	3.25	3.07	2.99	2.91	2.86	2.84	2.99	3.14
3.	PE 0.01 mm (IFP) Room	3.00	2.82	2.79	2.74	2.72	2.68	2.79	4.00	3.81	3.73	3.68	3.68	3.63	3.76	3.25	3.19	2.82	3.15	3.10	3.02	3.09	3.21
4.	PE 0.01 mm(IFP) ZEC	3.00	2.89	2.89	2.83	2.80	2.73	2.86	4.00	3.95	3.88	3.77	3.71	3.70	3.84	3.25	2.88	3.18	3.12	3.06	3.04	3.09	3.26
5.	PE 0.05 mm (IFP) Room	3.00	2.96	2.95	2.84	2.78	2.70	2.87	4.00	3.84	3.84	3.71	3.69	3.66	3.79	3.25	3.18	3.17	3.15	3.12	3.10	3.16	3.27
6.	PE 0.05 mm (IFP) ZEC	3.00	2.97	2.94	2.86	2.80	2.78	2.89	4.00	3.94	3.86	3.80	3.76	3.72	3.85	3.25	3.23	3.18	3.11	3.14	3.13	3.17	3.30
7.	PE 0.01 mm (1 kg bag) Room	3.00	2.92	2.78	2.77	2.74	2.67	2.81	4.00	3.99	3.95	3.86	3.74	3.70	3.87	3.25	3.21	3.20	3.13	3.12	3.07	3.16	3.28
8.	PE 0.01 mm (1 kg bag) ZEC	3.00	2.98	2.95	2.93	2.86	2.79	2.92	4.00	3.86	3.85	3.83	3.80	3.76	3.85	3.25	3.23	3.19	3.14	3.11	3.08	3.17	3.31
9.	PE 0.05mm (1 kg bag) Room	3.00	2.87	2.82	2.71	2.66	2.60	2.78	4.00	3.93	3.89	3.87	3.84	3.72	3.88	3.25	3.19	3.15	3.15	3.13	3.08	3.16	3.27
10.	PE 0.05 mm (1kg bag) ZEC	3.00	2.96	2.91	2.84	2.80	2.73	2.87	4.00	3.88	3.82	3.77	3.76	3.72	3.83	3.25	3.22	3.20	3.14	3.19	3.16	3.19	3.29
Overall Mean for		3.00	2.89	2.84	2.78	2.74	2.68		4.00	3.87	3.82	3.76	3.72	3.67		3.25	3.14	3.10	309	3.07	3.04		
	Room	3.00	2.86	2.80	2.73	2.69	2.64		4.00	3.85	2.81	2.75	2.71	3.64		3.25	3.16	3.06	3.10	3.07	3.02		
	ZEC	3.00	2.92	2.88	2.82	2.78	2.72		4.00	3.88	3.83	3.76	3.73	3.70		3.25	3.13	3.15	3.08	3.07	3.05		
	Storage	3.41	3.30	3.25	3.20	3.17	3.12																
	Variety	2.82	3.80	3.11																			
	CD at 5%															CD at 5% for Packaging							
	Storage	0.02		S x P		0.07			CFB	Corrugated fibre board boxes						Patharnakh	0.04						
	Variety	0.02		S x V		0.04			IFP	Individual fruit packing						Kashmirinakh	0.04						
	Packaging	0.03		V x P		0.05			ZEC	Zero energy chamber						Baggugosha	0.07						
				S x V x P		NS			PE	Polyethylene													
	Room	0.05							Room	Room temperature													
	ZEC	0.03																					

Table.4 Effect of packaging materials on total sugars (%) during storage of pear at room temperature and zero energy chamber

