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Research Paper :

Comparative study of low cost evaporative cooling systems for storage of tomato

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ABSTRACT

Tomato is the most important and remunerative crop in India. It undergoes physiological changes even after harvest. These changes have pronounced effect in chemical composition, keeping quality and spoilage. The fruit quality is mainly deteriorated due to physiological activities such as respiration, transpiration and also invasion due to disease causing pathogens. Three evaporative cooling systems to store the tomatoes *viz.,* Drip cooling chamber with gunny bag walls (T_1), Drip cooling chamber with Vetiver mat walls (T_2), Charcoal cooling chamber (T_3) and room temperature storage (T_0) were constructed. Treatment T_1 showed better results followed by treatment T_2, treatment T_3 and treatment T_0. The shelf-life of tomato in treatment T_1 was up to 21 days followed by treatment T_2 (18 days), treatment T_3 (15 days), treatment T_0 (12 days). Thus shelf-life of tomato was increased by 9 days in treatment T_1. Cost of evaporative cooling systems was estimated for Treatment T_1 as Rs.1,608.79 per meter cubic storage space followed by treatment T_2 as Rs.2,858.79 per meter cubic storage space, treatment T_3 as Rs.6,450 per meter cubic storage space. Considering the above all treatments, T_1 treatment *i.e.* Drip cooling chamber with gunny bag walls was best suited for storage of tomato with low cost and negligible operational cost.

Key words : Evaporative cooling, Storage structures for fruits and vegetables, Storage structures for perishable commodities

India is a developing country having tropical climate. Thus, the storage of perishable comedities like fruits and vegetables after harvest is one of the critical problems of the rural areas of the country. This large amount of spoilage of these products is observed. The only solution to avoid large amount of spoilage is low storage temperature and high relative humidity. There are two methods of creating these conditions *i.e.* either refrigeration or the evaporative cooling storage. Refrigerated storage is the best method for storing fruits and vegetables but it is associated with large amount of initial and operating cost. On the other hand, evaporative cooling chamber is based on the same principle, that it is space in which water is provided within the vicinity of the produce and outside air is blown through water saturated medium. Tomato undergoes various physiological changes even after harvest. These changes have pronounced effect in chemical composition, keeping quality and spoilage. Traditionally ECC are constructed with sand, cement and bricks with double walled structure and sand or brick bat is filled in between two walls which act as the cooling pad after application of water. Gunny bags are locally available and made from jute which has good water retaining property. Whereas, vetivar or *Khus* is a tall, perennial grass. It produces spongy, much branched root systems with fine rootlets, containing fragrant oil which is a perfumed by itself. The dry aromatic roots are also used to make curtains, mats, fans and other fancy goods as the products emits a sweet cooling aroma for a long period when moistened. While the charcoal obtained from burnt wood also has tendency to retain applied water for long time. Keeping these points into considerations, the following objectives were decided,

– To study and compare the shelf-life of perishable commodities like tomato in different evaporative cooling systems.

– To study and compare the costing of different low cost evaporative cooling systems.

METHODOLOGY

All the important points were considered while selecting site for construction of evaporative cooling chamber.

Erection of evaporative cooling systems:

Three evaporative cooling chambers and one room temperature storage chamber were constructed. Room temperature storage was plotted in an open tray while construction of other chambers is as follows.

Drip cooler with gunny bag walls:

The drip cooler was made up of three parts – basic

frame, covering material and water supply system. Basic frame of dimensions 60cm sides and 80cm height was constructed from locally available bamboo sticks. Three compartments of bamboo sticks of size 60 x 60 x 20cm were constructed from top leaving 20cm distance between floor and floor of the bottom compartment as a stand. Top of chamber was covered with plastic sheet. Four vertical sides of frame were covered with locally available gunny bags of dimension 80cm x 60cm to act as cooling pad. Water was applied to gunny bags with the help of assembly of laterals and drippers placed at periphery at the top of the frame and 16 drippers of 8 lph were attached to it at a distance of 15cm approximately from each other on all four sides. Water was supplied through elevated water tank under gravity of capacity 50 litres and supply was controlled by valve.

