EVAPORATIVE COOLING

Background

Much of the post-harvest loss of fruits and vegetables in developing countries is due to the lack of proper storage facilities. While refrigerated cool stores are the best method of preserving fruits and vegetables they are expensive to buy and run. Consequently, in developing countries there is an interest in simple low-cost alternatives, many of which depend on evaporative cooling which is simple and does not require any external power supply.

The basic principle relies on cooling by evaporation. When water evaporates it draws energy from its surroundings which produces a considerable cooling effect. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. The efficiency of an evaporative cooler depends on the humidity of the surrounding air. Very dry air can absorb a lot of moisture so greater cooling occurs. In the extreme case of air that is totally saturated with water, no evaporation can take place and no cooling occurs.

Generally, an evaporative cooler is made of a porous material that is fed with water. Hot dry air is drawn over the material. The water evaporates into the air raising its humidity and at the same time reducing the temperature of the air. There are many different styles of evaporative coolers. The design will depend on the materials available and the users requirements. Some examples of evaporative cooling designs are described below.

Pot designs

These are simple designs of evaporative coolers that can be used in the 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 double pot design is the Janata cooler, developed by the Food & Nutrition Board of India. 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 hot ground.

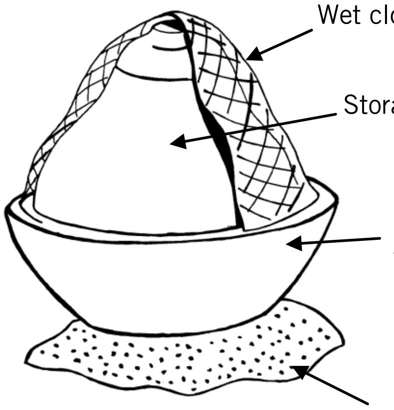

Figure 1: A Janata Cooler
Illustration: Practical Action / Neil Noble.

Mohammed Bah Abba a teacher in Nigeria, developed a small-scale storage "pot-in-pot" system that uses two pots of slightly different size. The smaller pot is placed inside the larger pot and the gap between the two pots is filled with sand. Mohammed won the Rolex 200 Award for Enterprise for his design. Further details are in Number 4 Volume 27 Oct/ Dec 2000 of *Appropriate Technology.*

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In Sudan, Practical Action and the Woman's Association for Earthenware Manufacturing have been experimenting with the storage design of Mohammed Bah Abba. The aim of the experimentation was to discover how effective and economical the Zeer storage is in conserving foods. Zeer is the Arabic name for the large pots used. The results are shown in the following table.

Produce	Shelf-life of produce without using the Zeer	Shelf-life of produce using the Zeer
Tomatoes	2 days	20 days
Guavas	2 days	20 days
Rocket	1 day	5 days
Okra	4 days	17 days
Carrots	4 days	20 days

Table 1: Vegetable shelf-life

As a result of the tests, the Woman's Association for Earthenware Manufacturing started to produce and market the pots specifically for food preservation.

Figure 2: The Zeer pot cooling system.
Photo: Practical Action Sudan.

A bamboo cooler

The base of the cooler is made from a large diameter tray that contains water. Bricks are placed within this tray and an open weave cylinder of bamboo or similar material is placed on top of the bricks. Hessian cloth is wrapped around the bamboo frame, ensuring that the cloth is dipping into the water to allow water to be drawn up the cylinder's wall. Food is kept in the cylinder with a lid placed on the top.

An Almirah cooler

The Almirah is a more sophisticated cooler that has a wooden frame covered in cloth. There is a water tray at the base and on top of the frame into which the cloth dips, thus keeping it wet. A hinged door and internal shelves allow easy access to the stored produce.

A charcoal cooler

The charcoal cooler is made from an open timber frame of approximately 50mm x 25mm (2" x 1") in section. The door is made by simply hinging one side of the frame. The wooden frame is covered in mesh, inside and out, leaving a 25mm (1") cavity which is filled with pieces of charcoal. The charcoal is sprayed with water, and when wet provides evaporative cooling. The framework is mounted outside the house on a pole with a metal cone to deter rats and a good coating of grease to prevent ants getting to the food.

The top is usually solid and thatched, with an overhang to deter flying insects (Not shown in Figure 2).