Sr. No.	Treatments	Varieties																			Over all Mean
		Patharnakh							Kashmirinakh							Baggugosha							
		Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	
		0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
1.	CFB boxes Room (Control)	8.45	8.92	9.64	10.15	10.74	11.26	9.86	9.87	10.34	10.98	11.52	11.95	12.30	11.16	10.20	10.78	11.44	11.95	12.51	12.96	11.64	10.89
2.	CFB ZEC	8.45	8.91	9.62	10.10	10.70	11.19	8.83	9.87	10.30	10.93	11.44	11.90	12.24	11.11	10.20	10.66	11.32	11.81	12.45	12.78	11.54	10.83
3.	PE 0.01 mm (IFP) Room	8.45	8.80	9.54	9.97	10.47	10.94	9.70	9.87	10.25	10.84	11.35	11.84	12.19	11.06	10.20	10.52	11.24	11.84	12.36	12.70	11.48	10.74
4.	PE 0.01 mm(IFP) ZEC	8.45	8.76	9.43	9.87	10.40	10.90	9.64	9.87	10.20	10.72	11.20	11.64	11.93	10.93	10.20	10.51	11.10	11.53	12.08	12.48	11.32	10.63
5.	PE 0.05 mm (IFP) Room	8.45	8.90	9.57	10.02	10.51	11.07	9.75	9.87	10.29	10.90	11.43	11.86	12.14	11.08	10.20	10.56	11.27	11.80	12.40	12.66	11.48	10.77
6.	PE 0.05 mm (IFP) ZEC	8.45	8.90	9.51	9.88	10.44	10.98	9.69	9.87	10.27	10.86	11.39	11.80	12.10	11.05	10.20	10.42	10.98	11.42	11.97	12.45	11.24	10.66
7.	PE 0.01 mm (1 kg bag) Room	8.45	8.87	9.60	10.08	10.62	11.12	9.79	9.87	10.23	10.82	11.30	11.78	12.09	11.02	10.20	10.63	11.32	11.77	11.96	12.76	11.44	10.75
8.	PE 0.01 mm (1 kg bag) ZEC	8.45	8.77	9.48	10.04	10.59	11.04	9.73	9.87	10.22	10.80	11.25	11.69	11.96	10.97	10.20	10.54	11.14	11.58	11.80	12.53	11.30	10.66
9.	PE 0.05mm (1 kg bag) Room	8.45	8.80	9.45	9.94	10.66	11.15	9.74	9.87	10.15	10.63	11.15	11.60	11.90	10.88	10.20	10.44	11.18	11.66	12.28	12.55	11.39	10.67
10.	PE 0.05 mm (1kg bag) ZEC	8.45	8.75	9.45	9.82	10.42	11.10	9.67	9.87	10.10	10.40	10.70	11.43	11.79	10.72	10.20	10.40	10.95	11.42	12.14	12.32	11.24	10.54
Overall Mean for		8.45	8.84	9.53	9.99	10.56	11.08		9.87	10.24	10.79	11.27	11.75	12.06		10.20	10.55	11.19	11.68	12.20	12.62		
Room		8.45	8.86	9.56	10.03	10.60	11.11		9.87	10.25	10.83	11.35	11.81	12.12		10.20	10.59	11.29	11.80	12.30	12.73		
ZEC		8.45	8.82	9.50	9.94	10.51	11.04		9.87	10.22	10.74	11.20	11.69	12.00		10.20	10.51	11.10	11.55	12.09	12.51		
Storage		9.51	9.87	10.50	10.10	11.50	11.92																
Variety		9.74	10.10	11.40																			

CD at 5%

Storage	0.20	S x P	NS	CFB	Corrugated fibre board boxes
Variety	0.14	S x V	NS	IFP	Individual fruit packing
Packaging	NS	V x P	NS	ZEC	Zero energy chamber
		S x V x P	NS	PE	Polyethylene
Room	0.34			Room	Room temperature
ZEC	NS				

CD at 5% for Packaging

Patharnakh	NS
Kashmirinakh	NS
Baggugosha	NS

Table.5 Effect of packaging materials on reducing sugars (%) during storage of pear at room temperature and zero energy chamber

