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A Study on Cost Effective and Eco Friendly Earthen Pot Cool Chamber (EPCC-2) System for Rural Population to Store Post Harvest Vegetables

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Present investigation was performed to assess the effect of storage of fruits and vegetables in eco-friendly earthen pot cool chamber (EPCC-2) for the purpose of house hold storages. Fruits and vegetables were stored in (EPCC-2) to find out the physiological loss in weight (PLW), heterotrophic microbial population, biochemical characteristics, organoleptic changes and shelf –life period. The results were compared with ambient and refrigerator storages. It was observed that the vegetables stored in earthen pot cool chamber remained fresh with a minimum changes in physiological weight loss, microbial load, organoleptic values and biochemical characteristics. EPCC-2 showed a higher degree of consumer preferences when compared with other two storage systems.

Key words: Post harvest, Earthen Pot Cool Chamber, Organoleptic Values, Physiological Weight Loss, Fruits and Vegetables Storage, Nutritive Value.

The world wide agricultural practices have been improved due to the results of high yielding varieties, irrigation facilities and modern technologies, but the worldwide post-harvest fruit and vegetables losses are as high as 30 to 40% and even much higher in some developing countries due to improper post harvest processing and handling[1]. The excellent quality of fruits and vegetables are generally available only for few days and it cannot be stored for long period under the ambient condition, because most of the agricultural products are perishable and harvested in summer time. In harsh dry climates, food preservation plays a vital role in maximizing both economic and nutritional yield from the rare opportunity of a good harvest. The dry heat significantly reduces the life of produce and the fruits and vegetables are spoiled in enormous amount[2]. Also, Fruit and vegetables are highly susceptible to microbial contamination during growth, harvest and postharvest operations[3]. There is more than 15% of postharvest decay of fruits and vegetables are due

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to the action of bacteria, fungal and mold, which in turn affects the quality of fruits and vegetables during storage[4]. Despite high market demand after production, 20 to 50% of commodities are lost before reaching consumers due to a shortage of cooling facilities[5]. These reports indicated that the producers have to suffer huge economic losses due to lack of proper preservation methods. Hence, the reduction of post harvest losses could enhance trade and distribution, and increase the farmer's income.

Fresh produces can play an important role in satisfying the demand of the customers, by providing high nutrition, good flavor and attractive color. There are several factors influencing the storage of fruits and vegetables including physical, physiological, mechanical, hygienic conditions, pathological and environmental factors such as temperature, relative humidity and oxygen balance. This is due to inadequate storage facilities. At present many chemical and mechanical refrigeration methods are widely used to reduce the post harvest losses. But most of these devices are not eco-friendly, high cost, and needs electricity. More over these kinds of storage will cause pollution. Hence, ground-breaking and low cost technology must be needed.

Traditional processing technologies are generally effective in storing fruits and vegetables by providing high nutrition, good flavor, and attractive color[6]. There are more work have been done in the field of zero energy cool chambers[7,8,9,10,11,12,13,14,15].The main aim of our study is to create and maintaining low temperature, high relative humidity storage facilities by natural means, because most tropical produces should be stored at 20-25^0 C and 85 - 95% of relative humidity. Currently only few house hold cooling storage chambers have been designed and used[15,16]. These chambers were made by traditional pottery making procedure and used for storing the harvested fruits and vegetables fresh for a reasonable time. However the cool chambers used by earlier workers have some demerits like needs two vessels (inner and outer), plenty of water and sand for cooling purposes, leakage of water into the inner vessel, (it leads to enhance more fungal growth) and very difficult to transfer from one place to another. Beside, all storage cool chambers do not have the routinely free air circulation facilities i.e. cool chain management. Uneven cooling will cause inconsistent product quality within the storage chamber. The cool chain management is essential for removing respiratory heat produced by the stored fruits and vegetables. The removal of respiratory heat is necessary, because it increases the product temperature and surrounding air temperature, which in turn is responsible for increasing respiration and causes acceleration of substrate utilization, predominantly sugars[17,18]. So cool chain management ensuring retains the quality, safety and extends shelf life of fruits and vegetables. Chain Cool method is usually 75-90% faster than room cooling. Due to high cost and high consumption of power supplies, make it impossible maintaining the cold chain management in poor countries. To overcome above mentioned problems, in the present investigation two feet height and 25 cm width EPCC-2 was designed and analyzed for house hold storage purposes.

