International Journal of Agricultural Engineering, Vol. 3 No. 1 (April, 2010) : 21-26

Research Paper :

Construction, performance and evaluation of double cooling pad evaporative cooling chamber for storage of tomato

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Accepted : *November, 2009*

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ABSTRACT

During the storage and transit from farmer's fields to market place, there is a substantial loss in quality and shelf-life of vegetable due to improper post harvest handling and storage methods which is about 30-35 per cent. To overcome this problem, the evaporative cooling chamber is introduce to the farmers. Three evaporative cooling chamber to storage the tomato vegetable *viz.*, Double cooling pad (T_2), Single cooling pad (T_1) and Room temp. storage (T_0) were constructed. Results of present investigation indicated that, depending upon quality parameters *viz.*, colour index, softness index, PLW, M.C, T.S.S. and acidity, double cooling pad showed better result followed by the single cooling pad and room temperature storage. The shelf life of tomato in double cooling pad was up to 27 days followed by treatment T_1 (21 days) and T_0 (12 days). The shelf-life of tomato was increased by 15 days in double cooling pad as compared to room temperature storage. Also, depending upon inside temperature and relative humidity treatment T_2 was reported better than other treatments. Considering the above double cooling pad was best suited for storage of tomato with low cost and negligible operational cost.

Key words : Colour index, Softness index, Acidity, Percentage loss in weight, Total soluble salt

Tomato is one of the most important vegetable crops grown throughout the world. It is mainly consumed as kitchen and table purpose. The pulp of fresh and ripened fruits is used for preparation of sauce, jam, ketch-up. Tomato is also used in preparation of tonic, antipyretic drug and febrifuge. Temperature plays an important and key role in maintaining the quality and shelf-life of fruit vegetable. To maintain the optimum temperature of fruit vegetable to its lowest safe temperature increase the quality and shelf life by lowering the respiration rate and water loss. Shriveling and wilting which causes serious post harvest losses are reduced by decreasing the rate of water loss. If the temperature of fruit vegetable decreases below the safe lowest temperature it causes the chilling injury. In Konkan region the environmental conditions are hot and humid. Economical conditions of farmers are not sound. Hence, there is necessity to store the tomato after harvesting for longer time by using low cost storage technique such as evaporative cooling chamber. Due to high operational cost and energy consumption, it is not possible to everyone to take advantage of the costly techniques and methods. The evaporating chamber gives better cooling effect with zero energy consumption to increase the shelf-life. Generally, evaporative cooling chamber is constructed with single cooling pad having thickness 7.5 cm with different cooling pad material. The inside temperature for this cooling chamber is recorded in range of 18^0 C to 24^0 C and relative humidity is recorded in range of 85 to 93% depending upon application of water, cooling pad material, prevailing wind direction, outside temperature etc. But evaporative cooling chamber is low cost and zero energy consumption method of storage of perishable products. It is generally constructed by locally available material such as bricks for chamber walls and mortar mixed clay for binding the brick layer in position. The gap between the outer wall and inner wall is generally filled with fine sand, coarse sand, brick batt or combination of either two or three materials mentioned earlier. By considering above condition the project was undertaken with following objectives : to study the effect of single and double cooling pad on shelf life of perishable commodity and to estimate the cost of double cooling pad evaporative cooling chamber

METHODOLOGY

Study area of evaporative cooling chambers was located at latitude (15^0 37' N to 20^0 20' N), longitude (70^0 17' E to 74^0 31' E) and altitude range (200 to 450m). Following material was used during the experiment. Tomato of variety Samrat was used as perishable commodity.

Bricks:

For construction of evaporative cooling chamber,

locally available burnt bricks of the 22 x 10 x 7.5cm size were used.

Cooling material :

Cavity of single cooling pad filled with brick batt and inner cavity of double cooling pad filled with brick batt and outer cavity filled with fine sand + brick batt (1:1) which gives better cooling effect for storage of perishable commodity in evaporative cooling chamber.

Perforated pipes and valves:

For continuous water supply to cooling pad perforated pipe with perforation of 2mm were made at spacing of 100 mm for equal distribution of water. For water flow regulation purpose, valve was used.

Weighing balance:

Average weight loss of vegetables in each evaporating cooling chamber was determined with weighing balance of capacity 1kg and least count 1mg.