Sr. No.	Treatments	Varieties																			Over all Mean
		Patharnakh							Kashmirinakh							Baggugosha							
		Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	
		0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
1.	CFB boxes Room (Control)	5.53	5.95	6.43	6.82	7.35	7.75	6.64	6.08	6.44	7.10	7.55	7.63	8.38	7.20	6.70	7.27	7.94	8.38	9.22	9.40	8.15	7.32
2.	CFB boxes ZEC	5.53	5.89	6.35	6.77	7.33	7.71	6.60	6.08	6.42	7.06	7.52	7.91	8.33	7.22	6.70	7.22	7.80	8.24	8.80	9.29	8.01	7.27
3.	PE 0.01 mm (IFP) Room	5.53	5.78	6.25	6.64	7.10	7.44	6.46	6.08	6.36	6.90	7.38	7.82	8.30	7.14	6.70	7.14	7.43	8.27	8.73	9.23	7.92	7.17
4.	PE 0.01 mm (IFP) ZEC	5.53	5.72	5.97	6.52	6.95	7.40	6.35	6.08	6.25	6.78	7.24	7.60	8.02	7.00	6.70	7.08	7.66	8.07	7.26	8.96	7.62	6.98
5.	PE 0.05 mm (IFP) Room	5.53	5.83	6.30	6.68	7.16	7.55	6.51	6.08	6.40	7.03	7.47	7.87	8.26	7.19	6.70	7.19	7.81	8.25	8.76	9.25	7.99	7.22
6.	PE 0.05 mm (IFP) ZEC	5.53	5.86	6.20	6.55	6.98	7.48	6.43	6.08	6.40	6.95	7.42	7.78	8.15	7.13	6.70	6.97	7.62	8.02	8.56	8.90	7.80	7.11
7.	PE 0.01 mm (1 kg bag) Room	5.53	5.80	6.33	6.75	7.24	7.63	6.55	6.08	6.33	6.86	7.35	7.73	8.19	7.09	6.70	7.21	7.85	8.20	8.50	9.27	7.96	7.19
8.	PE 0.01 mm (1 kg bag) ZEC	5.53	5.75	6.17	6.71	7.21	7.52	6.48	6.08	6.30	6.84	7.29	7.65	8.06	7.04	6.70	7.17	7.69	8.10	8.33	9.13	7.85	7.12
9.	PE 0.05 mm (1 kg bag) Room	5.53	5.77	6.15	6.60	7.29	7.67	6.50	6.08	6.26	6.89	7.30	7.56	8.00	7.02	6.70	6.98	7.73	8.25	8.72	9.27	7.94	7.15
10.	PE 0.05 mm (1 kg bag) ZEC	5.53	5.77	6.12	6.48	6.96	7.59	6.41	6.08	6.20	6.82	7.21	7.39	7.90	6.93	6.70	6.95	7.60	8.18	8.67	9.21	7.89	7.07
Overall Mean for		5.53	5.81	6.23	6.65	7.16	7.5		6.08	6.34	6.92	7.37	7.69	8.16		6.70	7.12	7.71	8.20	8.56	9.19		
	Room	5.53	5.83	6.29	6.70	7.23	7.61		6.08	6.36	6.96	7.41	7.72	8.23		6.70	7.16	7.75	8.27	8.79	9.28		
	ZEC	5.53	5.80	6.16	6.61	7.09	7.54		6.08	6.31	6.89	7.34	7.67	8.09		6.70	7.08	7.67	8.12	8.32	9.10		
	Storage	6.10	6.42	6.95	7.40	7.80	8.30																
	Variety	6.49	7.09	7.91																			

CD at 5%

Storage	0.15	S x P	NS	
Variety	0.10	S x V	0.25	
Packaging	NS	V x P	NS	
		S x V x P	NS	
Room	0.26			
ZEC	0.21			

CFB Corrugated fibre board boxes
IFP Individual fruit packing
ZEC Zero energy chamber
PE Polyethylene

CD at 5% for Packaging

Patharnakh	NS
Kashmirinakh	NS
Baggugosha	NS

Table.6 Effect of packaging materials on non-reducing sugars (%) during storage of pear at Room temperature and zero energy chamber