The outcome of the present study was aimed to help the rural population by providing them with low cost, easily handling storage facilities to store the fruits and vegetables fresh up to 9 days. This cooling device can store 7-8 kg of vegetables and the total cost of this cooling system is less than Rs 400 only, which is affordable to the poors.

MATERIALS AND METHODS

Experimental Design

The EPCC-2 consist of two water jackets (5 and 3.5 cm diameter each) one behind another at 1 feet interval for water storage (Figs.1- 2). Three numbers of holes (2cm diameter each) present at bottom and lid of the pot for free air circulation inside the pot. The pot system was standing on 2 feet height earthen pot stand. After the whole system was immersed in the water for 30 minutes, 1 lit of water was poured into the jackets and allowed the system for 2 to 3 hrs for cooling the water by evaporative principle method. After that 87- 92% of relative humidity and 4-5^o C less than room temperature was calculated inside EPCC-2.

Working principle of EPCC-2

Generally, pot is made of a porous clay material. When pot is fed with water; by evaporative principle method the water evaporates into the air raising its humidity and at the same time reducing

Table 1. Table showing evaluation scale for organoleptic qualities.

Scale	Skin color Appearance	Flavour	Texture	Taste & Odour	Overall quality expected
10	Very Attractive	Excellent	Very hard	Excellent	Excellent
08	Attractive	Very acceptable	Hard	Quiet acceptable	Quiet acceptable
06	Good	Good	Soft	Good	Good
04	Fair in Appearance	Poor	Very soft	Fair	Fair
02	Poor	Poor	Too Soft	Poor	Poor

Table 2. Changes in the total weight of different products after storage in different storage system for nine days

S. No.	Nature of the Storage	Samples	Weight changes (gms) during storage intervals (Days) loss(Percentage)					Final Weight
			1st day	3rd Day	5th Day	7th Day	9th Day	
1.	Room Temperature	Carrot	123±2	122.5±2	119.3±2	115.5±1	103±2	15.57
		Ladies finger	49.36±2	45.79±2	41.94±2.5	37.30±2	35.58±3	27.91
		Banana	78.08±3	73.47±2	67.19±1	61.04±2	56.02±1	28.24
2.	Refrigerator storage	Carrot	130±2	130±2	125±3	120±2	118±1	9.23
		Ladies finger	46.59±1	46.39±2	45.52±2	44.74±2	42.84±1	8.04
		Banana	85.13±2	84.38±2	82.07±2	78.91±3	75.59±2	11.19
3.	EPCC2	Carrot	137±3	135.6±1	132.9±2	130.5±2	128±0.8	6.50
		Ladies finger	41.3±2	41±2	40.9±1	40±2	39.6±2	4.11
		Banana	79±1	78±1	77.7±1	76±1	74±1	7.59

Table 3. Total heterotrophic bacterial load in the stored products during different storage periods

S. No.	Nature of storage	Sample	Total heterotrophic bacterial population after different storage duration ($_x 10^5$ cfu/ g)				
			1st day	3rd day	5th day	7th day	9th day
1.	Room Temperature	Carrot	30	61	210	TNTC	TNTC
		Ladies finger	32	56	196	TNTC	TNTC
		Banana	16	53	103	190	TNTC
2	Refrigerator storage	Carrot	4	22	50	63	137
		Ladies finger	2.0	12	20	65	185
		Banana	13	20	39	50	70
3	EPCC2	Carrot	13	24	73	90	120
		Ladies finger	20	35	70	85	97
		Banana	8	24	43	51	80

TNTC – Too Numerable Too Count

Table 4. Total fungal colonies in the stored products during different storage periods

S. No.	Nature of storage	Sample	Total heterotrophic fungal population in different periods days($_x10^5$ cfu/ g)				
			1st day	3rd day	5th day	7th day	9th day
1.	Room Temperature	Carrot	12	48	187	TNTC	TNTC
		Ladies finger	16	42	234	TNTC	TNTC
		Banana	9	27	80	272	TNTC
2	Refrigerator storage	Carrot	16	30	47	74	98
		Ladies finger	2	22	50	67	82
		Banana	-	7	22	33	60
3	EPCC2	Carrot	4	9	12	18	38
		Ladies finger	8	13	23	42	46
		Banana	2	7	10	14	23

TNTC – Too Numerable Too Count

Table 5. Changes in the carbohydrate content in the stored products during the different storage periods (percentage loss is given in parenthesis)

