

A study on advance solar passive cool chamber (friz without electricity)

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ABSTRACT

Due to harsh conditions, fruits & vegetables after being harvested tend to have high deterioration and low shelf life. This paper deals with the increase in their shelf life and decrease in their deterioration rate using a solar passive cooling chamber which is most suited for countries like India where the weather is dry and hot. The equipment operates on the zero energy phenomenon and principle of direct evaporative cooling and the Trombe's wall effect. The efficiency of solar passive cooling chamber depends mainly on humidity of the surrounding air. This paper reviews some new modifications in the cooling chamber like the placement of bricks to the flow of air. This chamber can be used to preserve the fruits and vegetables for next 5-6 days after being harvested. The loading capacity of the chamber is around 200kg and requires 45-50litres daily for the soaking of insulating material.

INTRODUCTION

In India quality deterioration of horticultural produce takes place immediately after harvest due to lack of on-farm storage. India is the second largest producer of fruits and vegetables in the world after Brazil and China respectively. Storage of fresh horticultural produce after harvest is one of the most pressing problems of a tropical country like India. Due to their high moisture content, fruits and vegetables have very short life and are liable to spoil. Moreover, they are living entities and carry out transpiration, respiration and ripening even after harvest.

Due to the short shelf life of these crops, it is estimated that about 30 to 35% of India's total fruits and vegetables production is lost during harvest, storage, grading, transport, packaging and distribution in a year which reduces the growers share. Only 2% of these crops are processed into value added products. Hence, there is a need for maximum commercial utilization of fruits and vegetables. If the nutritive value of the processed food products could be maintained, this sector will emerge as a major value-added food industry. At present, the grower is getting hardly 25-35 paisa of out of a rupee of the consumer. Therefore, there is a need to evolve a marketing system where benefit is prevailed to both growers and consumers. The fruits and vegetables, being perishable, need immediate post-harvest attention to reduce the microbial load and increase their shelf life, which can be achieved by storing them at low temperature and high relative humidity conditions. These conditions are usually achieved in cold storages.

Several simple practices are useful for cooling and enhancing storage system efficiency wherever they are used, and especially in developing countries, where energy savings may be critical. Mechanical refrigeration is, however, energy intensive and expensive, involves considerable initial capital investment, and requires uninterrupted supplies of electricity which are not always readily available, and cannot be quickly and easily installed. Available cold storage in India is used primarily for the storage of potatoes. Appropriate cool storage technologies are therefore required in India for on farm storage of fresh horticultural produce in remote and inaccessible areas, to reduce losses. Low-cost, low-energy, environmentally friendly cool chambers made from locally available materials, and which utilize the principles of evaporative cooling, were therefore developed in response to this problem. These cool chambers are able to maintain temperatures at 10–15 °C below ambient, as well as at a relative humidity of 90%, depending on the season.

The evaporative cooled storage structure has proved to be useful for short term, on-farm storage of fruits and vegetables in hot and dry regions. Evaporative cooling is an efficient and economical means for reducing temperature and increasing the relative humidity of an enclosure, and has been extensively tried for enhancing the shelf life of horticultural produce which is essential for maintaining the freshness of the commodities. Evaporative cooling is an environmental friendly air conditioning system that operates using induced processes of heat and mass transfer where water and air are working fluids.

Such a system provides an inexpensive, energy efficient, environmentally benign (not requiring ozone-damaging gas as in active systems) and potentially attractive cooling system

In this paper, an attempt is made to review the basic concepts and principle, use of solar energy to increase the flow of air and the alignment of the bricks in order to have more passage of air through the bricks.

