Short communication

Post harvest quality parameters of papaya stored in Zero Energy Cool Chamber under humid tropics

S.G. Lekshmi, C. Mini* and R.V. Manju

College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram 695 522, India

Received 27 May 2020; received in revised form 07 May 2021; accepted 08 May 2021

Abstract

Papaya fruits (CO-1) were stored under Pusa Zero Energy Cool Chamber (PZECC) during June-September, October-February and March-May by maintaining 85-95 per cent relative humidity inside the chamber along with fruits kept under ambient storage conditions as control treatments to assess the feasibility of PZECC as a low cost on-farm storage structure. Fruits stored under PZECC during March-May had highest shelf life (7.22 days) with 100 per cent marketability and good textural parameters. Papaya had least shelf life when stored in PZECC during June-September. Microbial load and majority of the sensory parameters were not influenced by season and storage conditions. Fruits under ambient storage had higher TSS and carotene, whereas storage condition had no influence on acidity and vitamin C content. Though PZECC is a low cost structure which could be constructed at Rs.5000/- per unit, it helped in marginal enhancement of 1.66 days shelf life compared to their corresponding ambient storage, that too only during March-May and October-February, proving that PZECC, designed for Rural North India cannot be recommended as such as an efficient on farm storage structure for papaya under humid tropics.

Key words: Fruit quality, Low cost storage, Papaya, Postharvest Loss, Pusa Zero Energy Cool Chamber.

Kerala, considered a consumer state, imports almost all fruits and vegetables from neighboring states and has achieved great success in increasing the production of fruits and vegetables too. Even then post-harvest loss remains a major threat and this loss is due to lack of several management practices including refrigerated storage. Setting up of cold storages would be ideal to reduce post harvest loss and manage price fluctuation considerably. But setting up of cold storages for horticultural commodities has not gained pace in Kerala and is not easily acceptable to small and marginal farmers, as refrigeration is energy intensive, expensive and not always environment friendly. In the absence of cold storages and related cold chain facilities, the farmers are forced to sell their produce immediately after harvest which results in glut situations and low price realization.

Considering acute energy crisis, a low cost storage facility accessible to the farmers will go a long way in removing the risk of distress sale to ensure better returns. Pusa Zero Energy Cool Chamber (PZECC) is an accepted model of on-farm storage in North India during summer when high temperature and low humidity prevails. It is a low cost double walled storage structure made of bricks, developed at IARI, New Delhi, which operates on the principle of evaporative cooling (Roy and Khurdiya, 1983). If this structure is suited to humid tropics of southern Kerala, it would be a satisfactory option for short term maintenance of horticultural perishables during glut period, reducing the wastage and thus providing remunerative prices to the growers. As papaya is one of the fruits having highest percentage of post harvest loss, an experiment was conducted at College of Agriculture, Vellayani during 2018-19

*Author for correspondences : Phone: 9447281300, Email: minichandran123@gmail.com

Plate 1. Construction of ZECC

to assess the feasibility of Pusa Zero Energy Cool chamber for storage of papaya under humid tropical climate of southern Kerala by evaluating the fruit quality parameters.

A leveled land with good air circulation and sunlight having a nearby source of water supply was selected for construction of Pusa zero energy cool chamber (PZECC) of 165cm length, 115 cm breadth and 75 cm height with a thatched roof (Roy and Khurdia,1983) (Plate 1). After construction, structure was drenched twice a day during morning and evening hours so as to maintain 85-95% RH and this was continued throughout the period of study.

Good quality fruits of papaya var. CO-1 were harvested at 125 - 140 days from flowering when they were at ½ to ¾ yellow stage. The harvested fruits were kept in perforated plastic crates and subjected to storage studies during three different seasons viz., June-September (S_1) , October-February (S_2) and March-May (S_3) under two different conditions viz., inside ZECC (Z_0) and ambient storage (Z_1). The six treatments were replicated thrice in Completely Randomized Design and two to three fruits weighing two to three kg were maintained per replication.