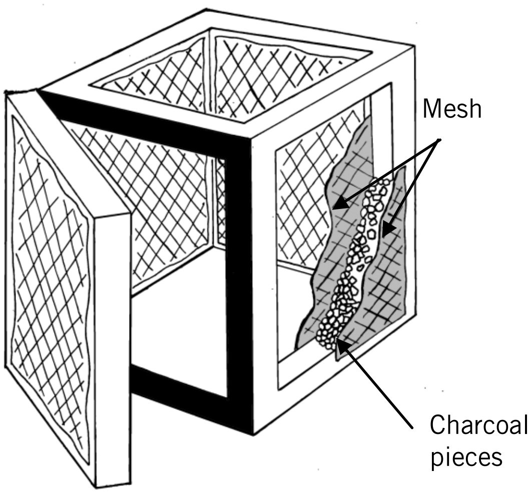

Figure 3: A charcoal cooler.
Illustration: Practical Action / Neil Noble.

All cooling chambers should be placed in a shady position, and exposure to the wind will help the cooling effect. Airflows can be artificially created through the use of a chimney. For example using a mini electric fan or an oil lamp to create airflows through the chimney - the resulting draft draws cooler air into the cabinet situated below the chimney. The Bhartya cool cabinet uses this principle to keep its contents cool. Wire mesh shelves and holes in the bottom of the raised cabinet ensure the free movement of air passing over the stored food.

Static cooling chambers

The Indian Agricultural Research Institute has developed a cooling system that can be built in any part of the country using locally available materials.

The basic structure of the cooling chamber can be built from bricks and river sand, with a cover made from cane or other plant material and sacks or cloth. There must also be a nearby source of water. Construction is fairly simple. First the floor is built from a single layer of bricks, then a cavity wall is constructed of brick around the outer edge of the floor with a gap of about 75mm (3") between the inner wall and outer wall. This cavity is then filled with sand. About 400 bricks are needed to build a chamber of the size shown in Figure 3 which has a capacity of about 100kg. 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 the sun by making a roof to provide shade.

After construction the walls, floor, sand in the cavity and cover are 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 system can also be added as shown in Figure 3.

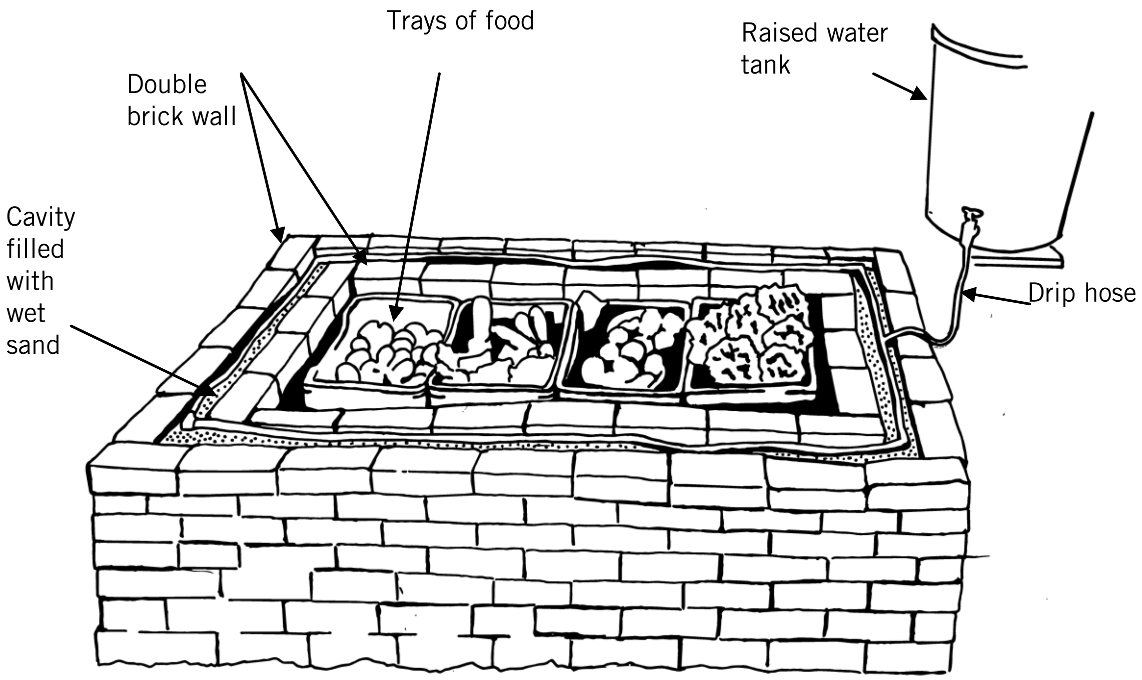

Figure 4: A static cooling system. Illustration: Practical Action / Neil Noble.

