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Dr. Karuna Kumari
Scientist, Krishi Vigyan Kendra, Jamtara, Jharkhand, India

Sanjeev Kumar
Scientist, Krishi Vigyan Kendra, Jamtara, Jharkhand, India

Gopal Krishna
Scientist, Krishi Vigyan Kendra, Jamtara, Jharkhand, India

Correspondence
Dr. Karuna Kumari
Scientist, Krishi Vigyan Kendra, Jamtara, Jharkhand, India

Storage analysis of fruits and vegetables stored in low cost earthen pot cooling chamber and Pusa zero energy cool chamber

Dr. Karuna Kumari, Sanjeev Kumar and Gopal Krishna[2]

Abstract
India ranks second in fruit and vegetable production in the world after China. Despite having such a huge production of eatables, India still fails to fulfill the daily food requirement of an average citizen. Also there is an immense loss in post production processing, with a huge difference between gross production and net availability. As per an estimate, 30-40% of the produced fruits and vegetables in the country are lost due to wastage and value destruction. Post harvest losses are very difficult to be curbed, but with the help of better techniques, these losses can be effectively minimized. Earthenware Cool Chamber (ECC) is an eco-friendly, non-toxic, less expensive and biodegradable pot which is made up of readily available materials. In this study, a double vessel ECC is designed to increase the shelf life of stored fruits and vegetables. Working on the principle of evaporation, a Pusa Zero Energy Cool Chamber (PZECC) can be effortlessly constructed anywhere with locally available materials. Evaporative cooling system not only lowers the air temperature surrounding the produce, but also increases the relative humidity of the air. The higher relative humidity retains the water content of post harvested sample. This helps prevent the drying of the products, therefore extending the shelf life of horticultural products. Evaporative cooling system is well suited in areas where temperature is high, humidity is low, and sparse air movement is available. The evaporative chambers are easy and efficient cooling systems that can reduce energy use by 70% and are less expensive to install, operate and maintain. It is economical and can store the fruits and vegetables for 7 to 9 days without any significant loss and is a blessing for the tribal-prone remote areas in Jamtara district of Jharkhand where electrical energy input is hardly available.

Keywords: fruits and vegetables, pot cooling chamber, cool chamber

Introduction
As per National Horticulture Board during 2014-15 India produced 86.602 million Metric Tons of fruits and 169.478 million Metric Tons of vegetables. India ranks second in fruit and vegetable production in the world after China. Despite having such a huge production of eatables, India still fails to fulfill the daily food requirement of an average citizen. Also there is an immense loss in post production processing, with a huge difference between gross production and net availability. All fresh field products are high in water content and subject to wilting and shriveling. They are also susceptible to attack by micro-organisms resulting in pathological damage. An increased emphasis needs to be given to post harvest management of these perishable crops. As per an estimate, 30-40% of the produced fruits and vegetables in the country are lost due to wastage and value destruction. Post harvest losses are very difficult to be curbed, but with the help of better techniques, these losses can be effectively minimized.

Since the beginning of human civilization, man has learnt the art of developing earthenware utensils for food preparation, consumption and storage. Earthenware Cool Chamber (ECC) is an eco-friendly, non-toxic, less expensive and biodegradable pot which is made up of readily available materials. In this study, a double vessel ECC is designed to increase the shelf life of stored fruits and vegetables. Preservation of organoleptic values in fruits and vegetables were tested to evaluate the efficiency of the ECC over Pusa Zero Energy Cool Chamber and Room Temperature.

To retain the freshness and for the storage of newly harvested fruits and vegetables for a short period, an on-farm storage chamber known as Pusa Zero Energy Cool Chamber (PZECC) was designed. Working on the principle of evaporation, a PZECC can be effortlessly constructed anywhere with locally available materials which include sand, bricks, bamboo, straw, gunny bags etc along a source of water. Hence, the spoilage of fresh fruits and vegetables can be controlled by reducing the storage temperature and maintenance of appropriate amount of humidity in a PZECC.

Methodology

An OFT was conducted in Jamtara district of Jharkhand. Seven villages were randomly chosen where the comparison and evaluation of effective storage techniques was done using three technology options.