Observations were recorded on physiological parameters such as shelf life, physiological loss in weight, chemical parameters viz., TSS and titratable acidity (Ranganna, 1986), nutritional parameters viz., total carotene and vitamin C (Sadasivam and Manickam, 1992), microbial load (Somashegaran and Hoben, 1985) and sensory parameters (Amerine et al., 1965) of stored papaya fruits at regular intervals till the end of shelf life so as to assess the possibility of storage of papaya fruits in ZECC. A one to nine rating scale with 1 = unusable; 3= unsalable; 5= good; 7= very good; and 9= excellent was used to evaluate the marketability. The quality attributes were determined by the sensory panellists by observing level of decay, colour, firmness, shrivelling and surface defects as visual parameters. The number of fruits receiving a rating of 5 and above was considered marketable, while those rated less than 5 were considered unmarketable and marketability was calculated in percentage (Mohammed et al., 1999). Fruit firmness and bio yield point of the stored fruits were measured in Newton (N) by generating force deformation curves using a Texture Analyser TA. HD Plus (Stable Microsystems, UK) using the compression mode test. The machine was calibrated using the test conditions as 1mm/sec pre-test, 2mm/sec test speed, 10mm/sec post-test speed, 15 mm distance, 200 pps data acquisition rate and 0.049 N trigger force. The penetration test was carried out using 2mm (P/2) dia cylinder and the pressure required to cause 5 mm deformation was measured thrice on each fruit. Temperature (^{o}C) and relative humidity (%) inside the PZECC and weather data were recorded during the period of study. The data generated from the experiment were statistically analysed using Completely Randomised Design. The sensory scores were statistically analysed using Kruskall-Wallis test (Chi- Square value).

PZECC is a low cost on-farm storage structure which could be constructed at a cost of Rs.5000/- per unit. During the storage period, the average ambient temperature varied between 28.01°C during June-September and 31.04°C during March-May, whereas the temperature inside evaporative cooler varied between 17.20°C during June-September and 23.77°C during March-May. Average relative humidity ranged between 70.59% during March-May and 83.51% during June-September under ambient conditions, whereas it was between 90.70% in PZECC during March-May and 98.23% during June-September.

The fruits stored under PZECC during S_1 (June-September) were discarded after 4th day of storage and hence comparison was made on 6th day after storage between the treatments other than those stored under PZECC during S_1.

Physiological quality parameters

Shelf life, physiological loss in weight and marketability are the three physiological parameters deciding quality of a perishable commodity. Papaya fruits stored under PZECC in S_3 (March-May) had highest (6.39 days) shelf which was on par with fruits stored in S_2 (October- February) (6.33 days). Fruits stored in S_1 (June-September) had least (5.40 days) shelf life. When interaction effects were considered, shelf life of papaya fruits stored under PZECC during March- May (S_3) had highest (7.22 days) shelf life which was on par with the fruits kept under the same condition during S_2 (October-February) (7.11 days) (Fig 1.). These observations are in accordance with the observations of Dadhich et al. (2008) who had reported seven days shelf life of papaya stored under ZECC as compared to 3 days

