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Low Cost Storage Structures for Fruits and Vegetables Handling in Indian Conditions

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ABSTRACT

India is the second largest producer of fruits and vegetables in the world with huge postharvest losses. One of the reasons for postharvest losses is inappropriate infrastructure for storage. Storage of fruits and vegetables becomes essential step to make them available during off season and also to control glut situations in the market. Appropriate storage structures like evaporative cooling chambers (ECC) for safe storage of horticultural crops become essential for regular supply of commodities.

Key words: Storage structures, Low cost, Fruits, Vegetables, Handling

India produces huge amounts of horticultural crops including fruits, vegetables, spice crops, many cash crops such as coffee and cotton (Rais and Sheoran 2015). Though fruits and vegetables are produced in such a large quantity, they are seasonal and are grown region wise in India. It has been estimated that postharvest losses associated with fruits and vegetables alone in India stands in the range of 6-18% (Nanda *et al*. 2012). The demand for fruits and vegetables is year round throughout the country and thus their storage becomes an integral part and general practice of ensuring continuous supply. Moreover, proper storage practices become a strategy for achieving higher returns. Fruits and vegetables are held temporarily in order to overcome gluts situation in the market and thus limiting price falls or to address shortage when prices are high. By creating appropriate facilities for storage, such huge postharvest losses can be minimized to a certain level. In order to certify appropriate storage conditions, various types of storage structures and techniques have evolved with time. Most of them are still practiced to ensure safe storage of fruits and vegetables.

Low cost storage structures for safe storage of fruits and vegetables

- Clamps
- Cellars
- Ventilated storage structures
- Evaporative cool chambers
  - Pot-in-pot
  - Charcoal cooler
  - Evaporative cool chamber (ECC) or zero energy cool chamber (ZECC)

Clamps, cellars, ventilated structures &evaporative cool chambers are some of the cost effective traditional storage structures. Whereas cold or refrigerated storage, controlled atmospheric storage, modified atmospheric storage, hypobaric storage etc are costly, modern storage techniques. For a developing country like India both types of structures stands equally important. Most of the Indian farmers are poor and can afford to construct only low cost structures. Some of the low cost storage structures have been discussed below:

Clamps

Tropical roots and tuber crops must be stored at temperatures that will provide protection against chilling, which causes internal browning, surface pitting and increased susceptibility to decay. To conquer these conditions in potatoes, a field storage clamp is a simple and low cost technology that can be designed using local available materials for ventilation and insulation. For ex. potato for processing, should have less sugars as they turn dark during heating. Whereas for house hold consumption they should be stored in dark to avoid development of solanine (toxic alkaloid) (CIP 1981). A storage clamp (Fig 1) is used in agricultural fields for temporary storage of root crops. Clamps are usually used in temperate regions but are also effective at higher elevations and in warmer climates. In tropical climates of India, extra straw casing is made to give extra ventilation instead of soil. In cold climates, a second layer of straw and soil can be added whereas in hot regions, chimney type air outlets at the top of the clamp can be made. However, during rainy weathers clamp can be constructed under the tree or roof for protection from rainfall.

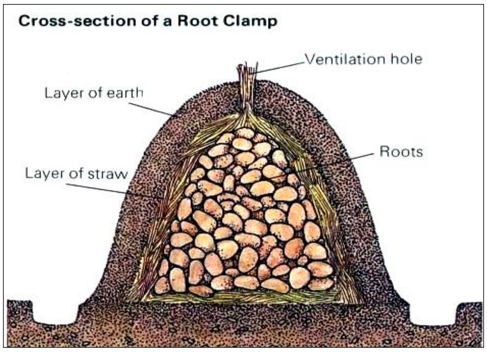


Fig 1 Clamp (Potatoes)

Cellars

Cellar refers to the underground or partially underground structures that are used to store vegetables, fruits, nuts etc (Fig 2). Cellars keep fruits and vegetables at lower temperature and steady humidity conditions. The structure helps in keeping the produce safe from freezing during winters and keep cool during summers.

Common construction methods for storage cellars are:

- Digging down into the ground and erecting a shed or house over the cellar (access is via a trap door in the shed).
- Digging into the side of a hill (easier to excavate and facilitates water drainage).
- Building a structure at ground level and piling rocks, earth, and/or sod around and over it. This may be easier to build on rocky terrain where excavation is difficult.

These structures can be built in cold (Himalayan region) as well as hot climatic regions (North western and western India). A root cellar can be constructed by digging out a pit to a depth of about 2 meters (7 to 8 feet) and framing the sides with wooden planks.

