

On-Farm Evaporative Cooled Storage Structure

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ABSTRACT: Most of the post-harvest activities of the agricultural farms are being done in open under relatively adverse environmental conditions, which in turn enhances the post harvest losses besides drudgery to the farm workers. To provide appropriate suitable working environment for the persons as well as to the produce, an On-Farm Structure using evaporative cooling concept has been designed and developed. The structure is suitable for carrying out different on-farm post harvest activities such as sorting, grading, washing, trimming, peeling etc. besides on-farm storage of the perishable commodities. Different components of the structure such as walls, roof, wet pad system, water supply system, natural air draft system, etc. have been designed as per the normal requirement of green vegetables. The structure was constructed and evaluated in field. It was found that very pleasant environment of about 10-12°C lower temperature than the outside ambient could be maintained inside the structure. All the activities mentioned above could be performed comfortably inside the structure. The on-farm structure was also found suitable for intermediate storage of about 2000 kg of vegetables. The shelf-life of the produce was almost three times higher than that under ambient conditions. The structure is easy to fabricate, install and operate. As it does not require electricity, and consume very little water, the total energy cost for carrying out the post harvest activities and intermediate storage of perishable commodities is almost negligible.

KEYWORDS: Evaporative Cooled (EC), Evaporatively Cooled Storage Structure (ECSS). Relative Humidity (RH), On-Farm Storage Structure, Shelf-Life.

I. INTRODUCTION

India is second largest producer of fruits and vegetables in the world after China, but wastages about 30%, due to lack of information on post harvest practices and proper on-farm storage facilities [Dadhich et al, 2008; Kadar, 1987; Dash et al, 2006]. A wide range of vegetables are grown under India's varying agro-climatic conditions but considerable amount of perishable produce is lost due to poor post-harvest practices [Pal et al; 1998]. Higher the temperature of handling more is the rate of respiration and other biochemical processes, resulting in more loss of quality and nutritive value [Chopra, 2009].

The post-harvest activities at the farm are being done in the open under relatively adverse environmental conditions which in turn enhance post-harvest losses causing fatigue to the persons carrying out these activities. Cold storage facilities cannot be constructed at farm level because of both high investment and operating cost and is not suitable for rural or on-farm storage [Dash and Chandra, 2001, Dash et al, 2006]. To provide appropriate working atmosphere for the persons as well as suitable environment to the produce for on-farm post-harvest handling of perishables, at present there is no system which can serve the purpose. Keeping these facts in mind, a post-harvest activity structure suitable for perishable commodities has been developed, using evaporative cooling principle.

II. REVIEW OF LITERATURE

Evaporative cooling storage structure (ECSS) is a double wall structure having space between the walls which is filled with porous water absorbing materials called pads (Roy and Khurdiya, 1986; Singh and Satapathy, 2006).

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ECSS due to their low investment, almost no energy requirement and with other advantages over refrigeration system become a quite popular and better alternative for storage of horticultural produce (Dash and Chandra, 2001; Rayaguru et al., 2010). In India hot and dry weather prevails for a significant part of the year. Ambient hot and dry weather is suitable for efficiently working of the evaporative cooling concept storage structure (Jha and Chopra, 2006; Vala and Joshi, 2010). Perishable agriculture commodities can be safely stored in ECSS. Evaporative cooling is the simplest and cheapest method for extending shelf life of fruits and vegetables and can also be used as ripening chamber (Bhatnagar et al., 1990; Das and Chandra, 2001; Dharmasena and Kumari, 2005; Jha, 2008; Okunade and Ibrahim, 2011).

Many scientists carried out its efficacy for increasing shelf-life of fruits and vegetables. The EC storage structure have been found suitable for extending shelf-life of potato, grape, orange, banana, carrots, ber, pointed gourd, aonla, leafy vegetables, sapota, kinnow, bitter guard, capsicum, cauliflower, pineapple, peach and some other fruits and vegetables (Roy and Pal, 1991; Das and Chandra, 1999; Das and Chandra, 2001; Singh and Satapathy, 2006; Jha, 2008). The EC storage structure can be utilized for short-term storage of perishable commodities, when outside climate is hot and dry.

The shelf life of bitter guard, capsicum & cauliflower was increased for 5 days whereas shelf life of tomato, pineapple, peach increased for about 6 to 9 days under evaporative storage as compared to ordinary room condition (Singh and Satapathy, 2006).