S. No.	Nature of storage	Sample	Carbohydrate content (mg/1g)				
			1st day	3rd day	5th day	7th day	9th day
1.	Room Temperature	Carrot	102±4	99±4 (2.94)	97±3 (4.90)	93±3 (8.82)	86±4 (15.68)
		Ladies finger	79.0±3	76.1±3 (3.67)	65.3±2 (17.34)	64.2±3 (18.73)	60.2±3 (23.79)
		Banana	402±0.6	390±0.4 (2.98)	379±.6 (5.72)	368±0.8 (8.45)	359±0.5 (10.69)
2	Refrigerator storage	Carrot	102±4	99±4 (2.94)	95±2 (6.86)	91±3 (10.78)	88±3 (13.72)
		Ladies finger	79.0±3	78.3±2 (0.88)	76.8±3 (2.78)	75.3±2 (4..68)	73.1±2 (7.46)
		Banana	402±0.6	390±0.8 (2.98)	378±0.5 (5.97)	370±0.8 (7.96)	363±0.7 (9.70)
3	EPCC2	Carrot	102±4	100±3 (1.96)	98±4 (3.92)	96±4 (5.88)	94±4 (7.84)
		Ladies finger	79.0±3	77.9±3 (1.39)	77.0±3 (2.53)	76.4±2 (3.29)	75.0±3 (5.06)
		Banana	402±0.6	394±0.3 (1.99)	388±0.4 (3.48)	379±0.4 (5.72)	371±0.3 (7.71)

the temperature of the air inside the pot where kept the food samples for storing purposes.

Sample collection

For the present study freshly harvested Carrot, Ladies finger and banana were obtained from farmer's field, Alwarkurichi, Tamilnadu, India. The samples were collected in sterile polythene bags to avoid the possible contamination and dehydration[19].The collected samples were washed with sterile water and packed with sterile polythene pack with some respiratory holes and were stored in room temperature, refrigerator and in EPCC-2. The initial weight of the samples was noted and stored in all three types of storages. All stored

Table 6. Changes in the protein content in the stored products during the different storage periods (percentage of loss is given in parenthesis)

S. No.	Nature of storage	Sample	Protein content (mg/g)				
			1st day	3rd day	5th day	7th day	9th day
1.	Room Temperature	carrot	9.0±3	8.6±2 (4.44)	8.1±2 (10.00)	7.3±1 (18.88)	6.8±2 (24.44)
		Ladies finger	18.4±2	17.5±1 (4.89)	17±1 (7.60)	16±2 (13.04)	14.2±1 (22.82)
		Banana	11.0±0.8	10.2±0.6 (7.27)	10.0±0.6 (9.09)	9.5±0.6 (13.63)	9.0±0.7 (18.18)
2	Refrigerator storage	Carrot	9.0±3	8.7±1 (3.33)	8.3±3 (7.77)	7.5±4 (16.66)	7.1±4 (21.11)
		Ladies finger	18.4±2	17.5±1 (4.89)	17±2 (7.60)	16.2±1 (11.95)	15±1 (18.47)
		Banana	11.0±0.8	10.8±0.6 (1.81)	10.2±0.6 (7.27)	9.8±0.7 (10.90)	9.0±0.6 (18.18)
3	EPPC2	carrot	9.0±3	8.5±4 (5.55)	8.1±2 (10.00)	7.9±3 (12.22)	7.6±2 (15.55)
		Ladies finger	18.4±2	18.00±2 (2.17)	17.4±2 (5.43)	17.00±1 (7.60)	16.5±0.9 (8.15)
		Banana	11.0±0.8	10.9±0.5 (0.90)	10.7±0.3 (2.72)	10.6±0.4 (3.63)	10.3±0.7 (6.36)

vegetables were subjected to study on percentage of physiological loss in weight (PLW), total heterotrophic bacterial and fungal load, Changes in the carbohydrate and protein content and percentage changes in organoleptic values and results were recorded for every 48 hrs up to nine days.

Physiological Loss of Weight (PLW) (%)

The PLW of stored samples was calculated by considering the differences between initial weight and final weight of the stored samples divided by their initial weight by using the following formula[15, 20].

PLW= Initial weight- Final weight x 100/ Initial weight.