Fig 2 Cellars ventilated storage structures

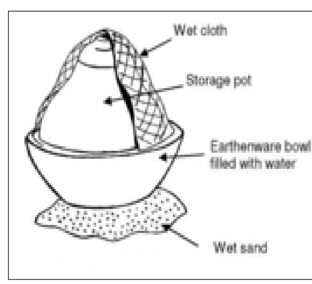
Naturally ventilated structures can be used for the storage of fruits and vegetables such as roots and tubers, pumpkins, onions and hard white cabbage. Such structures are designed and built specifically for each intended location. Any type of building can be used that allows free circulation of air through the structure and its contents.

The following points must be kept in mind during their construction:

- Site should have low night temperatures occur over the required storage period
- It should maximize the use of the prevailing wind for ventilation
- Roofs and walls should provide insulation against sun
- Shade of tree should be used : if they do not interfere with the prevailing air flow
- Provide ventilation spaces below the floor and between walls and roofs to give appropriate air flow

This type of storage structure is commonly used in India for the bulk storage of onion and garlic. Onions are stored in these sheds by spreading them on dry and damp proof floor or racks. Some of the improved storage structures for onions include concentric structures, low volume low cost structures (5-10 tons capacity) made of bamboo, high volume bottom and side ventilated storage structure (25-50 tons capacity), Nasik type storage structure etc.

Fig 4 Nasik type ventilated storage structure for onions



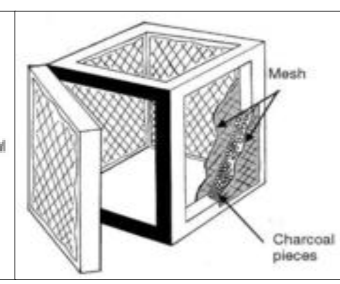


Fig 5 Pot-in-pot
Source: Roy and Khurdiya 1985

Fig 6 Charcoal Cooler
Source: Odesola and Onyebuchi 2009

Evaporative cool chambers

Evaporative cooling is a natural phenomenon that occurs when moving air passes over a wetted medium or water source like pond, fountain, river, sea, shower, etc. When water evaporates, it draws energy from its surroundings which produce a considerable cooling effect. Efficiency of evaporative cooler depends on humidity of the surrounding air which can be understood from a temperature drop chart (Table 1) as given below. Evaporative cooling is one of the methods to cool the environment where the temperature drops and humidity increases considerably to a suitable level for on-farm storage short-term of perishables (Jha and Kudas 2006).

Cooling by evaporation is an age old practice and is known in every part of the world. This technique is more popular in India, African countries and Middle East. Different types of evaporative cool chambers with varied size, capacity, volume have been developed in various parts of the world.

Table 1 Temperature drop chart

Ambient Temperature (°C)	Relative humidity (%)								
	10	20	30	40	50	60	70	80	90
10	4.0	4.5	5.5	6.0	7.0	7.5	8.0	9.0	9.5
15	7.5	8.5	9.5	10.5	11.0	12	13	13.5	9.5
20	11	12	13	14.5	15.5	16.5	17.5	18.5	19
25	14.5	16	17	18.5	20	21	22	23	24
30	17.5	19.5	21	22.5	24	25	26.5	28	29
35	20	23	25	26.5	28.5	30	31.5	32.5	34
40	23	26.5	29	31	32.5	34.5	NA	NA	NA
45	26	29	32.5	35	NA	NA	NA	NA	NA
50	29	32.5	36.5	NA	NA	NA	NA	NA	NA

Fig 8 Evaporative cool chamber (ECC) (A) and improved ECC (B & C)

Pot-in-Pot

It is a simple design of evaporative cooler for use at home. The basic design consists of a storage pot placed inside a bigger pot that holds water. The inner pot stores food that is kept cool. One adaptation on the basic pot design is the Janata cooler (Fig 5), developed by the food and nutrition board of India (Roy and Khurdiya 1985). A storage pot is placed in an earthenware bowl containing water. The pot is then covered with a damp cloth that is dipped into the reservoir of water. Water drawn up the cloth evaporates keeping the storage pot cool. The bowl is also placed on wet sand to isolate the pot from the ground.