Jha (2008) reported the safe storage period of 50, 25 & 4 days for potato, kinnow and tomato respectively with 10% loss in weight. Mishra *et al.* (2009) observed the shelf life of potato 60 days as against 30 days in ambient storage while tomato was safely stored for 14 days as against 7 days at ambient condition. Mandarin fruit could be stored up to 42 days for retaining post-harvest quality reported by Bhardwaj and Sen (2003). Roy and Khurdiya (1986) reported that the shelf life of leafy vegetables increased to 3 days with PLW of 13-18 % from less than 1 day with PLW of 30-58 % at ambient and for other vegetables the shelf life was increased to 6 days with 5-6.8% PLW as compared to 1-3 days in the month of May-June. Shelf life of orange can be extended up to 32 days with less qualitative loss and PLW reported by Umbarkar et al. (1991). Pal et al. (1998) reported that the shelf life of kinnow mandarins can be increased up to 40 days in EC chamber as against 15 days at room temperature.

III. METHODOLOGY/MATERIALS AND METHODS

The evaporative cooled storage structure can be utilized for short-term storage of vegetables, when outside climate is hot and dry. The EC storage structures have been found suitable for extending shelf-life of vegetables [Dash and Chandra, 2001, Singh and Satapathy, 2006, Jha, 2008]. Construction and operating cost of mechanical refrigeration cold storage is very high and cannot be set-up in farm, even it is not economical too. ECSS can easily be constructed on farm.

Storage Structure

For storing 2 tons of produce, hut shaped evaporatively cooled storage structure (4500x3250x3750 mm) have been designed and developed as shown in figure1. The structure was erected on a cement concrete raised (300 mm above ground level) platform in the farm. The structure was fabricated using mild steel sections. The walls of the hut were fabricated from welded mild steel wire mesh. The slopping roof was covered with asbestos sheet. A natural ventilator was provided in the roof.

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Figure 1: On-farm evaporatively cooled storage structure

Pad holder

The pad holding system has been fabricated using 25x25mm welded wire mesh all around the four sides as shown in Fig. 1. Two vertical walls upto the height of 1800 mm was erected in such a way that an annular gap of 50 mm is created on all the four sides of the structure. Aspen wood was filled-up in the annular gap with a density of 25 kg/m³.

Walls

The wall portion above the pad holder was made from transparent fibre reinforced plastic sheets to facilitate sunlight inside the hut. The total height of the structure at side and at centre was 3750mm and 195mm respectively. The roof height of the hut was kept more to give some chimney effect for natural/induced draft air circulation.

Pad wetting system

To keep pad material continuously wet, a PVC pipe was laid over the pad holder at the top and connected to overhead water tank. Holes were made in the pipe at regular intervals for continuous dripping of water over the pad.

Roof

The roof consists of cement asbestos sheet arranged to form two sloping slides & arrangement of chimney was kept for air circulation. Also natural ventilator was provided in the roof for more circulation of air inside the storage structure.

Other details

A door of 750x1950 mm was provided at the front side of the hut for loading & unloading and other use. For greater movement of the warm air out from inside the structure, two motor-less turbo ventilators were fitted on either side of the sloping roof. These rotating ventilators move with the ambient wind velocity and create suction at the bottom, thereby causing the movement of air from inside the chamber to the outside. The air removing capacity of each ventilator at 15 kmph wind speed is 1250m³/h.

IV. RESULTS AND DISCUSSION

On-farm storage structure works on principle of evaporative cooling. Outside ambient air when passed through the wet pad, air gets cooled and humidified. The structure was evaluated for four years for the months between March to July, until onset of monsoon. The performance evaluation of the developed storage structure was done in terms of variation in temperature and relative humidity inside it both under no load condition as well as with vegetable loading.