TO_1 – Farmer's Practice (Wet Gunny Bag)
TO_2 – Earthenware Cool Chamber (ECC)
TO_3 – Pusa Zero Energy Cool Chamber (PZECC)

Earthenware Cool Chamber (ECC):

ECC consists of two vessels, an outer and an inner vessel. The outer vessel is larger (diameter 18"; height 18") and the inner vessel is smaller (diameter 17"; height 17"). The smaller vessel can fit into the larger vessel in such a way that a gap is present in between the two vessels where wet sand is deposited. The presence of wet sand plays a vital role in maintenance of relative humidity and low temperature. To keep the ECC in position, the outer vessel is screwed to the inner vessel using bolts and nuts. A lid made of the same material (diameter 18") covers the vessels. Multiple small sized holes are punched out in the lid for effective evaporation. A beak-like mechanism is also developed which allows the drainage of excess water overflow.

Fig 1:A: Open ECC

1:B: Closed ECC

1:C: Open ECC with Lid

Pusa Zero Energy Cool Chamber (PZECC):

Choose an elevated site close to a water source where bricks are used to floor in an area of 165cm x 115cm. A double layered wall is erected 67.5cm high, leaving a cavity 7.5 cm wide between them. Fill the intermural cavity with wet sand. Make a cover frame from bamboo/straw/dry grass etc. Attach a tap, dripping water to the sand periodically from the water source. Build a thatched roof shed over the chamber to shield the chamber from direct sun and rain. Store the fruits and vegetables in perforated plastic bags or crates. Cover the crates with a thin polyethylene sheet. Rebuild the chamber with new bricks after three years for better efficiency.

Fresh fruits and vegetables were collected and washed with water and packed in plastic bags with holes for ventilations. The initial weights of the samples were noted and were stored in three different types of storage systems viz. gunny bags, ECC and PZECC. In duration of two days, the physiological loss in weight, changes in organoleptic characteristics were monitored and recorded. The storage was extended to ten days and the study parameters were recorded regularly. Physiological loss in weight (PLW) was calculated using the following formula:

$$PLW\ (\text{in } \%) = \frac{\text{Initial weight} - \text{Final weight})}{\text{Initial weight}} \times 100$$

To evaluate the organoleptic characteristics, viz. taste, texture, appearance, flavor, the following scale was used. 5 stood for Excellent, 4 stood for Very Good, 3 stood for Good, 2 stood for Fair and 1 stood for Poor.

Result and Discussion

Table 1: Organoleptic Test of Fruits and Vegetables in Farmer's Practice, Ecc and Pzecc

Technology Options	Organoleptic Test of Fruits and Vegetables						
	Parameters	2 days	4 days	6 days	8 days	10 days	12 days
TO_1 - Farmer's Practice	Color	4	3	1	-	-	-
	Smell	4	3	2	-	-	-
	Appearance	4	2	1	-	-	-
	Taste	4	2	1	-	-	-
TO_2 – ECC	Color	5	4	4	3	2	1
	Smell	5	5	4	4	3	2
	Appearance	5	5	4	4	4	3
	Taste	5	5	4	3	2	1
TO_3 – PZECC	Color	5	4	4	3	2	1
	Smell	5	4	3	3	2	1
	Appearance	5	4	3	3	3	2
	Taste	5	4	4	3	3	2

Table 1 compares the organoleptic standards of the sample fruits and vegetables in different Technological Options. It was shown that color, smell, appearance and taste have a very high rate of depreciation in the first option i.e. regular Farmer's choice of wet gunny bags where they turn bad in only 6 days. In the second option, ECC, the stored fruits and vegetables were seen as fresh as recently cultivated products even after 12 days with slight depreciation in color and taste. In the last option, PZECC, though the samples did not turn bad as quickly as in TO_1, but had a faster decline rate than TO_2.

Table 2 gives the comparison of storage life of different farm obtained fruits (Gooseberry, Banana, Guava, Mango, Lime and Orange) and vegetables (Amaranth, Okra, Pointed Gourd, Carrot, Potato, Peas, Cauliflower and Tomato) under the three discussed Technological Options over their time of annual production.