Total heterotrophic bacterial count

The initial and final microbial profiles were studied. Each vegetables stored at 1st 3rd, 5th, 7th and 9th days was taken out and it was not put into the storage again. One gram of sample was cut, homogenized and serially diluted with saline. Serially diluted samples (0.5 ml) were plated on plate count agar and potato dextrose agar to determine bacterial and fungal load respectively. All plates were incubated for 48 hrs at 37°C and 18-22° C for counting bacterial and fungal colonies respectively. Observations were recorded and the results were expressed as colony forming units (cfu) per gram[21].

Fig. 1. Earthen Pot Cool Chamber -2 (EPCC-2)

Bio-chemical analysis

The Bio-chemical content of

Table 7a. Organoleptic qualities of Carrot sample stored in different storage system

S.No	Nature of storage	Characters of sample	Storage of Carrot in days					Overall acceptability	Percentage change 9 days of Storage
			Day0	Day1	Day3	Day5	Day7		
1	Room Temperature	Skin colour appearance	10	9±0.6	7±0.2	6±0.4	4±0.5	6.00±0.4	57.50(F)
		Flavour		8±0.2	6±0.4	5±0.3	4±0. 6	5.75±0.3	
		Texture		8±0.4	5±0.2	4±0.2	3±0.1	5.00±0.2	
		Taste		9±0.3	5±0.2	5±0.3	2±0.4	5.25±0.3	
2	Refrigerator storage	Skin colour appearance	10	8±0. 2	7±0.5	4±0.6	3±0.3	5.50±0.4	50.60(F)
		Flavour		8±0.5	7±0.4	3±0.1	3±0.2	5.25±0.3	
		Texture		7±0.4	6±0.4	4±0.2	3±0.5	5.00±0.3	
		Taste		8±0.2	5±0.4	3±0.2	2±0.5	4.50±0.3	
3	EPCC2	Skin colour appearance	10	10	10	9±0.2	9±0.6	9.50±0.2	91.80(QA)
		Flavour		8±0.6	9±0.7	10	8±0.5	8.75±0.4	
		Texture		10	10	9±0.4	9±0.3	9.50±0.1	
		Taste		8±0.5	10	9±0.5	9±0.3	9.00±0.3	

Note : P – Poor; F-Fair ; A- Acceptable; Q.A-Quite Acceptable .

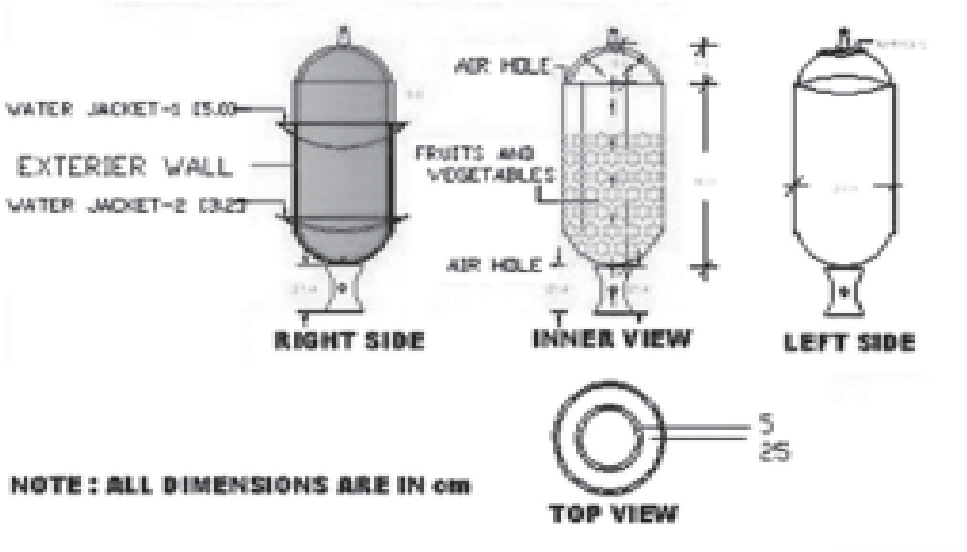

Fig. 2. Auto card of Earthen Pot Cool Chamber -2 (EPCC-2)

Table 7b. Organoleptic qualities of Ladies finger sample stored in different storage system.