Sr. No.	Treatments	Varieties																			Over all Mean
		Patharnakh							Kashmirinakh							Baggugosha							
		Days after storage						Mean	Days after storage						Mean	Days after storage						Mean	
		0	2	4	6	8	10		0	2	4	6	8	10		0	2	4	6	8	10		
1.	CFB boxes Room (Control)	2.92	2.97	3.21	3.33	3.39	3.51	3.22	3.79	3.90	3.88	3.97	4.32	3.92	3.96	3.50	3.51	3.49	3.57	3.28	3.56	3.49	3.55
2.	CFB ZEC	2.92	3.02	3.27	3.33	3.37	3.48	3.23	3.79	3.88	3.87	3.95	3.99	3.91	3.90	3.50	3.44	3.52	3.57	3.65	3.49	3.53	3.55
3.	PE 0.01 mm (IFP) Room	2.92	3.02	3.29	3.33	3.37	3.50	3.24	3.79	3.89	3.94	3.97	4.02	3.89	3.92	3.50	3.38	3.83	3.57	3.63	3.47	3.56	3.57
4.	PE 0.01 mm(IFP) ZEC	2.92	3.04	3.46	3.35	3.45	3.50	3.29	3.79	3.95	3.94	3.96	4.04	3.91	3.93	3.50	3.43	3.44	3.46	4.81	3.52	3.69	3.63
5.	PE 0.05 mm (IFP) Room	2.92	3.07	3.27	3.34	3.35	3.52	3.25	3.79	3.89	3.87	3.96	3.99	3.88	3.90	3.50	3.37	3.46	3.55	3.64	3.41	3.19	3.54
6.	PE 0.05 mm (IFP) ZEC	2.92	3.04	3.31	3.33	3.46	3.50	3.26	3.79	3.87	3.91	3.97	4.02	3.95	3.92	3.50	3.45	3.36	3.40	3.41	3.55	3.49	3.54
7.	PE 0.01 mm (1 kg bag) Room	2.92	3.07	3.27	3.33	3.38	3.49	3.24	3.79	3.90	3.96	3.95	4.05	3.90	3.93	3.50	3.42	3.47	3.57	3.46	3.49	3.45	3.55
8.	PE 0.01 mm (1 kg bag) ZEC	2.92	3.02	3.31	3.33	3.38	3.52	3.25	3.79	3.92	3.96	3.96	4.04	3.90	3.93	3.50	3.37	3.45	3.48	3.47	3.39	3.49	3.54
9.	PE 0.05mm (1 kg bag) Room	2.92	3.03	3.30	3.34	3.37	3.47	3.24	3.79	3.89	3.74	3.85	4.04	3.90	3.87	3.50	3.46	3.45	3.41	3.56	3.28	3.44	3.51
10.	PE 0.05 mm (1kg bag) ZEC	2.92	2.98	3.33	3.34	3.46	3.51	3.26	3.79	3.90	3.58	3.49	4.04	3.89	3.78	3.50	3.45	3.35	3.24	3.47	3.11	3.44	3.46
Overall Mean for		2.92	3.03	3.30	3.34	3.40	3.50		3.79	3.90	3.87	3.90	4.06	3.91		3.50	3.43	3.48	3.48	3.64	3.43	3.35	
	Room	2.92	3.03	3.27	3.33	3.37	3.50		3.79	3.89	3.88	3.94	4.08	3.90		3.50	3.43	3.54	3.53	3.51	3.44		
	ZEC	2.92	3.02	3.34	3.34	3.42	3.50		3.79	3.90	3.85	3.87	4.03	3.91		3.50	3.43	3.42	3.43	3.76	3.41		
	Storage	3.40	3.45	3.54	3.57	3.69	3.61																
	Variety	3.24	3.90	3.49																			

CD at 5%

Storage	NS	S x P	NS	CFB	Corrugated fibre board boxes	CD at 5% for Packaging	
Variety	0.17	S x V	NS	IFP	Individual fruit packing	Patharnakh	NS
Packaging	NS	V x P	NS	ZEC	Zero energy chamber	Kashmirinakh	NS
		S x V x P	NS	PE	Polyethylene	Baggugosha	NS
Room	NS			Room	Room temperature		
ZEC	NS						

Possibly, the increase in enzyme invertase activity that is responsible for conversion of acids into sugars might have decreased the acidity content of fruits. Nath *et al.*, (2012) also reported a similar decreasing trend in acidity in pear fruits during storage.