Table 2: Storage shelf life of different fruits and vegetables in farmer's practice, ECC and PZECC

Technology Options	Parameters	Name of Fruits						Name of Vegetables							
		Gooseberry	Banana	Guava	Mango	Lime	Orange	Amaranth	Okra	Pointed Gourd	Carrot	Potato	Peas	Cauliflower	Tomato
	Part of the year	Dec- Jan	Oct – Nov	Mar – May	May - Jun	Jan – Feb	Dec - Feb	May - Jun	May - Jul	May - Jun	Feb - Mar	Mar - May	Feb - Mar	Jan - Feb	Apr - May
TO1	Shelf Life in days	9	5	10	6	15	15	1	1	2	5	40	5	7	7
TO2	Shelf Life in days	15	8	12	8	24	30	3	7	5	10	80	9	9	12
TO3	Shelf Life in days	14	7	10	8	22	29	2	6	5	9	75	8	8	10

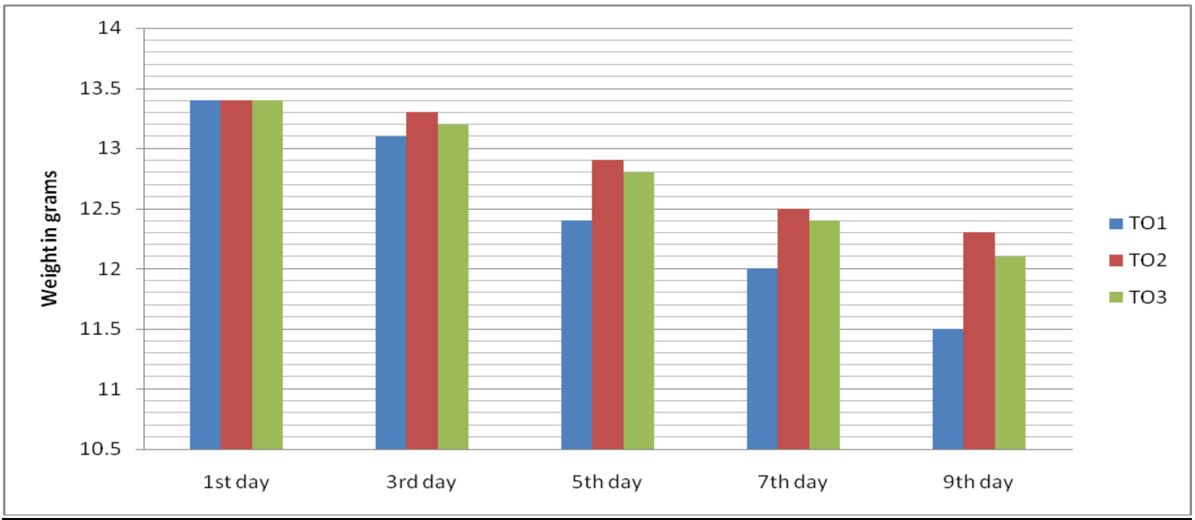


Chart 1: Loss of weight in tomato in different technology options

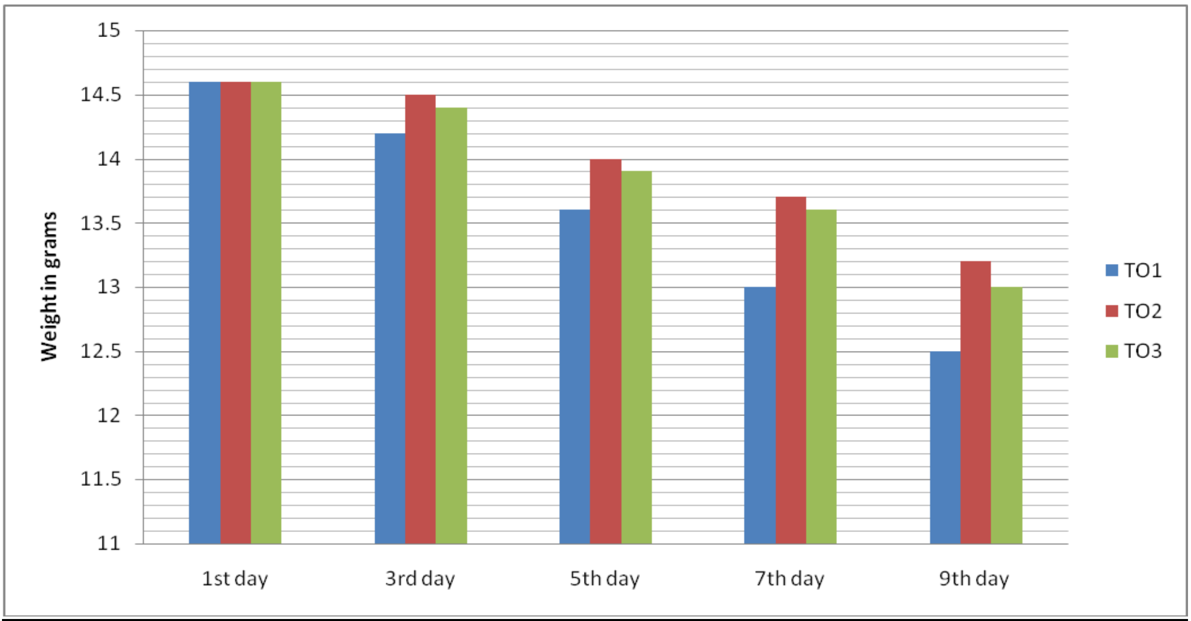


Chart 2: Loss of weight in okra in different technology options

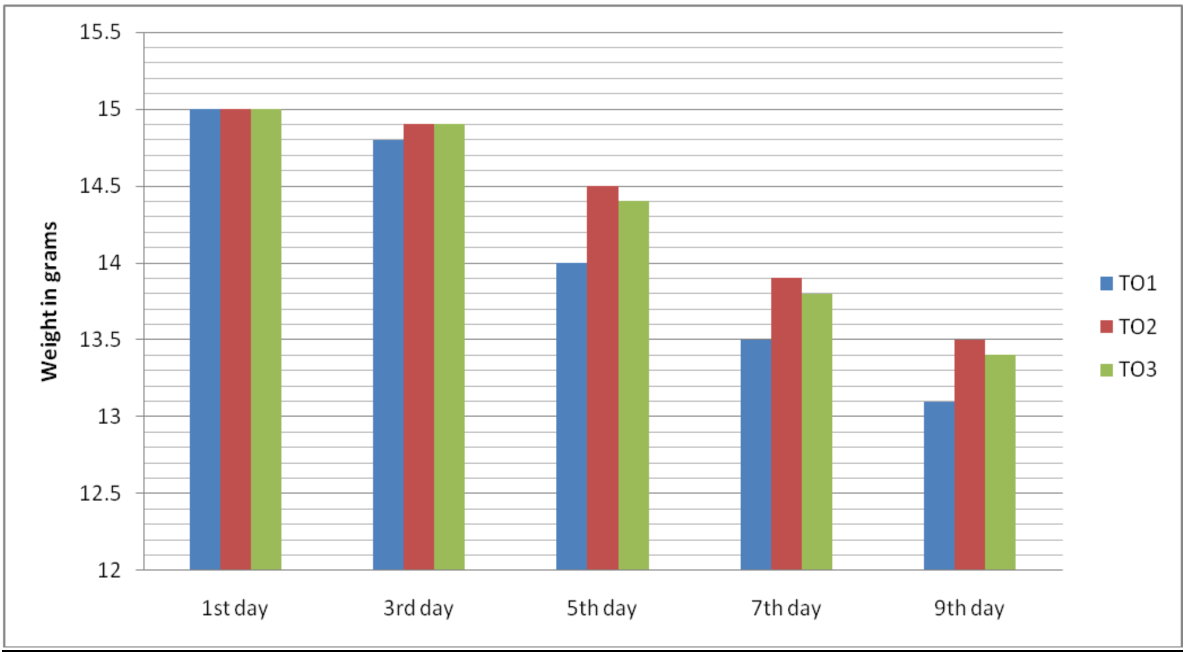
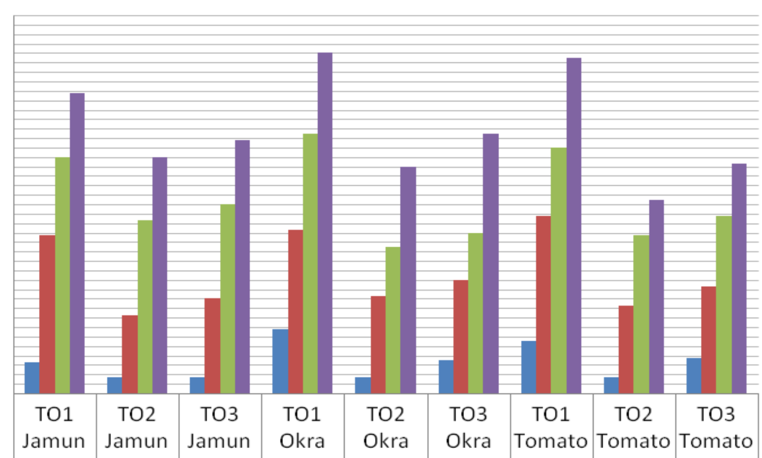