Drip cooler with vetiver mat walls:

This cooling chamber was also constructed as that of drip cooler with gunny bags. But the cooling pad material was vetiver mats. The vetiver mats of size 80cm x 60cm were prepared from vetiver and used to cover four vertical sides of frame. Water was applied through separate water tank of same capacity and in the same manner as that of drip cooling chamber with gunny bag walls.

Charcoal cooling chamber:

Four vertical sides of charcoal cooler frame were made up of timber of cross sectional area 5cm x 2.5cm. One of the vertical sides was used as door to which hinges were provided. The wooden frames were covered with plastic mats from inside and outside, leaving a 2.5cm cavity space in between. This cavity space was filled with charcoal and top of chamber was covered with the help of plastic mat. The water was applied to charcoal manually up to saturation.

Treatment details:

The following treatments were used for the experiment, 1. Room temperature storage was treated as treatment (T_0), 2. Drip cooling chamber with gunny bag walls storage (T_1), 3. Drip cooler chamber with vetiver mat walls (T_2) 4. Charcoal cooling chamber (T_3).

Application of water:

Water was applied to cooling pad of evaporative cooling chambers through drip system 3 times a day at an interval of 5 hr *i.e.* 7am, 12am and 5pm. Water was applied up to complete saturation of cooling pad.

Quality parameters:

The following physical parameters were tested during the experiment,

Colour index:

The score for colour index was given on the basis visual observations. The rating of colour index is defined as, Pink = 1, Light red = 2,Red = 3,Dark red= 4. Where, pink indicates just harvested, not edible and good condition. Light red indicates just ripen, not edible and good in condition. Red indicates ripen, edible and good condition. Dark red indicates not edible, over ripen and rotten.

Softness index:

The tomato fruits should undergo from slightly softened to moderately softened, advanced softened and fully softened stages during storage. The softness index of tomato fruits was determined by subjective assessment of the extent of softening the score of softness index was given on the basis sensory observation.Slightly softened= 1,Moderately softened= 2,Advanced softened=3,Fully softened= 4.Where, slightly softened indicates just ripen, not edible and good condition. Moderately softened indicates ripen, edible and good condition. Advanced softened indicates edible, over ripening starts. Fully softened indicates not edible and rotten.

Physiological loss in weight:

Physiological loss in weight is given in per cent by following formula by weighing the tomato fruits before and after the storage,

$$\text{Per cent PLW} = \frac{w_1 - w_2}{w_1} \times 100$$

where, w_1 = Weight of tomato fruits before storage
w_2 = Weight of tomato fruits after storage

For good and edible condition, physiological loss in weight is up to 10 per cent. For present study the observations were recorded at three days of interval for each treatment for physiological loss in weight taking three fruits which were kept aside for physiological loss in weight only.

Moisture content:

Moisture content was determined by weighing the tomato fruits before and after the drying and result presented as moisture loss in percentage by following formula :

$$M.C. = \frac{M_1 - M_2}{M_1} x100$$

where, M_1 = Weight of tomato fruit before drying,

M_2 = Weight of tomato fruit after drying

Chemical parameters:

The following chemical parameters were studied during the experiment:

Total soluble solids (TSS):

Total soluble solid in the pulp is estimated by using Erma Handrefractometer and the value is corrected to 20^0C with the help of temperature correction chart. For good and edible condition, total soluble solid ranged from 5.0^0 Brix to 5.5^0 Brix. For present study the observations were recorded at three days of interval for each treatment for total soluble solid taking two fruits from each chamber at a time.

Acidity:

The titrable acidity percentage of the pulp is diluted with 100ml of distilled water. This solution is titrated against 0.1N NaOH solution using phenolopthalein indicator as per the procedure given by Ranganna (1979). The per cent acidity is expressed in terms of maleic multiplying factor 45.

$$\text{Per cent total} = \frac{\text{Titrexnormality of NaOH equivalent weight of acid}}{\text{Weight of pulp x 100}} x100$$

For good and edible condition acidity ranged from 0.16 to 0.1 per cent. For present study, the observations were recorded at three days of interval for each treatment for acidity taking two fruits from each chamber at a time.

Environmental parameters:

The environmental parameters such as temperature, relative humidity was measured by thermometer and digital hygrometer in three times a day *viz.,* 6 am, 2 pm and 10 pm.