Trombe wall:-

A Trombe wall is a passive solar building technique where a wall is built on the winter sun side of a building with a glass external layer and a high heat capacity internal layer separated by a layer of air. Heat in close to UV spectrum passes through the glass almost unhindered then is absorbed by the wall that then re-radiates in the far infrared spectrum which does not pass back through the glass easily, hence heating the inside of the building. Trombe walls are commonly used to absorb heat during sunlit hours of winter then slowly release the heat over night. Trombe walls may be constructed with or without internal vents. Non-vented walls rely on conduction through the wall to heat the

space behind the wall, while vented walls allow the user to actively or passively circulate room air past the heated

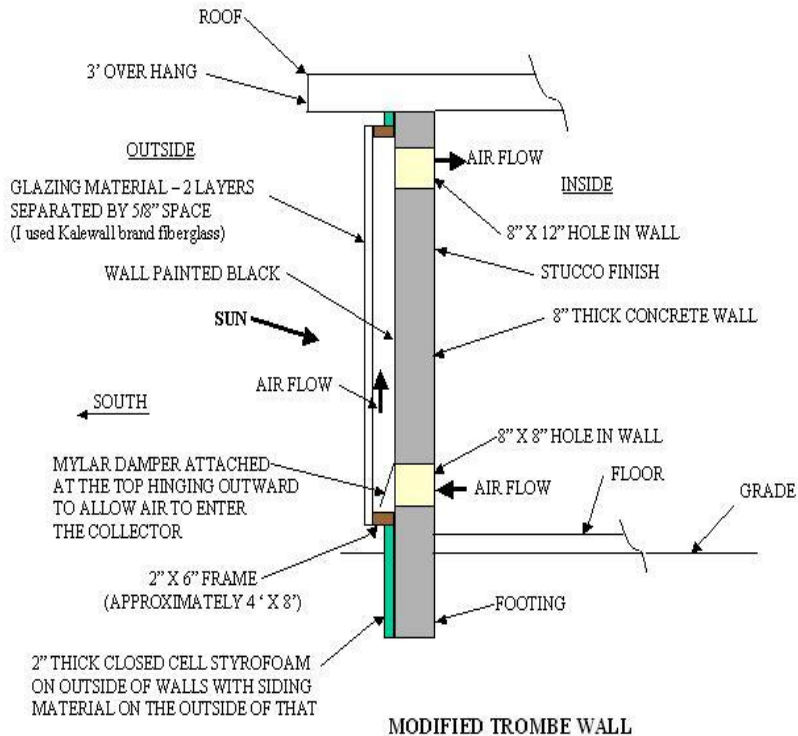


Fig 1: Modified Trombe wall

side of the wall for more immediate heating. Vented Trombe walls may use passively or actively controllable flaps to prevent convection in the undesired direction, as when the wall cools at night in winter or heats during the day in summer. In climates that have higher summer temperatures Trombe walls may also be designed with external vents to improve the shedding of heat at night. Vented walls offer the advantage of being able to shed more heat earlier in the evening when it is more commonly required while higher heat capacity non-vented walls offer the advantage of improved overall diurnal stability. Views differ among the passive solar community as to which is more advantageous.

A simplistic rule of thumb that is often used when designing dense masonry walls is that heat will be absorbed and lost at around two hours per inch.

Experimental setup

Constructional details:-

For the construction of solar passive cooling chamber we should select the site for the construction of the cooling chamber, depending on the requirement of storage of vegetables and other types of fruits or flowers.

The construction of the solar passive cooling chamber in continuous steps as follows:-

1. Base of the solar passive cooling chamber-

The main base of cooling chamber should have the sufficient strength to providing the strength in different weather conditions .In the rainy days the mud laying at the bottom of cooling chamber may be removed and thus the main base should be a cemented surface.

- **Length** = 330 cm
- **Width** = 240 cm
- **Area** = 79200 cm²

In this cooling chamber the main base is cemented and there are 30 pillars of doubles bricks and 15 pillars of singles bricks that are placed on the main base. Height of each pillar is 22 cm. At the middle of main base some pillars are arranged in zigzag manner so as to contain the cooling. The mixture of sand and water is filled in between the pillars.

Now for making the sub-base on the pillars a single brick layer is constructed. The dimension of sub-base is as follows:-

- **Length** = 240 cm
- **Width** = 180 cm
- **Area** = 43,200cm



Fig 2: Main base with pillars



Fig 3 : Sub-base

2. **Outer wall and inner wall of solar passive cooling chamber:-**

The outer wall is constructed over the sub-base and the dimensions of it is :-

- **Length** = 208 cm
- **Width** = 193 cm
- **Height** = 60 cm
- **Thickness** = 11.43cm

We modified the arrangement of the bricks in the outer and inner wall .We arranged the outer wall bricks in horizontally manner and **average gap** between the two bricks is **1.2 cm** so that the flow of air into the cooling chamber can be at maximum level which can lead to the increase in cooling rate.