S.No	Nature of storage	Characters of sample	Storage of Ladies finger in days					Overall acceptability	Percentage change 9 days of Storage
			Day0	Day1	Day3	Day5	Day7		
1	Room Temperature	Skin colour appearance	10	8±0.2	4±0.3	3±0.2	1±0.5	4.00±0.3	57.50(F)
		Flavour		8±0.6	8±0.7	8±0.5	6±0.3	7.50±0.5	
		Texture		7±0.5	6±0.1	4±0.2	2±0.4	4.70±0.3	
		Taste		8±0.4	8±0.3	7±0.5	6±0.4	6.70±0.4	
2	Refrigerator storage	Skin colour appearance	10	9±0.5	7±0.6	6±0.4	5±0.3	6.70±0.4	62.50(F)
		Flavour		9±0.2	8±0.3	8±0.2	6±0.3	7.80±0.2	
		Texture		8±0.3	7±0.4	7±0.5	7±0.2	5.50±0.3	
		Taste		7±0.3	6±0.4	6±0.4	5±0.5	5.00±0.4	
3	EPCC2	Skin colour appearance	10	10	10	8±0.5	6±0.3	8.50±0.2	90.00(A)
		Flavour		10	10	8±0.3	8±0.4	9.00±0.1	
		Texture		9±0.3	9±0.7	9±0.5	8±0.6	8.80±0.4	
		Taste		10	10	10	9±0.5	9.75±0.1	

Note : P – Poor; F-Fair ; A- Acceptable; Q.A-Quite Acceptable .

carbohydrate and protein in all the stored vegetables were determined by Anthrone and Lower's method respectively[22].

Organoleptic quality analysis

Organoleptic quality includes the typical sensory properties of the vegetables: its skin color appearance, flavor, texture, taste and odor were also assessed by using evaluation scale (Table 1). Samples stored in the three storage systems were presented to a laboratory panel of five judges for sensory evaluation by using suitable method[23]. The panel was asked to rate the samples for skin color appearance, flavor texture, taste and odor on a 10 points hedonic scale using a numerical scale ranging from 2 to 10, where 2,4,6,8 and 10, represented as Poor, fair, good, attractive and very attractive respectively (Table 1). All the scales were converted into percentage wise. Vegetables scoring lower than 4 out of 10 were considered unacceptable. There were five samples assessed for each storage in order to get average results. The same vegetable was examined only once.

RESULTS AND DISCUSSION

In the present investigation the efficiency of an EPCC-2 system to store vegetables was studied in relation to the storage efficiency. Vegetables stored in the EPCC-2 had good acceptance at the end of nine days of storage period than room temperature and refrigerator storages. During this study period, changes in physiological loss in weight (PLW), total heterotrophic bacterial and fungal load, Changes in the carbohydrate and protein content and organoleptic changes have been analyzed and it was compared with room

Table 7C. Organoleptic qualities of Banana sample stored in different storage system.

S.No	Nature of storage	Characters of sample	Storage of Ladies finger in days					Overall acceptability	Percentage change 9 days of Storage
			Day0	Day1	Day3	Day5	Day7		
1	Room Temperature	Skin colour appearance	10	7±0.3	6±0.3	6±0. 4	4±0.3	5.75±0.3	55.60(F)
		Flavour		8±0.2	6±0. 5	5±0.3	4±0.1	5.75±0.2	
		Texture		8±0.3	7±0.4	4±0.2	3±0.1	5.50±0.2	
		Taste		8±0.6	6±0.2	5±0.3	2±0.4	5.25±0.3	
2	Refrigerator storage	Skin colour appearance	10	8±0.5	6±0.3	4±0.1	2±0.1	5.00±0.	51.80(F)
		Flavour		8±0.4	7±0.3	3±0.1	3±0. 5	5.25±0.3	
		Texture		7±0.4	6±0.3	6±0.2	3±0.2	5.50±0.2	
		Taste		8±0.5	6±0.3	3±0.2	3±0.4	5.00±0.3	
3	EPCC2	Skin colour appearance	10	9±0.3	8±0.4	10	9±0.4	9.00±0.2	85.70(A)
		Flavour		9±0.4	8±0.5	9±0.5	8±0.4	8.50±0.4	
		Texture		9±0.3	9±0.6	9±0.5	8±0.2	8.75±0.4	
		Taste		9±0.4	9±0.5	7±0.4	7±0.3	8.0±0.4	

Note : P – Poor; F-Fair ; A- Acceptable; Q.A-Quite Acceptable .

temperature and refrigerator storages. Physical parameters like temperature and relative humidity was noted in all storage systems. It was observed that the relative humidity was higher (87- 92%) in EPCC-2 than room temperature (58- 60%) and refrigerator (58 -61%). In terms of temperature, the EPCC-2 has maintained 25-26^0 C i.e. less than 4-5^{o}C than room temperature (29-30^{o}C). Where as in refrigerator it was measured as 4-5^o C

