LOW COST STORAGE TECHNOLOGIES FOR PRESERVATION OF HORTICULTURAL PRODUCE AND FOODGRAINS

India produces about 46.97 million tonnes of fruits, 88.62 million tonnes of vegetables, and 227 million tonnes of foodgrains including14 million tonnes of pulses annually. Being a potential source of minerals, vitamins, proteins and carbohydrates, these agricultural commodities play an important role in the health and nutritional security of the people. Proper packaging, storage and processing will utilize market surplus during glut season and thus give a boost to the food industry. Cereals and pulses are important components of Indian food as they serve as a major source of dietary protein for a vast majority of people. Horticultural crops are considered a viable diversification proposition for the traditional foodgrain crops owing to their higher per unit returns.

Owing to improper post-harvest operations, especially storage, over 10% of foodgrains and 30-40% of the fruits and vegetables produced in the country are lost resulting in poor returns to farmers and high cost to consumers. While dry foodgrains can be stored in bulk without significant damage for relatively longer period of time, storage of fresh horticultural produce, being highly perishable, particularly under the tropical climate in India, is a major challenge needing immediate attention. Both foodgrains and horticultural produce are living entities and carry out all the vital activities such as respiration and/or transpiration, etc., while in storage. The spoilage of these commodities can be controlled to a large extent by maintaining proper storage conditions. This will go a long way in accelerating peri-urban agriculture. In this direction, the Indian Agricultural Research Institute has been working to provide indigenous low cost storage technologies for the preservation of different horticultural produce and foodgrains. The indigenous low cost methods for storage of horticultural crops and foodgrains are designed to check microbial, enzymatic and oxidative spoilage in the stored/preserved materials. These produces can be stored safely up to a few months without excessive spoilage. Specific storage technology would further cater to domestic and overseas markets.

To retain the freshness and for the storage of fresh fruits and vegetables for a short period, an on-farm storage chamber, known as Pusa Zero Energy Cool Chamber, was designed on the principle of evaporative cooling system. A solar refrigerator was also constructed for the storage of potato in the areas where electric supply was irregular. For safe storage of food grains, Pusa Bin/Pusa Kothar was constructed. For easy handling and safe storage of pigeonpea at the household level without any loss in quality, an economical container, known as Pusa Domestic Metal Bin, was made. A concentric onion storage structure was made to check the spoilage and for retaining the quality of onion during storage.

The description and utilities of different storage structures developed at the Indian Agricultural Research Institute, namely, Pusa Zero Energy Cool Chamber for fruits & vegetables, Solar Powered Cooling System for potato storage, Pusa Bin/Pusa Kothar for safe storage of foodgrains, Pusa Domestic Metal Bin for pigeonpea and Pusa Concentric Onion Storage Structure are given below:

1. Pusa Zero Energy Cool Chamber

Storage of fresh horticultural produce after harvest is one of the most challenging problems of a tropical country like India. Fruits and vegetables because of their high water content are liable to rapid spoilage. The spoilage of fresh fruits and vegetables can be controlled by reducing the storage temperature.

Pusa Zero Energy Cool Chamber

Refrigerated cool storage is not only energy intensive and expensive, but also involves large initial capital investment. Therefore, there is a need for low cost technology, which can be adopted widely.

Pusa Zero Energy Cool Chamber (Pusa ZECC) can be constructed easily anywhere with locally available materials like bricks, sand, bamboo, *khaskhas*/straw, gunny bags, etc., with a source of water. The chamber can keep the temperature 10-15°C cooler than the outside temperature and maintain about 90% relative humidity. Studies at different agro-climatic zones have shown it to be very useful. It is most effective during the dry season.