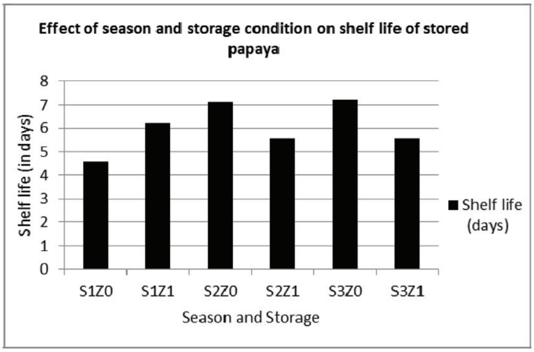

Figure 1. Effect of season and storage condition on shelf life of stored papaya

when stored in ambient condition in an experiment conducted in IIT, Delhi. Azene et al. (2014) reported that the evaporative cold storage improved the shelf life of papaya fruits by more than two fold in Ethiopia. Maintenance of a high relative humidity inside the chamber when outside RH was low, helped to retain turgidity in stored papaya by lowering the water loss, thereby resulting in enhanced shelf life. Evaporative cooling helped in reducing temperature and increasing the relative humidity of an enclosure, and has been extensively tried for enhancing the shelf life of horticultural produce (Jha and Chopra, 2006; Odesola and Onyebuchi, 2009) and was helpful in maintaining the freshness of the commodities (Dadhich et al., 2008). The evaporative cool storage structure was proved to be efficient and economical means for short term, on-farm storage of fruits and vegetables in hot and dry regions. But under tropical humid climatic condition, only marginal increase in shelf life could be obtained in the present study, that too only during March-May and October-February period. The papaya fruits stored in PZECC during S_1 (June-September) had least (4.56 days) shelf life. During rainy season, relative humidity could not be maintained in the prescribed range of 85-95 per cent and was in the high range of 98.2 to 98.3 per cent; high RH together with the very low temperature inside the PZECC resulted in rotting and rapid spoilage of the commodity compared to ambient storage.

Physiological loss in weight

Papaya fruits kept under PZECC had less physiological loss in weight (0.99%) than those kept under ambient storage condition (2.01%) (Table 1). Fruits stored during S_2 (October-February) had least physiological loss in weight (1.26%) which was on par with S_1 (June- September). Fruits stored during S_3 (March-May) had highest physiological loss in weight (1.82%). Physiological loss in weight increased from 1.41% on 2nd day after storage to 1.58% on 4th day after storage. Interaction had no significant effect on physiological loss in weight of papaya. Papaya fruits stored in PZECC during S_2 (October-February) had least physiological loss in weight (0.72%) on 6th day after storage and fruits stored under ambient storage condition during S_2 (October-February) had the highest (2.16%) physiological loss in weight. Azene et al. (2014) reported that weight loss of papaya fruits progressively increased during the storage period both under the evaporative cooler and ambient storage conditions and highest weight loss was recorded for papaya fruits stored under ambient conditions.

Marketability

Papaya fruits stored under PZECC had higher marketability (96.30%) than those stored under ambient storage condition (Table 1). There was no significant effect of seasons on marketability of papaya fruits. Marketability decreased from 100 per cent on the day of storage to 81.48 per cent on 4th day after storage. Interaction effect of seasons and storage condition on marketability of papaya showed that fruits kept under PZECC during S_3 (March-May) and S_2 (October-February) had highest marketability (100%) which were on par with those stored under ambient storage condition during S_1 (June-September) (96.30%). Fruits stored under ambient storage condition during S_2 (October-February) had least marketability (85.19%).

Papaya fruits stored under PZECC during S_3

Table 1. Effect of season and storage condition on physiological loss in weight and marketability of stored papaya.

Treatments	Physiological loss in weight (%)				Marketability (%)				
	Days after storage		Treatment mean	6th day after storage	Days after storage			Treatment mean	6th day after storage
	2nd day	4th day			0th day	2nd day	4th day		
S_1Z_0	0.89	0.93	0.91	-	100	100	66.67	88.89	-
S_1Z_1	2.06	1.76	1.91	0.88	100	100	88.89	96.30	55.56
S_2Z_0	0.89	0.87	0.88	0.72	100	100	100	100	22.22
S_2Z_1	1.60	1.70	1.65	2.16	100	100	55.55	85.19	0
S_3Z_0	0.93	1.40	1.17	1.04	100	100	100	100	66.67
S_3Z_1	2.11	2.84	2.48	1.04	100	100	77.78	92.59	22.22
Days mean	1.41	1.58			100	100	81.48		
Mean	S_1- 1.41	S_2- 1.26	S_3- 1.82		S_1- 92.59	S_2- 92.59	S_3- 96.29		
		Z_0- 0.99	Z_1- 2.01		Z_0 -96.30		Z_1- 91.40		
CD (0.05)	D-NS	S-0.25	Z- 0.20	0.51	D-5.31	S-NS	Z-4.34		38.85
	S × Z-NS		D × S × Z- NS		S × Z-7.51		D × S × Z- 13.014		

(March-May) had highest marketability (66.67%) which was on par with those stored under ambient condition during S_1 (June-September) (55.56%) on 6th day after storage. Similar results were reported for mango by Workneh and Woldetsadik (2004) and Tefera et al.(2007), and for tomato by Hirut et al. (2008).