The loss of PLW of all stored products is given in the Table 2. The weight of all three products was recorded before keeping them in all three storage units. After storage, weight changes due to physiological stress were noted on 3rd, 5th, 7th and 9th days respectively and highly significant differences were recorded. At the end of 9 days of storage the total weight loss in EPCC-2 was noted as 6.50 % in carrot, 4.11 % in tomato, 7.59 % in banana respectively (Table 2). Whereas the total weight loss in room temperature 15.57 %, 27.91 % and 28.24 % and in refrigerator 9.23 %, 8.04 % and 11.09 % were noted respectively in different produces. These results indicated that EPCC-2 showed low increase in PLW when compared to other two storages. This might be due to minimum mechanical stress, high relative humidity, reduced temperature and minimum evaporation process prevailing inside the cool chamber as compared to room temperature and refrigerator. High mechanical stress leads loss of quality during the post harvest period[19]stated that stress leads to loss of membrane integrality, leakage, loss of permutation changes in the enzyme activity. Temperature is the major environmental factor that considerably affects the postharvest physiological weight loss of stored vegetables[24]. In most of the

cases moisture content of fresh fruits and vegetables are very high (usually greater than 70%). Therefore, the air inside the flesh is nearly saturated that is, close to 100% relative humidity. The lower humidity ratio causes desiccation and marked softening of carrots together with some increase in decay. High relative humidity is therefore desirable for reducing physiological weight loss during storage of fruits and vegetables[25].Temperature is the other major environmental factor that considerably affects the postharvest physiological weight loss of stored vegetables[24]and the lower temperature and high relative humidity must have reduced the respiration and transpiration losses thereby lower mean weight loss in stored products stored in Zero energy cool chamber (ZECC). Fruit weight loss during storage is attributed to loss of moisture and reserve food materials by evapotraspiration and respiration respectively [26]. The high increase in PLW in room and refrigerator, due to high mechanical stress, water stress, freezing and chilling injury and freezing injury reduced the physiological weight loss of produces; it was reported[15, 27]that vegetables stored in modified earthen pot cool chamber showed low level of PLW than room and refrigerator storages.

The total heterotrophic bacterial load in the products stored at room temperature, refrigerator and EPCC-2 at the end of nine days of storage indicated significant variation (Table 3).In the product stored at room temperature the bacterial load was too numerable too count (TVC) while in refrigerator storage the bacterial and fungal colonization was less at the end of 9 days of storages respectively and where as in the EPCC-2 preserved products the bacterial and fungal colonization was minimum (Table 4). The main reason for highest bacterial and fungal count in the vegetable kept at room temperature was because of the fact that room environment is a good medium for the dispersion of microorganisms whereas in refrigerator was due to mechanical stress, chilling injury, ethylene stress, which leads to the ooze out of nutrients, which provide a better growth medium for the organisms. But in the EPCC-1 the low temperature did not support the growth of mesosphillic as well as psyhcrophillic bacteria. Also, EPCC-1 has more fungal load it might be caused more antibiosis effect on bacterial cells and inhibiting the growth of bacterial cell[15].Even though EPCC-2 could maintain high level of humidity a very low number of fungal colonies were noted (Table 4). The reason might be the effect of calcium carbonate adheres in the wall of EPCC-2. The Use of calcium carbonate nanoparticles as an anti-microbial agent is recommended in different fields of medicine, food industry and agriculture and can be of importance considering health and economic issues[28].

The carbohydrate and protein content of three stored products were recorded before and after storage (Table 5). It was found that after nine days of storage period the carbohydrate and protein content was reduced much in room temperature than in refrigerator and EPCC-2 in all stored samples. At the end of nine days of storage the percentage of carbohydrate content decreased in room temperature was noted as 15.68%, 23.79% and 10.69% in carrot, ladies finger and banana respectively where in refrigerator was 13.72%, 7.40% and 9.70% respectively. However there was slight decrease in carbohydrate content of EPCC-2 noted as 7.84%, 5.06% and 7.71% in all three stored samples. It was found that the loss of carbohydrate in the products stored in earthenware storage system was less. Like carbohydrate content, the protein content of the stored products kept at earthenware storage system showed less change compared to refrigerator and room temperature storages (Table 6). The reason for the low level of nutrient loss in EPCC-2 due to less physiological changes in the samples, low mechanical stress, less microbial activity especially fungal growth by the inhibition of calcium carbonate present in the pot and reducing more respiration of fruits and vegetables by continuous air supply through air holes of the pot. In general, the storage life of commodities varies inversely with the rate of respiration. During storage period, organic materials (carbohydrates, proteins, and fats) are broken down into simple end products with a release of energy by respiration process[5]. Respiration which increases in free sugars in some fruit and vegetables are due to the breakdown of polysaccharide and reduce the carbohydrate content[29]. Temperature also regulates the rate at which the Biochemical changes occur during storage[5].But in refrigerator storage, due to wounding stress, as a result of chilling or