Cost estimation:

The cost estimation of each low cost evaporative cooling system was found out by taking into account construction cost, material cost and operating cost and finally compared the results.

RESULTS AND DISCUSSION

The main objective of tomato storage is to provide an environment that will permit to store produce as long as possible without deterioration of quality. The quality of tomato depends upon the physical and chemical properties *viz.*, colour index, softness index, and physiological loss of weight, total soluble solids, moisture content and acidity.

Quality parameters:

In the quality parameter, the physical as well as the chemical parameters were measured. The physical parameter included, colour index, softness index and physiological loss in weight was measured.

Colour index:

The data pertaining to colour index are presented in Fig.1. Score for colour index was given on the basis of visual observations. The data obtained from present study on colour index property indicated that the colour of peel changed from pink to dark red. It was observed that in Treatment (T_1) colour was changed slowly from pink to dark red followed by in treatment T_2, T_3 and T_0. The tomatoes were edible and good in condition in T_1 treatment in between 18 to 21 days depending upon colour index mark that is in between 3 to 4 followed by treatment T_2 (in between 15 to 18 days), treatment T_3 (in between 12 to 15 days) and treatment T_0 (9 to 12 days).

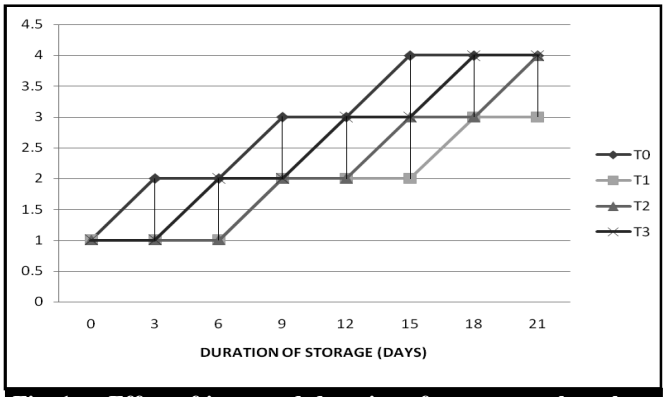

Fig. 1 : Effect of increased duration of storage on the colour of the tomato

Softness index :

The data relevant to softness index of tomato are presented in Fig. 2. The data obtained from present study on softness index indicated that the softness index was developed from slightly soften to fully soften. The score for softness index was given on the basis of sensory evaluation. It was observed that in T_1 treatment softness index was changed slowly from slightly soften to fully soften followed by in treatment T_2, T_3 and T_0. The tomato was edible and in good condition in T_1 treatment up to 18 to 21 days depending upon softness index marks, followed

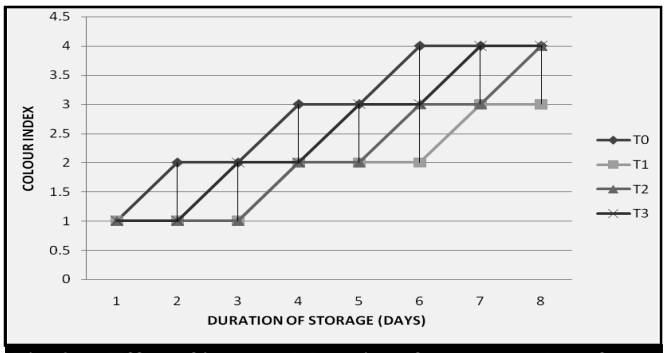

Fig. 2 : Effect of increased duration of storage on the softness of the tomato

by treatment T_2 (15 to 18days), treatment T_3 (12 to 15days) and treatment T_0 (9 to 12days).

Physiological loss in weight (PLW)

The data related to Physiological loss in weight of tomato are presented Fig.3. The data obtained from present study on Physiological loss in weight was indicated that Physiological loss in weight is maximum in T_0 treatment followed by treatment T_3, T_2 and T_1. The tomato were edible and good condition in T_1 treatment up to 21days of storage with Physiological loss in weight 9.995% followed by treatment T_2 18days (9.960%), treatment T_3 in between 15days (9.972%) and treatment T_0 12days (9.810%).