Physical quality parameters

Textural parameter - Flesh firmness & Bio-yield point

Texture measured in terms of bio-yield point and flesh firmness is a major quality parameter influencing marketability and acceptability of any horticultural produce. Effect of season, storage conditions and their interaction on flesh firmness of stored papaya fruits is shown in Table 2. Papaya fruits stored under the PZECC had higher flesh firmness (410.11 N) than those stored under ambient conditions. Texture of papaya fruits in terms of flesh firmness was highest (456.71 N) for those stored during S_3 (March-May) and was on par with those stored during S1 (444.29 N). Papaya fruits stored during S_2 had the lowest flesh firmness (180.36 N). The flesh firmness decreased with the days after storage and it ranged from 492.89 N on the day of storage to 104.57 N on 4th day after storage.

When the interaction effect of seasons and storage conditions were considered, the papaya fruits stored under PZECC during S_3 (March-May) had the highest flesh firmness (550.68 N) which was on par with those stored under ambient condition during S_1 (June-September) (468.06 N). The fruits stored under ambient condition during S_2 (October-February) had the minimum (101.58 N) flesh firmness. Fruits stored under PZECC during S_2 (October-February) had the highest (77.73 N) firmness on 6th day after storage, and was on par with fruits stored under ambient condition during S_2 (October-February) (75.99 N).

The point at which the appropriate probe of a texture analyser punctures through the fruit skin and begins to penetrate into the fruit flesh, is called "bio-yield point" and it causes an irreversible damage. As the fruits become firmer the force required to puncture through the skin is more, resulting in higher bio-yield point. Correlation between bio-yield and fruit firmness has been reported earlier (Lu et al., 2005). Papaya fruits stored under PZECC had higher bio-yield point (1267.93 N) compared to the fruits stored under ambient condition (1153.80 N) (Table 2). Bio-yield point of papaya fruits stored in S_3 (March-May) was highest (1488.58 N) and was significantly different from fruits stored in other two seasons. The papaya fruits stored during S_1 (June-September) had the lowest bio-yield point (1069.58 N).

Considering the interaction effect of seasons and storage conditions, the papaya fruits stored under PZECC during S_3 (March-May) had highest bio-

Table 2. Effect of season and storage condition on textural parameters of stored papaya.

Treatments	Textural parameters									
	Flesh firmness (N)					Bio-yield point (N)				
	Days after storage (DAS)			Treatment mean	6thDAS	Days after storage (DAS)			Treatment mean	6th day after storage
	0th day	2nd day	4th day			0th day	2nd day	4th day		
S_1Z_0	650.21	594.59	16.77	420.52	-	1453.43	1385.19	58.25	965.63	-
S_1Z_1	757.76	563.02	83.40	468.06	50.63	1411.41	1508.36	600.84	1173.54	409.86
S_2Z_0	297.03	350.55	129.83	259.14	77.73	1199.28	1128.54	959.70	1095.84	939.97
S_2Z_1	128.83	66.27	109.65	101.58	75.99	1147.60	1186.71	824.71	1053.01	668.62
S_3Z_0	690.87	733.83	227.34	550.68	15.00	1953.17	1883.16	1390.60	1742.31	421.51
S_3Z_1	432.63	595.12	60.45	362.74	24.42	1660.47	1469.90	574.20	1234.86	474.35
Days mean	492.89	483.90	104.57			1470.89	1426.98	734.72		
Mean	S_1- 444.29	S_2- 180.36	S_3- 456.71			S_1- 1069.58	S_2- 1074.43		S_3- 1488.58	
	Z_0-410.11		Z_1- 310.79			Z_0- 1267.93			Z_1- 1153.80	
CD (0.05)	D-62.23	S-62.23	Z- 50.81		19.10	D-59.77	S-59.77		Z-48.81	156.20
	S × Z- 88.01		D × S × Z- NS			S × Z-84.5			D × S × Z-146.42	

yield point (1742.31 N) which was significantly different from all other treatments. The papaya fruits stored under the same condition during S_1 (June-September) had the lowest bio-yield point (965.63 N).