Charcoal cooler

The charcoal cooler is made from an open timber frame of approximately 50mm × 25mm in section. The door is made by simply hanging one side of the frame. The wooden frame is covered in mesh, inside and out, leaving a 25 mm cavity which is filled with pieces of charcoal. The charcoal is sprayed with water and when wet provides an evaporative cooling. The frame work is mounted outside the house on a pole with ametal cone to deter rats and a good coating of grease to prevent ants from getting to the food (Odesola and Onyebuchi 2009). The top is usually solid and thatched, with an overhang to deter flying insects.

Evaporative cooling chamber (ECC)/Zero energy cool chamber (ZECC)

IARI, New Delhi developed a cooling chamber that can be built in any part of the country using locally available materials (Roy and Khurdiya 1985). The basic structure of the chamber can be built from bricks and river sand, with a cover made from cane or other plant materials such as straw and sacks or cloth. This structure requires a nearby source of water. Its construction is simple. Floor is built from a single layer of bricks and then a cavity wall is constructed of bricks around the outer edge of the floor with a gap of 75 mm between the inner wall and the outer wall. This cavity is then filled with sand. About 400 bricks are needed to build a chamber of the size shown below (Fig 8). A covering for the chamber is made with canes covered in sacking all mounted in a bamboo frame. The whole structure should be protected from sunlight by making a roof to provide shade. After construction of the walls and floor, the sand in the cavity is thoroughly saturated with water. Once the chamber is completely wet, a twice daily sprinkling of water is enough to maintain the moisture and temperature of the chamber. A simple automated drip watering ECC has been shown in Fig 7(A). Number of attempts has been made to modify existing ECC and some of the improved structures of evaporative cool chambers have been developed recently. Fig 7(B) and Fig 7 (C) show the improved ECC structures developed by ICAR-IARI, New Delhi and ICAR-Central Institute of Postharvest Engineering and Technology, Abohar (Punjab), respectively. It has been reported that ECC can keep the temperature 10-15°C cooler than the outside temperature and maintain about 90% relative humidity. Effect of ECC environment on storage life of different fruits and vegetables has been presented in (Table 2).

Table 2 Storage life of fresh fruits and vegetables in zero energy cool chamber and ambient conditions

Crop	Duration	ECC		Ambient condition	
		Days	Weight loss (%)	Days	Weight loss (%)
Mango	June-July	9	5.0	6	14.9
Banana	Oct-Nov	20	2.5	14	4.6
Grapefruit	Dec-March	70	10.2	27	11.9
Sapota	Nov-Dec	14	9.5	10	20.9
Lime	Jan-Feb	25	6.0	11	25.0
Kinnow	Dec-Feb	60	15.3	14	16.0
Potato	March-May	90	7.7	46	19.1
Tomato	April-May	15	4.4	7	18.6
Amaranth	May-June	3	11.0	<1	49.6
Methi	Feb-March	10	10.8	3	18.0
Parwal	May-June	5	3.9	2	32.4
Okra	May-July	6	5.0	1	14.0
Carrot	Feb-March	12	9.0	5	29.0

A study was conducted at ICAR-CIPHET, Abohar (Punjab) to understand the effect of storage conditions provided by evaporative cooling chamber (ECC), cold store (CS) and ambient conditions (room) on stored tomatoes. During study, room temperature varied from 30 to 45°C whereas, evaporative cooling chamber (ECC) provided the temperature 5 to 10°C lower than room temperature. Ambient RH varied from 15 to 56% whereas RH inside ECC was found to be 74-80%. Temperature and RH inside cold store was set as 5°C and 90%, respectively. Tomato samples were stored for a period of 15 days and were analyzed for selected physico-chemical parameters like physiological loss in weight (%), colour, texture, pH and total soluble solids (°Brix). It was observed that lower the storage temperature lesser was the changes in physico-chemical properties and vice versa. At the end of storage period, physiological loss in weight was more in tomatoes stored at room temperature (16%) followed by ECC (7%) and cold store (2%). Remaining parameters showed similar results. Thus, tomatoes stored at room temperature showed more quantitative as well as qualitative losses compared to that stored in ECC structure. At room conditions, temperature was higher and RH was lower compared to ECC structure which resulted in severe deterioration in quality.

SUMMARY

Storage structure for fruits and vegetables hold huge importance considering in mind the amount of postharvest losses taking place in a developing country like India. In this aspect information regarding low cost storage structures for holding fruits, vegetables and other horticultural produce is even more important. In India where major population of farmers is poor, stay in the remote locations they can only afford construction of low cost storage structures to overcome gluts, limiting price falls and overcome shortage of a particular commodity when prices are high.

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