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Zero energy cool chambers for extending the shelf-life of green vegetables

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Abstract
A zero energy cool chamber (ZECC) consisting of a brick wall cooler and a storage container made of new materials has been developed. The ZECC requires no electric energy. The brick wall cooler made of bricks with a mixture of moistened sand with cement allows low inside temperature and high relative humidity to be maintained based on the principles of a natural evaporative cooling mechanism.
Several types of storage containers coated with different antibacterial materials were applied to reduce decay. For example, silver-ion (Ag+)coated storage containers were used to reduce decay and nutrition of vegetables. Washing of vegetables was also applied to the commodities in order to maintain freshness. Generally leafy vegetables, tomatoes and brinjals and cauliflowers had a shelf life of ½, 1, 1and 1 day at room temperature, respectively, as compared to 5, 6, 5 and 6 days in summer season when stored in the ZECC but in stored in winter season generally leafy vegetables, tomatoes and brinjals and cauliflowers had a shelf life of 1, 3, 2 and 2 days at room temperature, respectively, as compared to 10, 12, 11 and 12 days when stored in the ZECC.

Keywords: Room temperature, postharvest loss, relative humidity, shelf life, storage, Nutrition

1. Introduction
Fresh fruits and vegetables generally need proper postharvest management to reduce loss and maintain quality. Today, the postharvest handling practices regarding vegetables throughout the marketing channels in most developing countries remain inadequate. The growers have no storage facilities, while the transport and marketing channels also lack storage facilities. As a result, most harvested fruits and vegetables are usually stored in the open, exposed to high temperature and low relative humidity conditions, by a middleman, wholesaler or vegetables growers these commodities. The quality of fruits and vegetables, and related shelf life are reduced by the loss of moisture, decay and physiological breakdown, and such deterioration is directly related to storage temperature, relative humidity, air circulation, mechanical damage, and improper postharvest sanitation. High food prices are a major concern especially for low-income food deficit countries that may face problems in financing food imports, and for poor households that spend a large portion of their income on food. The combination of higher humidity and lower temperature facilitates extended shelf life. These conditions can be achieved by using a semi-underground storage system with moistened walls. The use of a shading curtain is also an effective means of reducing temperature. Higher humidity and lower temperature inside the ZECC offers a unique advantage for maintaining the firmness of fruits and vegetables by lowering the physiological loss in weight (PLW) and other metabolic processes.

2. Materials and methods
This experiment was conducted at Farmers Field under supervision of Krishi Vigyan Kendra palamu from April to August 2015 and October 2015 to January 2016. Two ZECCs were set up under the shaded place. Average room temperature of 25°C was recorded. The load condition refers to leafy vegetables, tomatoes, bringasl and cauliflowers stored inside the ZECC. No load condition refers to when the ZECC is empty. In addition to considering the physiological loss in weight a storage as an important indicator for qualitative evaluation, visual appearance in terms of stored vegetables (from bright to deep dark color) was checked, along with surface observation (from glossy to a spotted surface). The observations were made at one-day interval during the experiment period. The experiment used a total of fifty tomatoes and brinjals, and 20 cauliflowers and was repeated in both seasons.

Structure of the ZECC

Brick wall cooler - The complete randomized block design of the ZECC. The dimensions of the outer and inner brick walls were 151 (L) × 151 (W) × 50 (H) cm and 118 (L) × 118 (W) × 50 (H) cm, respectively. The 7.5-cm gap left between the outer and inner wall was filled with a mixture of sand (100%). Tap water was supplied to the sand area through drip irrigation using an valve. The cool chamber's storage area was 100 (L) × 100 (W) × 50 cm (H) in size. A bamboo made frame measuring 118 (L) × 118 (W) cm was used to cover the chamber.

2. Storage container

Use of Ag+ coated plastic container Silver ion (Ag+) is well known to possess antibacterial properties and much research has been conducted on Ag+ when used in nanosize form11, 17, 20, 22, 23, 34. Tomatoes and Brinjals stored inside the ZECC decayed due to microbial activities.

3. Qualitative evaluation

Physiological loss in weight determinationof leafy vegetables,tomatoes, brinjals and cauliflowers-Physiological loss in weight (PLW) is one of the main factors in determining the quality of stored fruits and vegetables. Observations of PLW and the shelf life of leafy vegetables, tomatoes, brinjals and cauliflowers were recorded periodically. The readings were made at one-day intervals during the experiment period. The shelf life of vegetables was determined on the basis of 5% PLW. A decrease of only 5% in PLW often results in a loss of freshness and a wilted appearance. The stored leafy vegetables, tomatoes, brinjals and cauliflowers were evaluated daily by using the digital electronic balance.

3. Results and discussions

1. Performance of the ZECC

The fundamental performance relative to temperature and relative humidity inside the ZECC was first investigated from the stand points of both dynamic and static characteristics. Table 1- Storage of vegetables on low cost technology (ZECC) and Table- 2 Storage of vegetables on benefit cost ratio. Table 1 –shows and finding from Table 1 show that that improve the shelf life of green vegetables under zero energy cool chamber compare to general storage in normal conditions. In winter season vegetables were storage in days like green leafy vegetables-10Days,Tomato-12Days,Brinjal-11Days and Cauliflower-12Days and summer season green leafy vegetables-5Days, Tomato-6Days, Brinjal-5Days and Cauliflower-6Days in respect of winter season general storage of green Leafy vegetables-1Day, Tomato-3Days, Bringal-2Days and Cauliflower-2Days and summer season 1/2Day, 1Day, 1Day and 1Day. Table -2 resulted was very beneficiary in benefit cost ratio likewise winter season green leafy vegetables-1.7, Tomato-2.9, Brinjal-3.5 and Couliflower-3.7 and summer season 3.0, 2.7, 3.5 and 5.3 compare then in general storage practice in winter season of green Leafy vegetables-1.0, Tomato-1.4,Bringal-2.8 and Cauliflower-2.6 and summer season 1.6, 1.5, 2.2 and 3.6. All vegetable growers were accepted to low cost technology ZECC and management of fresh vegetables and prevent spoilage of produce.

Table 1: storage of vegetables on low cost technology (ZECC)

Vegetables	General(Days)		ZECC(Days)	
	Winter	Summer	Winter	Summer
Leafy vegetables	1	½	10	5
Tomato	3	1	12	5
Bringal	2	1	11	5
Cauliflower	2	1	12	6

Table 2: storage of vegetables on benefit cost ratio

Vegetables	General(B:C)		ZECC (B:C)	
	Winter	Summer	Winter	Summer
Leafy vegetables	1.0	1.6	1.7	3.0
Tomato	1.4	1.5	2.9	2.7
Bringal	2.8	2.2	3.5	3.5
Cauliflower	2.6	3.6	5.3	3.7

Conclusion

A zero energy cool chamber (ZECC) consisting of a brick wall cooler and a storage container made of new materials has been developed. Generally leafy vegetables, tomatoes and brinjals and cauliflowers had a shelf life of ½, 1, 1and 1 days at room temperature respectively as compared to 5, 6, 5 and 6 days in summer season when stored in the ZECC but in stored in winter season generally leafy vegetables, tomato and brinjal and cauliflower had a shelf life of 1, 3, 2 and 2 days at room temperature, respectively, as compared to 10, 12, 11 and 12 days when stored in the ZECC.

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