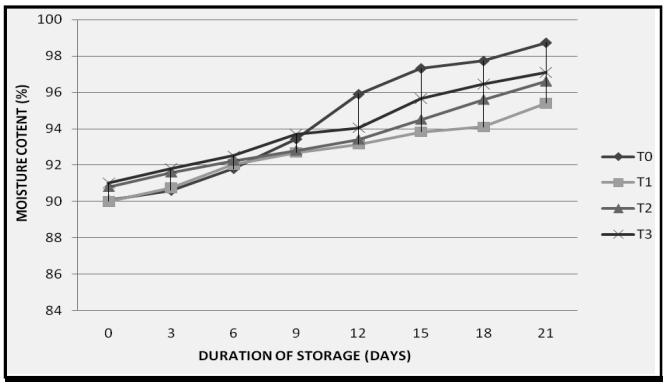

Fig. 3 : Effect of increased duration of storage on the physiological loss in weight

Moisture content:

It could be observed from the data presented in Fig.4. The data obtained from present study on moisture content was indicated that moisture content was maximum in T_0 treatment followed by treatment T_3, T_2 and T_3. The tomato were edible and in good condition in T_1 treatment in between 18 to 21days of storage with moisture content 95.41% followed by treatment T_2 15 to 18days (95.60%), T_3 12 to 15days (95.65%) and T_0 9 to 12 days (95.90%)

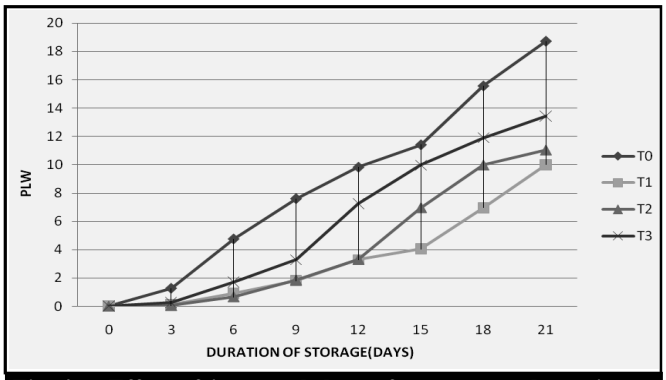

Fig. 4 : Effect of increased days of storage on the moisture content of tomato

Chemical quality parameters:

The chemical quality parameter such as total soluble solids, acidity were measured on the experiment.

Total soluble solid (TSS):

The data related to total soluble solids (TSS) of tomato are presented in Fig. 5. The data obtained from present study on total soluble solids indicated that a total soluble solid was maximum in T_0 treatment followed by treatment T_3, T_2 and T_1. The tomatoes were edible and in good condition in T_1 treatment up to 21days of storage with total soluble solid 5.4^{0}Brix followed by treatment T_2(18 days, 5.3^{0}Brix), T_3 (15 days, 5.4^{0}Brix) and T_0 (12 days, 5.1^{0}Brix).

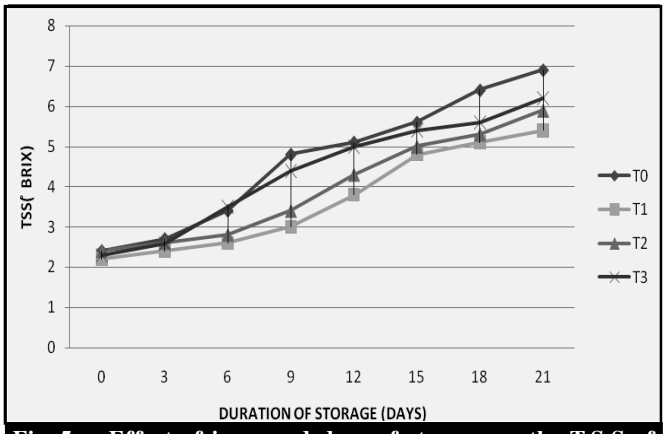

Fig. 5 : Effect of increased days of storage on the T.S.S of tomato

Acidity:

The perusal of data regarding the acidity of tomato during different storage conditions are presented in Fig.6. The data obtained from present study on acidity indicated that acidity was maximum in T_1 treatment followed by treatment T_2, T_3 and T_0 at twenty-first day of storage. The tomato was edible and in good condition in T_1 treatment up to 21days of storage with acidity 0.101% followed by