Bio-yield point recorded on 6th day after storage revealed that the papaya fruits stored under PZECC during S_2 (October-February) had the highest (939.97 N) bio-yield point and fruits stored in ambient condition during S_1, June-September had the lowest (409.86 N).

In general textural parameters measured in terms of flesh firmness and bio-yield point were good for papaya kept in PZECC during S_3 (March-May). This was in accordance with the findings of Ramakrishnan and Godara (1993) who had reported better fruit firmness in ber fruits stored under ZECC.

Chemical quality parameters

Total soluble solids

Papaya fruits stored under ambient condition had higher total soluble solids (13.85^{o}B) than those stored under PZECC (13.06^{o}B) (Table 3.). The low TSS could be attributed to the lower temperature and higher humidity resulting in slower rate of respiration rate and ripening. Azene et al. (2014) reported that packaging and cooling maintained the chemical quality of papaya fruits better than the control sample fruits towards the end of storage periods. Increase in TSS under ambient storage might be due to physiological loss in weight that increased the concentration of juice.

Total soluble solids of papaya fruits stored during S_3 (March-May) was highest (13.93^{o}B) and was significantly different from those stored during the other two seasons. The fruits stored during S_1 (June-September) had lowest (13.09^{o}B) total soluble solid content.

When the interaction effect of season and storage condition were considered, it was seen that the fruits stored under ambient condition during S_3 (March-May) had the highest total soluble solids (14.78^{o}B) which was on par with those stored under same condition during S_1 (June-September) (14.07^{0}B) and those stored under PZECC during S_2 (October-February) (14.00^{0}B). Papaya fruits stored under PZECC during S_1 (June-September) had lowest (12.11^{0}B) total soluble solids.

Papaya fruits stored in PZECC during S_2 (October-February) had maximum TSS (20.33^{0}B) on 6th day after storage, which was on par with those stored under ambient condition during S_3, March-May (19.37^{o}B).

Acidity

Storage condition had no significant effect on acidity of papaya fruits (Table 3). When considering the individual effect of seasons, papaya fruits stored during S_3 (March-May) had the least acidity (0.15%)

Table 3. Effect of season and storage condition on TSS and acidity of stored papaya.

Treatments	Total soluble solids (^{0}B)					Titrable acidity (%)				
	Days after storage (DAS)			Treatment mean	6thDAS	Days after storage (DAS)			Treatment mean	6th DAS
	0th day	2nd day	4th day			0th day	2nd day	4th day		
S_1Z_0	9.47	12.27	14.60	12.11	-	0.09	0.12	0.18	0.13	-
S_1Z_1	10.03	15.07	17.10	14.07	18.63	0.21	0.25	0.30	0.25	0.29
S_2Z_0	10.27	13.87	17.87	14.00	20.33	0.13	0.19	0.25	0.19	0.29
S_2Z_1	10.03	11.90	16.17	12.70	18.50	0.09	0.16	0.18	0.14	0.23
S_3Z_0	10.77	12.57	15.90	13.08	18.50	0.11	0.14	0.21	0.15	0.23
S_3Z_1	10.87	15.73	17.73	14.78	19.37	0.07	0.18	0.18	0.14	0.23
Days mean	10.24	13.57	16.56			0.12	0.17	0.22		
Mean	S_1- 13.09	S_2- 13.35	S_3-13.93			S_1- 0.19	S_2- 0.17	S_3-0.15		
	Z_0- 13.06		Z_1- 13.85			Z_0-0.16		Z_1- 0.18		
CD (0.05)	D-0.56	S-0.56	Z-0.46		0.856	D-0.03	S-0.03	Z-NS		NS
	S × Z-0.79		D × S × Z-1.37			S × Z-0.04	D × S × Z- NS			

which was on par with those stored during S_2 (October-February) (0.17%). Papaya fruits stored during S_1 (June-September) had maximum acidity (0.19 %).