Ascorbic acid

Ascorbic acid content in fruits of all the three pear varieties, irrespective of treatments decreased linearly throughout storage period. Among interactions of storage (S), variety (V) and packaging (P) *viz*., S x P, S x V and V x P were found significant and second order interaction S x V x P was not significant (Table 3). Hence, maximum retention of ascorbic acid in fruits of all the varieties was found in PE 0.01mm of 1 kg bag stored at ZEC (3.31 mg/100g fruit pulp), which was at par with PE 0.05 mm of individual fruit packing. However, Kashmirinakh stored in PE 0.05 mm of 1 kg bag at room temperature showed maximum ascorbic acid content (3.88 mg/100g), which was at par with PE 0.05mm of IFP at ZEC (3.85mg/100 gm) and PE 0.01mm of 1 kg bag both at room temperature and ZEC storage (3.87 and 3.85 mg/100g) while, minimum was in control (3.11 mg/100g).Decrease in ascorbic acid content was observed with advancement in storage period. Similar decreasing trend of ascorbic acid content was reported by Soliva and Martin (2003) in pear. This might be due to enzymatic oxidation of L-ascorbic acid to dehydro-ascorbic acid during metabolic process causing decrease in ascorbic acid levels in fruits. Polyethylene packed fruits showed higher ascorbic acid content in comparison to control treatment which can be due to slower rate of physiological activities in fruits stored in polyethylene, which resulted in lower physiological loss in weight and loss due to transpiration.

Sugar contents

The perusal of result in all varieties indicated that sugar content increased continuously with increasing period of storage irrespective of packaging treatments from minimum to maximum (8.45 to 11.08%) in Patharnakh; 9.87 to 12.06% in Kashmirinakh and 10.20 to 12.62% in Baggugosha on 10th day of storage (Table 4). However, total sugar content of fruits was not affected significantly by packaging treatments in all three varieties. Observation on storage showed total sugars 9.51% in the beginning to maximum of 11.92% at the end of storage, whereas, in case of varieties irrespective of storage and packaging treatments, the minimum sugar was recorded in *Patharnakh* (9.74%) which was significantly lower as compared to Kashmirinakh (10.10%) and Baggugosha (11.40%). The various treatment interactions of storage, variety and packaging were absent. Among various interactions of storage(S), variety (V) and packaging (P) only S x V for reducing sugars was found significant, whereas others effects were not significant (Table 5). Hence on 10th day of storage minimum reducing sugar content was found in variety *Patharnakh* (7.57%) and maximum in Baggugosha (9.19%).Various interactions of storage (S), variety (V) and packaging (P) were found non-significant. However, in varietal comparisons Patharnakh showed minimum (3.24%) and Kashmirinakh recorded maximum (3.90%) non reducing sugars (Table 6). Increase in sugar content might be attributed to conversion of polysaccharide (starch) into monosaccharide (sugars) and due to hydrolysis of starch into sugars reported by Banday (1996) and Mahajan *et al.*, (2004) in pear. Kumar (2009) also mentioned similar increasing trend up to 21 days and Kaur *et al.*, (2013) up to 60 days in pear. Conversion of starch and complex organic compounds into simple soluble sugar might have lead to the increased level of reducing sugars in pear fruits (Barreiro *et al.*, 1995). Sugar content did not vary significantly in fruits under various storage material treatments. Probably that fruits stored in CFB boxes did not ripe properly but attained total sugars level merely by losing weight through respiration and transpiration processes as seen earlier in comparing PE packed fruits, which showed

minimum weight loss but attained that level of total sugars during ripening process.

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