Small farmers can easily construct Pusa Zero Energy Cool Chambers (ZECC) near their fields and store a few days' harvest before dispatching it to the market. In this way, the farmers can avoid the clutches of the middlemen and are not forced to make any distress sale. In India, 90% of horticultural produce is sold in fresh form. Owing to the presence of middlemen, the price of horticultural raw material is 60-100% higher in *mandis* than in growing areas. Apart from farmers' fields, the cool chambers can be installed profitably wherever fruits and vegetables are held temporarily, e.g., (i) packing stations, (ii) village *mandis*, (iii) whole sale markets in metropolitan cities, (iv) railway stations, (v) interstate bus terminals, (vi) retail outlets, (vii) big hotels and institutional catering centres, (viii) defence establishments in remote places where supplies come once in a week or so, and (ix) fruits and vegetables processing factories.

The technology of Pusa ZECC was transferred to a large number of farmers and Krishi Vigyan Kendras through regular k*rishi vigyan melas* organized by IARI, training programmes sponsored by the National Horticulture Board, the U.P. Diversified Agriculture Support Project, and the Ministry of Food Processing Industry. The technology of Pusa ZECC is included in the Technology Vision 2020 documents of Technology Information Forecasting and Assessment Council (Department of Science and Technology), and of ICAR. The ICAR has also published a technology bulletin on this subject.

The following table gives a comparison of the storage life of different horticultural produce under cool chamber and ambient conditions.

Storage life of fresh fruits and vegetables in cool chamber and at ambient temperatures

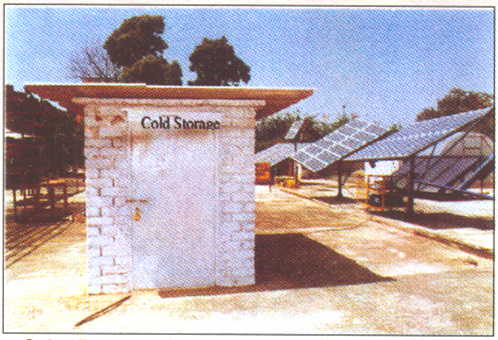
Crop	Part of the year	Cool chamber		Ambient temperatures	
		Days	Weight loss (%)	Days	Weight loss (%)
Mango	June-July	9	5.0	6	14.9
Banana	Oct.-Nov.	20	2.5	14	4.6
Grapefruit	Dec.- March	70	10.2	27	11.9
Sapota	Nov.- Dec.	14	9.5	10	20.9
Lime	Jan.-Feb.	25	6.0	11	25.0
Kinnow	Dec.-Feb.	60	15.3	14	16.0
Potato	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

Some specific advantages of Pusa ZECC

- Can be constructed by an unskilled person
- No mechanical or electrical energy needed
- Allows small farmers to store produce for a few days so that they are not forced to sell at low prices
- Reduces losses and pays for itself in a short time.
- Useful for temporary storage of curd, milk and cooked food.
- Can also be used for mushroom cultivation, sericulture, storage of bio-fertilizers, hardening of tissue-cultured plants, etc.

2. Solar Powered Cooling System for Potato Storage

For the safe storage of potato in the areas where electric supply is erratic or is not available, a Solar Powered Cooling System was developed and evaluated for its performance at IARI. The Solar powered cooling system consists of a photo-voltaic (PV) solar generator, two batteries, an inverter, a vapour compression refrigeration system and an insulated storage structure. The vapour compression refrigeration system is attached to the insulated storage structure of about 2.5 m^3 capacity. This system was evaluated by storing potato safely for about 5 months. The attainable temperature inside the cold store ranged from 8 to 10°C, while the averages of relative humidity were 81% and 86% without storage and with storage of potato, respectively. These are acceptable limits for storage of most of the horticultural produce. The technology has a great scope of adoption in areas with scarce power supply.