While considering the interaction effect of storage condition and seasons on acidity, papaya fruits stored under PZECC during S_1 (June-September) had least acidity (0.13%) and was on par with those stored under ambient condition during S_3 (March-May) and S_2 (October – February) (0.14%) and under PZECC during S_3 (March-May) (0.15%). The papaya fruits stored under ambient condition during S_1 (June-September) had maximum acidity (0.25%) Papaya fruits stored in PZECC during S_2 (October-February) and those stored under ambient during S_1 (June-September) had highest (0.29%) acidity on 6^{th} day after storage. All other treatments had 0.23% acidity. Slow respiration as well as transpiration rate might contribute to higher retention of water in fruits and therefore, the concentration effect caused by water loss might be reflected on acidity values of fruits (Wills and Widjanarko, 1995).

Nutritional quality parameters

Total carotene

Papaya fruits stored under ambient condition had greater (0.77 mg/100g) total carotene content than those stored under PZECC (0.65 mg/100g) (Table 4.). Papaya fruits stored during S_1 (June-September) had the highest total carotene content (0.77 mg/100g) and was on par with those stored during S_3 (March-May) (0.74 mg/100g). Papaya fruits stored during S_2 (October-February) had the least total carotene content (0.62 mg/100g).

While considering interaction effect of seasons and storage conditions on total carotene content, the papaya fruits stored under ambient condition during S_3 (March-May) had the highest total carotene content (0.94 mg/100g) and was on par with those stored under PZECC during S_1 (June-September) (0.89 mg/100g). The papaya fruits stored under PZECC during S_2 (October-February) had the lowest total carotene content (0.53 mg/100g) and was on par with the fruits stored under PZECC during S_3 (March-May) (0.54 mg/100g).

Papaya fruits stored under ambient condition during S_2 (October-February) had maximum (1.50 mg/100g) total carotene on 6^{th} day after storage which was on par with all other conditions except those stored under PZECC during S_3 (March-May) In another study, quality in terms of retention of â-carotene, ascorbic acid and chlorophyll was equivalent in both the storage conditions (Negi and Roy, 2004).

Vitamin C

Storage condition had no significant effect on vitamin C content of papaya fruits. (Table 4). Papaya fruits stored during S_2 (October-February) had highest vitamin C content (58.81 mg/100g) and

Table 4. Effect of season and storage condition on nutritional quality parameters of stored papaya.

Treatments	Total carotene (mg.100g^{-1})					Vitamin C (mg.100 g^{-1})				
	Days after storage (DAS)			Treatment mean	6thDAS	Days after storage (DAS)			Treatment mean	6th DAS
	0th day	2nd day	4th day			0th day	2nd day	4th day		
S_1Z_0	0.20	1.11	1.34	0.89	-	50.48	52.86	55.24	52.86	-
S_1Z_1	0.21	0.85	0.93	0.66	1.33	50.95	52.86	55.71	53.18	57.62
S_2Z_0	0.26	0.45	0.90	0.53	1.22	58.09	58.57	58.57	58.41	60.00
S_2Z_1	0.25	0.52	1.35	0.70	1.50	55.71	60.00	61.90	59.21	63.81
S_3Z_0	0.28	0.38	0.94	0.54	1.10	54.76	57.14	58.57	56.82	60.95
S_3Z_1	0.26	1.23	1.32	0.94	1.44	55.71	57.62	60.48	57.94	
Days mean	0.24	0.76	1.13			54.28	56.51	58.41		
Mean		S_1- 0.77	S_2- 0.62	S_3-0.74			S_1- 53.02	S_2- 58.81	S_3- 57.38	
		Z_0- 0.65		Z_1- 0.77			Z_0 -56.03		Z_1- 56.77	
CD (0.05)	D-0.04	S-0.04	Z-0.0		0.29	D- 1.24		S-1.24	Z- NS	2.64
	S × Z-0.06		D × S × Z- 0.11			S × Z- NS			D × S × Z- NS	