No Load Testing

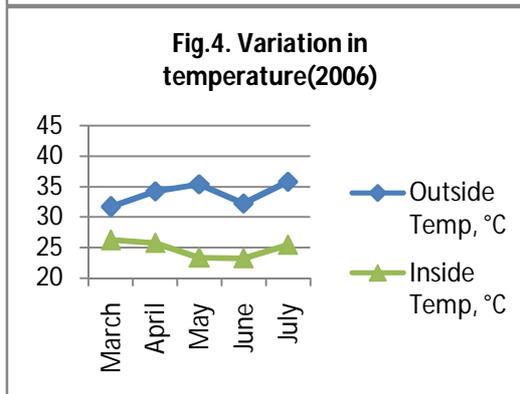
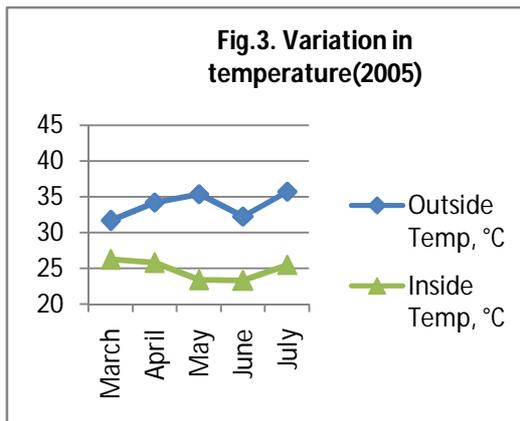
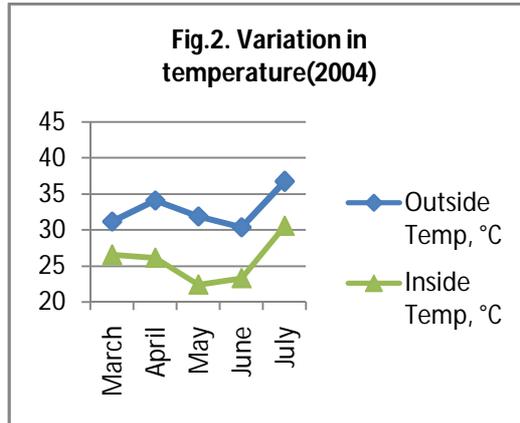
No agriculture produce were kept inside the storage structure and the observations regarding temperature and relative humidity inside the chamber were recorded at morning, noon and afternoon.

Variation in temperature: Inside the structure, average maximum temperature observed was 7-12°C lower than that of ambient. Average temperature drop of 7.1°C, 9.0°C, 10.0°C & 10.1°C were observed lower than ambient during the years 2004, 2005, 2006 & 2007, respectively (Fig. 2,3,4,and 5).

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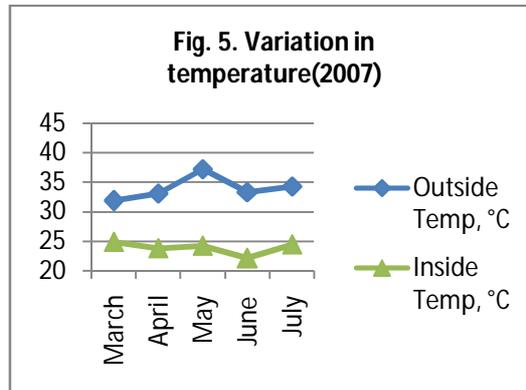
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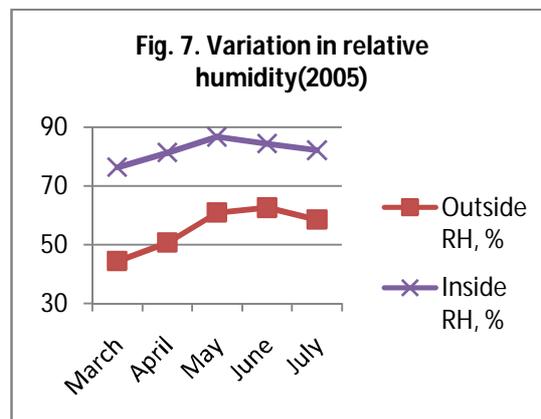
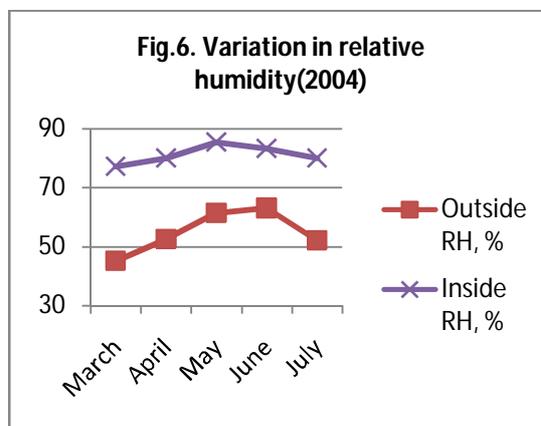
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Average reduction in temperature of 4.7°C, 5.5°C, 6.8°C, 7.0°C for the March, 7.9°C, 8.4°C, 10.5°C, 9.4°C for the April, 9.5°C, 12.0°C, 11.2°C, 13.0°C for the May, 7.1°C, 8.9°C, 10.2°C, 11.3°C for the June, and 6.2°C, 10.3°C, 11.3°C, 9.8°C for the July were observed during the year 2004, 2005, 2006 & 2007, respectively.