Naya cellar storage

Practical Action Nepal has been successful in transferring cooler technology, similar to the Indian Agricultural Research Institute design, especially to rural areas. It is called the Naya Cellar Storage and was originally designed by Dr. Gyan Shresthra from the Green Energy Mission and Mr. Joshi. It is comparatively easy to adapt the design to the users' requirements and the construction is made from locally available materials. The results have been encouraging for rural food processors who had little or no income and have been unable to acquire costly refrigerators.

The following basic materials are required to construct the Naya Cellar Storage:
1. Bricks -1200-1500
2. Sand - 400-500 Kilograms (880 lb – 1100 lb)
3. Polythene hose - 6 meters (26')
4. Water tank/bucket – 100 litre capacity (22 gal)
5. Bamboo/wood – 1.82 meters (6') two pieces and 2.15 meters (7') two pieces
6. Straw - 2 bundles
7. Sacks

Construction details
Choose a small piece of land about 1.52 meters square (5'x 5') facing away from the sun or where the sun does not shine directly. The ground should slope a little so that ground water drains away and does not seep into the chamber.

The size of the cellar storage can be varied to suit the user. The greater the volume to be stored, the bigger the size of the chamber. Normally, a 0.92x1.22 meters (3'x 4') rectangular mortarless stone or brick structure is built to a height of around 1.22 meters (4').

A layer of sand, about 25mm (1") thick is, spread on the ground over the area where the chamber is to be built and a layer of bricks or stones is laid onto the sand.

A doubled walled chamber is created from the bricks. The gap between the outer and inner wall of the chamber is about 125mm (5"). The cavity between these two walls is filled with clean sand. It should be free from soil to ensure against contamination from organic impurities. A high-density polythene hose with pinholes made along its length is laid on the sand within the cavity. The hose is blocked at the end so that water released from a tank spreads through these holes and keeps the sand moist. A thatched roof supported by four bamboo poles is placed above the cool chamber.

To keep the chamber cool, the circulation of air around the chamber must be unhindered. The air around the chamber is cooled by the effect of the water evaporating from the porous bricks and sand thus prolonging the shelf-life of the food stored within it. Sacks and bamboo sticks are used to cover the chamber, which is kept moist by sprinkling water

Operation
To prevent damage to the fruit and vegetables they should be carefully stored in bamboo or plastic mesh trays/baskets takes place. The trays/baskets have four legs so that their contents are raised off the floor of the chamber. The flow of water through the hose needs to be regulated in response to changes in the outside temperature to allow conditions within the chamber to remain constant.

> In one of the villages where Practical Action Nepal has been installing 'Satso' solar dryers, one young mother also had a Naya cool chamber and was successfully storing cabbage and ginger for up to 2 weeks longer than she had done without the chamber. She used locally available stones from rivers to construct the walls, and covered the chamber with a piece of sack mounted on a criss-cross of bamboo.

References and further reading

- *Evaporative Cooling - The Ceramic Refrigerator* Technical Drawing
- *Evaporative Cooling - The Clay Refrigerator* Technical Brief
- *Evaporative Cooling in Gambia* Stories of Change
- *Evaporative Cooling in India* Stories of Change
- *Cooling your cucumbers* Appropriate Technology Journal Volume 24, Number 1 June 1997 page 27
- *Kitchen Trails,* Food Chain, Number 18 July 1996, Practical Action

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- *Cooling without Power,* Food Chain, Number 12 July 1994, Practical Action
- *Keep it Cool: Quality Maintenance of Vegetables and Fruit During Storage*, AT Source Volume 19 Number 2
- *Village-level Technology for Better Life & Higher Income*, UNICEF has two pages describing an evaporative charcoal cooler
- *Appropriate Village Technology for Basic Services*, UNICEF
- *Tomato and Fruit Processing, Preserving and Packaging, An example of a village factory,* Guus de Klein, TOOL. There is a description of a charcoal evaporative cooling room in this book.
- The Centre for Alternative Technology has a leaflet entitled *Green Refrigeration*. This provides useful information on the best designs of standard refrigerators.
- Changing Villages: Rural News and Views Vol. 14, No 2 April-June 1995, Consortium on Rural Technology (CORT)

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