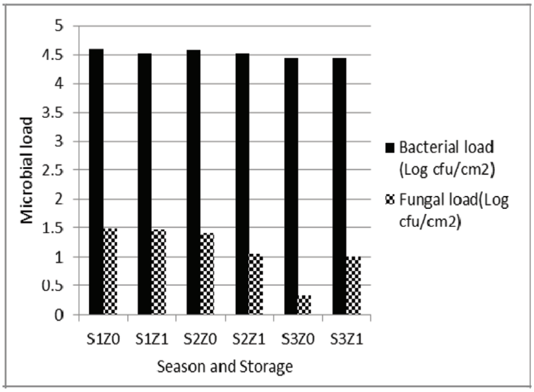

Figure 2. Effect of season and storage condition on microbial load of stored papaya

those stored during S_1 (June-September) had the least vitamin C content (53.02 mg/100g). There was no interaction effect for seasons and storage condition on Vitamin C content of papaya fruits. Papaya fruits stored under ambient condition during S_2 (October-February) had maximum (63.81mg/100g) total carotene on 6th day after storage. Similar result was obtained by Azene et al. (2014), wherein fruits stored in the evaporative cooler had higher ascorbic acid content than those stored under ambient conditions.

Microbial load

Interaction effect of season and storage conditions had no significant effect on bacterial and fungal load of papaya fruits (Fig 2). However the fungal load was least (0.33 log cfu/cm^2) for fruits kept in PZECC during S_3 (March-May). Pareek et al., 2009 reported that microflora of ber fruits could be reduced by storing in PZECC, whereas Balogun et al. (2020) reported increased microbial load of mango stored in Evaporative Coolers. The difference in microbial growth observed in the present study might be due to several factors like quality of the raw material selected, pre harvest factors adopted, prevailing atmospheric conditions etc.

Table 5. Effect of season and storage condition on organoleptic quality parameters of stored papaya.

Treatments	Appearance (mean score)			Colour (mean score)		
	0th day	2nd day	4th day	0th day	2nd day	4th day
S_1Z_0	5.3	6	3.9	4.8	5.4	6.3
S_1Z_1	5.6	6.5	7.3	5.1	6	6.4
S_2Z_0	5.6	6.1	7.3	6.1	7.3	7.1
S_2Z_1	5	5.9	4.7	6.2	5.7	6.7
S_3Z_0	6	6.7	7.2	6	7.3	6.5
S_3Z_1	6.4	7.3	5.7	6.3	6.7	6.6
k value	16.04	15.94	38.54	15.69	22.53	5.30
Treatments	Texture (mean score)			Taste (mean score)		
	0th day	2nd day	4th day	0th day	2nd day	4th day
S_1Z_0	5.4	5.3	5.1	4.5	5	4.5
S_1Z_1	6	5.7	5.4	4.9	5.3	4.7
S_2Z_0	5.9	4.8	5.4	5.2	5.3	5.1
S_2Z_1	5.6	5.7	6	5.2	5.1	4.9
S_3Z_0	6.6	6.4	6.2	5.6	5.9	5.1
S_3Z_1	6.5	6.4	4.9	5.4	5.7	5.1
k value	9.4	10.34	10.22	9.8	7.19	3.9
Treatments	Flavour (mean score)			Overall acceptability (mean score)		
	0th day	2nd day	4th day	0th day	2nd day	4th day
S_1Z_0	4.1	5.3	5	4.7	5.6	5
S_1Z_1	4.2	5.4	4.9	4.9	5.7	5.2
S_2Z_0	4.7	5.3	5.1	5.3	5.8	5.1
S_2Z_1	4.9	4.9	4.9	5.1	5.4	5.5
S_3Z_0	5.1	5.5	5.2	5.1	6.5	5.9
S_3Z_1	5	5.6	5.2	5	5.6	5.3
k value	8.32	4.30	1.70	3.66	5.64	4.02
x^2				11.07		

Sensory quality parameters

Sensory parameters have a key influence on how consumers perceive the quality of a product and on consumers' preferences. Appearance and colour of papaya fruits were significantly affected by treatments (Table 5). Mean organoleptic scores for appearance and colour were higher for papaya fruits stored under PZECC during S_2 (October-February) whereas texture, taste, and flavour of papaya fruits were not affected by the treatments.

PZECC is a low cost on-farm storage structure which could be constructed at a cost of Rs.5000/- per unit. However, the structure helped in marginal enhancement in shelf life of papaya fruit only during March-May and October-February. The fruits were fresh, firm and turgid in acceptable form when stored in PZECC .The structure was not at all suitable during the rainy season (June-September) and the fruits in rainy season had better physiological parameters and shelf life under ambient condition compared to storage under PZECC. The result of the present study showed that the PZECC, designed for the Rural North India cannot be recommended as such as an efficient on-farm storage structure for papaya fruits in Kerala. It has to be suitably modified for tropical humid climate and proper post harvest management practices have to be adopted so that it would be a better option for temporary storage of commodities awaiting marketing and short term maintenance of quality horticultural perishables.