Chart 3: Loss of weight in jamun in different technology options



	TO1 Jamun	TO2 Jamun	TO3 Jamun	TO1 Okra	TO2 Okra	TO3 Okra	TO1 Tomato	TO2 Tomato	TO3 Tomato
% Weight Loss of sample on 3rd day	1.3	0.7	0.7	2.7	0.7	1.4	2.2	0.7	1.5
% Weight Loss of sample on 5th day	6.7	3.3	4	6.9	4.1	4.8	7.5	3.7	4.5
% Weight Loss of sample on 7th day	10	7.3	8	11	6.2	6.8	10.4	6.7	7.5
% Weight Loss of sample on 9th day	12.7	10	10.7	14.4	9.6	11	14.2	8.2	9.7

Chart 4: Physiological Loss in Percentage Weight of Samples

Chart 1 shows the loss of weight in Tomato in the three Technological Options at alternate days over a period of $1^1/_2$ weeks. Similarly, Chart 2 and Chart 3 show the losses in weight in Okra and Jamun respectively every other day until the 10^{th} day. In all the three samples the rate at which the organoleptic values start degrading are the highest in TO_1 i.e. Farmer's Regular Practice. Due to maintenance of humidity and optimum temperature, TO_2 i.e. ECC preserves the samples in good state even until 9 days. While the last TO_3 i.e. PZECC is not as effective as ECC but it's way ahead of Farmer's Practice and thus is a highly moderate storage option.

Chart 4 comprises of an inclusive table showing the percentage loss in weight of the three samples viz. Jamun, Okra and Tomato compared over the three available options. After recording the observations on the 9^{th} day, we find that the most distinct falls in PLW of Jamun, Okra and Tomato were 12.7%, 14.4% and 14.2% respectively in TO_1 (Farmer's method) while the least distinct falls were 10%, 9.6% and 8.2% respectively in TO_2 (ECC). TO_3 (PZECC) maintains equilibrium between the two techniques with a PLW of 10.7%, 11% and 9.7% respectively in Jamun, Okra and Tomato.

Conclusion

To prevent the post harvest losses from desiccation and decaying, a strong foothold system needs to be installed at grass root level of farmers in villages. ECC and PZECC are important evaporative cooling systems and have a very large potential to pacify thermal balance. Nowadays, evaporative cooled storage systems (ECC & PZECC) are increasingly being used for on-farm as well as off-farm storage of fruits and vegetables. Evaporative cooling system not only lowers the air temperature surrounding the produce, but also increases the relative humidity of the air. The higher relative humidity retains the water content of post harvested sample. This helps prevent the drying of the products, therefore extending the shelf life of horticultural products. Evaporative cooling system is well suited in areas where temperature is high, humidity is low, and sparse air movement is available. They are the most suitable for the short term storage of vegetables and fruits soon after their harvest even in hilly regions. The fruits and vegetables stored inside look fresh and taste better than those stored at room temperature. The marketing ability of fruits and vegetables depend upon their freshness, which is effectively maintained in ECC and PZECC. Thus, it can be said that evaporative chambers are an easy and efficient cooling systems that can reduce energy use by 70% and are less expensive to install, operate and maintain. It is economical and can store the fruits and vegetables for 7 to 9 days without any significant loss and is a blessing for the tribal-prone remote areas in Jamtara district of Jharkhand where electrical energy input is hardly available.

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