Inner wall is to be constructed for the cooling chamber in which the material will be stored. The arrangement of the bricks are placed or fixed as vertically because the air passing from the bricks can be increased. Thickness of the inner wall is 6.5 cm. Bricks are used in the whole project is of second grade which have more porosity then normal bricks. This type of brick absorbs more water and contain it for

long time. This results in the increased humidity inside the cooling chamber compared to normal grade bricks. The dimensions of main inside cooling chamber is following -:

- **Length** = 152.5 cm
- **Width** = 137cm
- **Height** = 63.5
- **Volume** = 13,26,674 cm³

The gap between the outer wall and inner wall is 10 cm. In this gap, jute bags as the insulating materials are inserted. These jute bags are best in absorbing absorbed the water and providing the cooling for longer time.



Fig 4: Outer wall of chamber



Fig 5: Gap between outer wall and inner wall

3. Gate of cooling chamber :-

There are three gates that are used to cover the chamber. They are used to maintain the moisture inside the cooling chamber. The gates are made by steel wire in a cage like structure. The jute bags are inserted in between the gate present in the gate. The dimensions of each gate are following:-

- **Length** = 55 cm
- **Width** = 150 cm
- **Thickness** = 1.5 cm



Fig 6: Gates are placed on cooling chamber

4. **Black surfaces of cooling chamber:-**

This is the modification that we are introducing in the cooling chamber. Solar passive cooling chamber increases the air flow rate inside the cooling chamber. The concept of making the south faced wall of the cooling chamber with black color is to increase the air flow based on the Trombe's effect.

Dimension of the black coated wall is as follows:-

- (a) **Vertical wall area, $A_1 = 5770.6 \text{ cm}^2$**
- (b) **Horizontal wall area, $A_2 = 7320 \text{ cm}^2$**
- (c) **Triangle shape walls area, $A_3 = 3600 \text{ cm}^2$**

The total area of black coated surface is

$$A = A_1 + A_2 + A_3 = 16690.6 \text{ cm}^2$$

5. **Glass properties and it's dimensions:-**

The purpose of using extra clear glass is to increase the passive cooling and increase the air flow rate inside the cooling chamber. This glass is used to trap the heat and flow of air from cool region to hot region and pass the fresh air continuously. This glass should be clear and less bluish i.e. the iron content must be less in the glass. The glass is divided in two sections.

Dimensions of the each glass as following:-

- **Length = 81 cm**
- **Width = 66 cm**

The framing should be proper so as to avoid the leakage of air from that region and also it will be easier to change the glass if broken. The framing is made of the teakwood which also provides the strength to the glass.



Fig 7: Extra clear glass

Modifications:-

- Introduction of solar passive house in cooling chamber which works on temperature difference.
- Outer walls of cooling chamber have an average gap of 1.2cm in between the bricks.



Fig 8: Arrangement of bricks

- At the south facing wall, extra clear glass at 45° is used for heat trapping in that region.



Fig 9: Solar passive region

- Inner walls of chamber have bricks in vertical direction which have 2.5 mm thickness.



Fig 10: Gap between inner and outer wall

- Automatic water flow circulation on the jute bags.



Fig 11: Automatic water circulation

Conclusion:-

The solar passive cool chamber can maintain relatively low inside temperature and high relative humidity as compared with outside temperature and relative humidity. Temperature inside the solar passive cool chamber can be reduced through the process of an evaporative cooling mechanism and by using shading device to protect the solar passive cool chamber against direct exposure to solar radiation. The moisture condition on the walls in the solar passive cool chamber and the ground condition also help to maintain higher relative humidity. The cool chamber increased the shelf life of vegetables significantly. Most significant change in shelf life was recorded in case of ladyfinger, green chilies and brinjal.

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