mechanical injuries, microbial activity, and the respiration rate and overall metabolic activities usually increase. so it leads to decrease the carbohydrate and protein content while in the room temperature due to the higher temperatures increase ethylene production and result in advanced physiological and biochemical changes in vegetables[30].

The products stored in EPCC-2 were noted the highest overall acceptability i.e. more than 90% for the period of nine days with the retention of fresh appearance, color, texture, taste and flavor and was rated (Tables7A, 7B, 7C). So all the products stored in EPCC-2 were mostly acceptable or quit acceptable. But the overall acceptability of the products stored under room and refrigerator storage systems were noted as in-between 50-60% only and all produces were retained fair quality. From the result it is quite evident that earthenware storage system is an efficient device to preserve raw vegetables like Carrot, Tomato, and banana for more than 9 days in a good condition. The reason for high organoleptic value in EPCC-2 were mainly because the rise in relative humidity, low PLW, and maintenance of other quality characteristics like minimum loss of nutrient composition, staying microbial activity and fall in temperature from ambient condition . But in room temperature storage low humidity was maintained hence the water loss was higher whereas in refrigerator dehydration process was taken placed. This might be reason for maintained low level organoleptic quality both in room and refrigerator storages respectively. The higher relative humidity which retains the water content of post-harvested sample and higher temperature during storage, as a result, fruits and vegetables loose firmness faster at higher temperature due to high enzymatic activity[31].Water is an important factor in maintaining post harvest quality; it helps to maintain pH inside the storage area. Any change in pH results in water loss and affect the appearance, texture and in some case flavors. Water loss also affects the crispness and trimness[32]. Maintaining of cool chain management might be reduced worm temperature around the vegetables and reduce the respiration rate and maintained high level of organoleptic qualities. In general, the storage life of commodities varies inversely with the rate of respiration. This is because respiration supplies compounds that determine the rate of metabolic processes directly related to quality parameters, eg. firmness, sugar content, aroma, flavor, etc. Commodities and cultivars with higher rates of respiration tend to have shorter storage-life than those with low rates of respiration and the loss of freshness of perishable commodities depends on the rate of respiration[33].The main physiological manifestation of metabolic activities include increased respiration rate and in some cases, ethylene production and the calcium chloride treatment which extent storage life and reduce the incidence of physiological disorder and storage rots[34, 35].

CONCLUSION

Fresh produce has become one of the most desirable foods because todays's consumer perceives it as being healthy, tasty, convenient and fresh. All of these characteristic are strong selling point to a busy and healthy conscious consumer. Once harvested or purchased fruits and vegetables must be stored under proper conditions, the most important of which are temperature and humidity. Very high and very low temperature which affect rate of chemical reactions and the shelf life of the produces. Hence, ambient temperature and refrigerator like electrical instrumental storages not suitable for fruits and vegetables storage because both are maintain high and very low temperature respectively. In order to overcome these problems zero energy cool chambers was developed and stored the produces[11, 12, 14, 36, 37].But it could be used to store fruits and vegetables for mass scales storage in open space not for house hold. So in order to house hold utility in the present study, EPCC-2 was designed and studied. At the end of nine days storage all stored produces in the EPCC-2 had minimized the physiological loss of weight and preserved organoleptic qualities, biochemical chaecterisitics and extended the shelf-life compared to room temperature and refrigerator. The reason might be EPCC-2 remove respiratory heat produced by produces by cool chain management by natural means, maintain high relative humidity, low temperature and presence of natural preservatives calcium hydroxide on wall of the chamber. It is concluded that this house hold storage chamber EPCC-2 is affordable for everyone

and store fruits and vegetables effectively than room and refrigerator. Also, this should be promoting rural upliftment, body health and safe the environment.

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