Solar Powered Cooling System for potato storage

Specifications

System	:	SPV Panel, 14 module @ 35 Wp
Storage batteries	:	2 lead acid batteries of 2.26 kWh capacity each
Inverter	:	1250 VA (to convert DC to AC)
System configuration	:	1/6 Hp compressor Condenser 0.337m^2 Evaporator 0.223m^2
Cooling chamber	:	2.5 m^3 volumetric capacity

Removable storage bin	:	$0.83\ m^3$
Potato storage capacity	:	650 kg
Cost	:	Rs. 1.00 Lakh

3. Pusa Bin/Pusa Kothar for Safe Storage of Foodgrains

Pusa Bin

Interaction of biotic factors such as insects, fungi, bacteria, mites, and psocids, and abiotic factors such as relative humidity/ moisture content and temperature leads to various kinds of deterioration of grains during storage. Studies have revealed that a moisture content below 9 per cent and an oxygen content less than 2 per cent do not permit the development and multiplication of biotic agents. However, the grains are hygroscopic in nature and tend to absorb or loss water from the atmosphere depending upon the prevailing relative humidity. The storage container or structure, thus, plays a vital role in restricting the moisture content to a safe level. With these points in view, a Pusa Bin was developed at IARI during late 1960's and later modified as Pusa Kothar in 1974. The structures have proven record, and are widely acclaimed and adopted by farmers. A large number of structures were constructed at Patna (Bihar), Raebareli, Sultanpur, Deoria and Ghaziabad (U.P.) and at Cuttack (Orissa) by this Institute and the Centre for Environment, Agriculture and Development.

Pusa Bin

Characteristic features of Pusa Bin

- Moisture proof
- Air tight
- Thermally insulated
- Rodent proof

- Eco-friendly(use of chemicals avoided)
- Economical and within the reach of poor farmers

Material required for construction of a 1000-kg capacity Bin

Polythene sheet 1000 gauge	=	6.50 m
Unburnt bricks	=	900
Burnt bricks	=	95
Wood	=	Small quantity to give support to the roof
Exit pipe (Outlet)	=	One
Cost	=	Rs. 700/- (approximately)

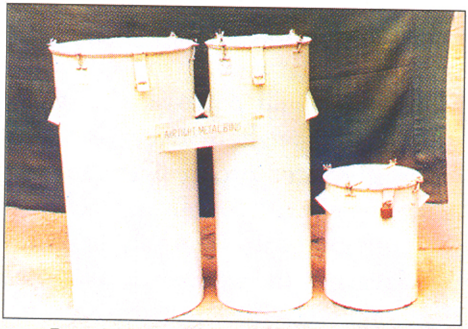
The size of the structure can vary depending on the requirement of the user. The Pusa Bin is constructed over the floor made of burnt bricks. A platform of unburnt bricks is made over the hard floor. A polythene film extending by 6 cm on all the extremities is placed over the platform and covered with another layer of unburnt bricks thus sandwitching the polythene sheet between the two layers. On the border of the platform, the walls with unburnt bricks are raised to the desired height and a roof is laid using mud slabs. A wooden frame gives support to the roof. A polythene cover, similar to mosquito net, is made and put over the structure. Thereafter, the outer wall, up to a height of 45 cm, is constructed with burnt bricks to make it rodent proof. The remaining portion of the wall is constructed with unburnt bricks. Similarly, the roof is again laid with mud slabs. The polythene sheet gets sandwiched between two layers of the structure on all the six sides. While raising the walls, a pipe is fixed near the bottom for taking out grains and a square hole is made in the roof for filling of the grains. The structure has to be dried and then filled with grains dried below 9 per cent moisture content. The structure can be used for a number of years provided due care is taken.

Pusa Kothar

The materials required for the construction of Pusa Kothar are the same as in Pusa Bin. Pusa Kothar was developed to avoid the wastage of space all around and to bring about the reduction in cost. It is a modified version of Pusa Bin. The existing 2 or 3 walls of the room are utilized to make the structure. And they serve as outer walls of Pusa Kothar, and then polythene sheet is spread over these existing walls. Later on, an inner wall is erected thus sandwiching the polythene sheet in-between the layers of the walls. The experiments were conducted way back in the Division of Entomology before releasing the technology for adoption by the farmers. A booklet related to details was also published. During the last ten years, the structures were built at various places (45 at Sultanpur, 14 at Raebareli and 8 at Ghaziabad in Uttar Pradesh; 12 at Patna in Bihar and 7 at Cuttack in Orissa). Besides, the farmers have been making these structures on their own with the help of Entomologists. For more details and help, one may contact the Head, Division of Entomology, IARI, New Delhi.