References

Amerine, M. A., Pangborn, R. M. and Roessler, E. B. 1965. Principles of Sensory Evaluation of Food. Academic Press, New York/London.

Azene, M., Workneh, T. S. and Woldetsadik, K. 2014. Effect of packaging materials and storage environment on postharvest quality of papaya fruit. J. Food Sci. Technol., 51(6):1041-1055.

Balogun, A.A., Ariahu, C.C. and Alakali, J.S. 2020. Quality evaluation of mango stored in evaporative coolers. Curr. J. Appl. Sci. Technol., 39 (6). 1-10

Dadhich, S. M., Dadhich, H. and Verma, R. 2008. Comparative study on storage of fruits and vegetables in evaporative cool chamber and in ambient. Int. J. Food Eng., 4(1): 13.

Hirut, B.G., Workneh, T. and Woldetsadik, K. 2008. The effect of cultivar, maturity stage and storage environment on quality of tomatoes. J. Food Eng., 87(4): 467-478.

Jha, S. N. and Chopra, S. 2006. Selection of bricks and cooling pad for construction of evaporatively cooled storage structure. Inst. Eng. (I)(AG), 87: 25-28.

Lu, R., Srivastava, A.K. and Beaudry, R. 2005. A new bioyield tester for measuring apple fruit firmness. Appl. Eng. Agric., 21(5). 893-900.

Mohammed, M., Wilson, L. A., and Gomes, P. L. 1999. Postharvest sensory and physiochemical attributes of processing and non-processing tomato cultivar. J. Food Qual., 9(22):167-182.

Negi, P. S. and Roy, S. K., 2004. Changes in â-carotene and ascorbic acid content of fresh amaranth and fenugreek leaves during storage by low cost technique. Plant Foods Hum. Nutr., 58(3): 225-230.

Odesola, I. F. and Onyebuchi, O. 2009. A review of porous evaporative cooling for the preservation of fruits and vegetables. Pac. J. Sci. Technol., 10(2): 935- 941.

Pareek, S., Kitinoja, L., Kaushik, R.A., and Paliwal, R., 2009. Postharvest physiology and storage of ber. Stewart Postharvest Rev., 5(5): 1-10.

Ramakrishan, N. R. G. and Godara, R. K., 1993. Physical and chemical parameters as affected by various storage conditions during-storage of Gola ber (*Zizyphus mauritiana* L.) fruits. Prog. Hortic., 25(1): 60-72

Ranganna, S. 1986. Handbook of Analysis and Quality Control for Fruit And Vegetable Products. Tata McGraw-Hill Education, New Delhi, 1103p.

Roy, S. K. and Khurdiya, D. 1983. Zero energy cool chamber for storage of horticultural produce. Science in Service of Agriculture. Indian Agricultural Research Institute, New Delhi, 93p.

Sadasivam, S. and Manikam, A. 1992. Biochemical Methods for Agricultural Sciences. Wiley Eastern Limited and Tamil Nadu Agricultural University Publication, Coimbatore. 246p.

Somashegaran. P. and Hoben, J.H. 1985. Methods in Legume-Rhizhobium Technology. Handbook for Rhizobia. Springer-Verlag Publishers, Netherlands. 450 p.

Tefera, A., Seyoum, T. and Woldetsadik, K., 2007. Effect of disinfection, packaging, and storage environment on the shelf life of mango. Biosystems Eng., 96(2):

201-212.

Wills, R.B.H. and Widjanarko, S.B. 1995. Changes in physiology, composition and sensory characteristics of Australian papaya during ripening. Aust. J. Exp. Agric., 35:1173–1176.

Workneh, T. S. and Woldetsadik, K., 2004. Forced ventilation evaporative cooling: a case study on banana, papaya, orange, mandarin, and lemon. J. Trop. Agric., 81(3):179-185.