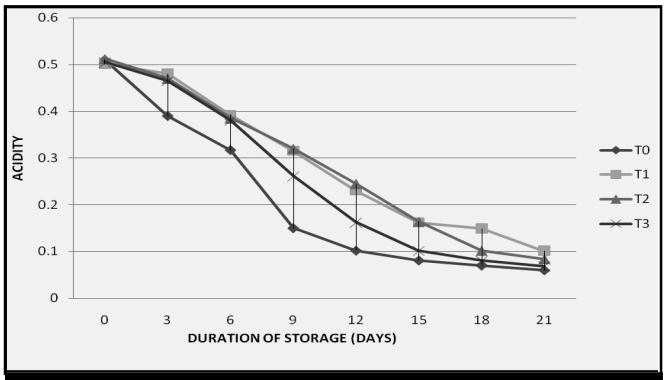

Fig. 6 : Effect of increased days of storage on the acidity of tomato

treatment T_2 18 days (0.102%), T_3 15days (0.101%) and T_0 12days (0.102).

Cost estimation of each EC system:

An attempt was made to find out cost per cubic meter of storage area of all the three chambers in Tables 1, 2 and 3. As far as storage of tomato was concerned, evaporative cooling chamber with gunny bag walls gave better results and increased shelf-life of tomato by 9 to 12 days as compared to room temperature storage. Hence, an evaporative cooling chamber with gunny bag walls is best suited for present study.

Table 1 : Cost estimation of drip cooling chamber with gunny bag walls

Particulars	Requirement	Rate (Rs.)	Total cost (Rs.)
Bamboo	2 No	15/-	30
Gunny bags	5 No	5/-	25
Drip system			
Lateral	3m	6/-	18
Dripper	16 No	2.5/-	40
End cap	1 No	2/-	2
Water	525lit.	0.10/lit	52.5
Labour	1 No	130/-	130
Miscellaneous			50
Total			Rs. 347.5

Conclusion:

– The evaporative cooling chamber with gunny bag walls (treatment T_1) was found better depending upon physical and chemical parameters of tomato stored followed by evaporative cooling chamber with vetiver mat walls (treatment T_2), charcoal cooling chamber (treatment T_3) and room temperature storage(treatment T_0).

– The shelf-life of tomato was 21 days in treatment

Table 2 : Cost estimation of cooling chamber with vetiver mat walls

Particulars	Requirement	Rate (Rs.)	Total cost (Rs.)
Bamboo	2 No	15/-	30
Vetivera (with transportation cost)	4 No	50/-	300
Drip system			
Lateral	3m	6/-	18
Dripper	16 No	2.5/-	40
End cap	1 No	2/-	2
Water	525lit.	0.10/lit	52.5
Labour	1 No	130/-	130
Miscellaneous			50
Total			Rs.617.5

Table 3 : Cost estimation of charcoal cooling chamber

Particulars	Requirement	Rate (Rs.)	Total cost (Rs.)
Wooden frame	1 No		90
Netlon mats	9 No	60/-	554
Charcoal	100kg	0.80/-	80
Bamboo	1 No	15/-	15
Water	630lit.	0.10/lit	63
Labour	1 No	130/-	130
Miscellaneous			100
Total			Rs. 1032/-

T_1 followed by treatment T_2 (18 days), T_3 (15 days) and T0 (12 days). Also shelf-life of tomato in treatment T_1 was increased by 9 days than that of room temperature storage.

– Evaporative cooling chamber with gunny bag walls (treatment T_1) was better depending upon inside temperature and relative humidity of structure followed by evaporative cooling chamber with vetiver mat walls (treatment T_2), charcoal cooling chamber (treatment T_3) and room temperature storage(treatment T_0).

– Evaporative cooling chamber with gunny bag walls (treatment T_1) was better than evaporative cooling chamber with vetiver mat walls (treatment T_2), charcoal cooling chamber (treatment T_3) and room temperature storage (treatment T_0) and cost of construction was estimated Rs.1,608.79 per cubic meter of storage space.

Considering above it was found that treatment T_1 is low cost, negligible operational cost, movable and required smaller space hence recommended for short term storage of fruits and vegetables. As far as temperature and relative humidity was concerned treatment T_1 and

treatment T_2 should be used in rural kitchens for the storage of fruits and vegetables.

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