4. Pusa Domestic Metal Bin for Pigeonpea

There is a need of proper storage structure for pigeonpea at domestic level due to considerable post harvest loss. The consumers not only have to pay higher price but are also forced to use chemicals for the control of insects and pests, which are harmful to public health in general and family in particular.



Pusa Domestic Metal Bins for pigeonpea

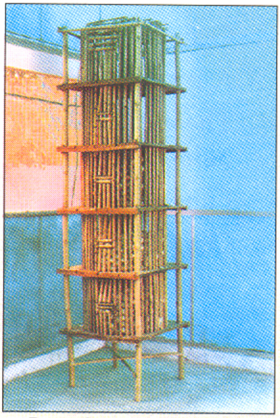
The Pusa Domestic Metal Bin developed by the Institute is a device for storing pigeonpea at household level without use of any chemical. The metal bins are developed in 25 kg, 50 kg and 120 kg capacities, which can be used by the consumers depending on their requirements. It comprises a cylindrical bin body, base, bottom ring, top lid assembly and two lifting handles. The bins have been constructed from G.I. sheet and joints are made with G.I. rivets. The bins are made airtight by pasting a rubber gasket at lower side on the periphery of top lid assembly and by tightening fly nuts and bolts. Some specific advantages of Pusa Domestic Metal Bins are given below:

Some specific advantages

- It is easy to handle and simple in construction
- It is moisture-proof, insect-proof and rat-proof
- It does not need any chemical for fumigation to control insects
- It helps in maintaining clean and hygienic environment in the house
- It provides an opportunity to purchase pigeonpea for family consumption for one year at cheaper rate during harvesting season
- It protects stored grain from all sorts of physical, chemical, mechanical and biological factors
- It is economical on unit storage cost basis
- It can store well sorted, washed and dried (up to 7% moisture content) pigeonpea for more than one year without any loss in quantity as well as quality and without the use of any chemical.

5. Pusa Concentric Onion Storage Structure

Considerable quantity as well as quality of onion is lost during post harvest period owing to lack of proper onion storage structures in rural area. The farmers not only get less price for their produce but also the environment is polluted because of spoilage of onion.



Pusa Concentric Onion Storage Structure

A concentric onion storage structure (5 tier) of 250 kg (5x50) capacity, made of bamboo and wooden planks, was developed by the Institute.

The size of structure can vary depending upon the requirements of the consumers. Pusa Concentric Onion Storage Structure can be used by small and marginal farmers and the consumers in rural as well as urban areas.

Concentric Onion Storage Structure (5 tier) comprises a concentric cylinder made of bamboos, a wooden base, an inlet and an outlet in each tier, four supporting legs and a top cover. The inner and outer walls are made of 25 mm dia. bamboos. The base of each tier is made of 740 mm x 740 mm perforated wooden planks. The whole structure is supported on four 50 mm dia. bamboos one at each corner. The height of bottom base above the ground level as well as the height of each tier is 450 mm. Each tier of the structure has one inlet at the top for filling and one outlet at the bottom for emptying. The top tier has a folding cover made of bamboo splits. The cost of storage of onion in this structure has been estimated as Rs.2.21/kg. Some specific advantages of Pusa concentric onion storage structure are given below:

Some specific advantages

- Robust in construction
- Peel and pulp of onion is not damaged during loading and unloading
- Onion is not damaged because of compressive load
- Occupies less space in the house or shed
- A rural artisan can easily construct the structure
- There is reduction in the quantitative and qualitative loss of onion
- Fungal infection and spoilage of onion is minimized
- Onion fetches better sale price
- The environment pollution is minimized

It could store well cured, sorted and graded onion from June to September without much loss in PLW (6%) and rotting (9%) in comparison to control having 15% PLW and 21% rotting.