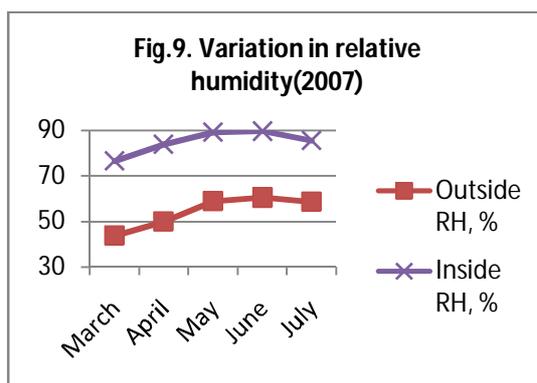
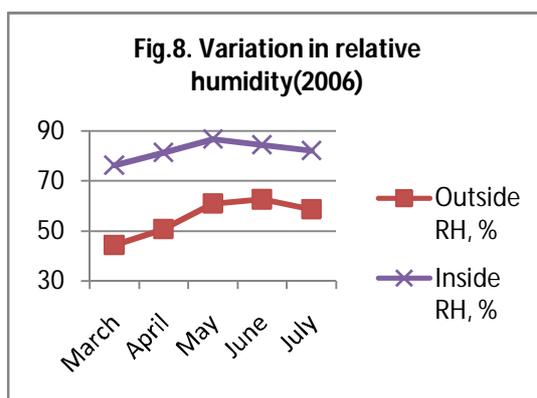
Variation in relative humidity: The average increase in RH inside structure was observed to be 26.39 – 30.67% lower than that of ambient. Average increase in RH was 26.39%, 26.73%, 26.73% & 30.67% during the year 2004, 2005, 2006 & 2007, respectively (fig. 6,7,8, and 9).



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With Load Testing

Fresh selected leafy vegetables (spinach, coriander, tandalajo & fenugreek) procured from the local market were immediately sorted and cleaned. Vegetables were weighed and kept in plastic crates. Two set of these were prepared with fixed sample size for each vegetable. One set was kept as control sample and kept under ambient condition, while other set of each vegetable was stacked inside the EC storage structure. The days of storage of each vegetable in structure are given in Table 1. Shelf-life of leafy vegetables was almost more than doubled when stored in developed structure as compared to the ambient storage. The vegetables were also seen to remain fresh and turgid throughout the storage.

Table 1. Storage life of leafy vegetables in EC structure.

Name of vegetable	Shelf-life(days)		
	Control storage	Inside structure storage	Gain over control storage
Spinach	1	3	2
Coriander	1	3	2
Tandalajo	1	3	2
Fenugreek	1	3	2

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V. CONCLUSIONS

From this study following conclusions can be made

- Considerable temperature reduction and elevation of RH of ambient air inside the on-farm EC structure is maintained during hot summer days for performing on farm post-harvest operations as well as storage of perishable produce.
- The shelf-life of stored leafy vegetables could be extended inside the structure by two-three times.
- As an inexpensive alternative of mechanical refrigeration, on-farm EC storage structure has potential for application in small-scale preservation of fruits and vegetables and by rural farmers.
- Maximum drop in temperature observed in the month of May and June as outside climate is dry & unsaturated during these months.
- Effectiveness of the on-farm EC storage structure depends on prevailing outside climatic conditions. In India hot and dry weather prevails for most of the time hence ECSS are suitable for short term storage of vegetables.
- On-farm EC storage structure could be adopted in places where cold storage facilities are not available and hot & dry weather prevails for a long period.
- On-farm ECSS helpful to reduce post harvest losses at the production place.

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