Steel frame rack:

Vegetables were stored in steel frame rack of 30 x 30 x 50 cm.

Covering material:

Steel bar frame covered with gunny bags was used as lid of evaporative cooling chambers.

Hand-refractometer:

It works on principle of light reflection and used to measure total soluble solids.

Thermometer:

To measure the temperature inside the evaporative cooling chamber.

Digital hygrometer:

To measure the relative humidity inside and outside the evaporative cooling chambers, digital hygrometer was used.

Planning and site selection:

Planning and site of evaporative cooling chamber based on following points:

-There should be sufficient availability of good quality water and electricity.

-The location should be such that there should be ample shade and free movement of air. Considering above site was selected:

Erection of evaporative cooling chamber:

– Site was selected for construction of two evaporative cooling chambers.

– Site was clean and leveled properly.

– A line of 900 mm x 750 mm was marked for ECC walls thickness of 75mm with proper diagonal check.

– Excavation was done for the wall of chamber up to 200mm.

– Outer walls of ECC were constructed up to height 700mm leaving cavity space 75mm.

– Bottom floor of ECC were prepared by ramming it and applying finished cement mortar of proportions 1:2. The thickness of cement mortar layer was 50mm. All the corners between wall and floor were plugged properly to avoid moisture penetration inside the chamber.

– For double cooling pad ECC chamber, outer wall of 75mm thickness was provided with cavity space of 75mm between outer wall of single cooling pad and outer wall with 700mm height.

– Curing was done for constructed chamber up to 7 days to attain the strength and stability.

– For single cooling pad ECC cavity is filled by using brick batt of size 2mm to 30mm, while double cooling pad ECC inner cavity filled by brick batt and outer cavity filled by brick batt + fine sand (1:1).

– Perforated pipes were installed on top cooling pad for applying water.

Treatment details

– Room temperature storage chamber is treated as treatment $T_{0.}$

– Single cooling pad storage chamber with brick batt is treated as treatment T_1

– Double cooling pad storage chamber with Brick batt + Sand is treated as treatment T_2

Application of water :

Water was applied to cooling pad of evaporative cooling chamber four times in the day at 4 hours interval (07.00 am, 11.00am, 03.00pm, and 07.00 pm) resp. up to saturation. For double cooling pad, only inner cavity was saturated which also saturate the outer cavity by providing the holes on middle wall of chamber.

Quality parameters (Physical and chemical properties):

Following quality parameters were studied during the experiment.

Colour index:

The colour of tomato fruits was changed from pink

to dark red during storage. The colour of fruit is an important feature of quality assessment. The score for colour index was given on the basis of visual observation. 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 condition.

Red indicates ripen, edible and good condition.

Dark red indicates not edible, over ripen and rotten

Softness index:

The tomato vegetable should undergo from slightly softened to moderately softened, advanced softened and fully softened stages during storage. The softness index of tomato vegetables was determined by subjective assessment of the extent of softening the score for 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 ripen.

Fully soften indicates not edible and rotten.

Physiological loss in weight:

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

$$\text{PLW (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

where, w_1 = Weight of tomato vegetable before storage

w_2 = Weight of tomato vegetable after storage

Moisture content:

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

$$\text{M.S. (\%)} = \frac{M_1 - M_2}{M_1} \times 100$$

where, M_1 = Weight of tomato vegetable before drying

M_2 = Weight of tomato vegetable after drying

For good and edible condition, the moisture content ranged from 93 to 96 per cent. For present study, the observations were recorded at three days of interval for each treatment for moisture content taking eighteen fruit at a time.

Total soluble solid (T.S.S):

The content of total soluble solid in the pulp was estimated by using Erma Hand Refractometer and the value was corrected to 20^0C with help of temperature correction chart.

For good and edible condition, total soluble solid ranged from 4.8^0 Brix to 5.3^0 Brix. For present study, the observations were recorded at three days of interval for each treatment for total soluble solid taking one tomato 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 phenolphthalein indicator.

The per cent acidity was expressed in terms of multiplying factor 0.022.

$$\text{Per cent total} = \frac{\text{Titrexnormality of NaOH x equivalent wt of acid}}{\text{Weight of pulp x 1000}} \times 100$$

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 interval for each treatment for acidity taking eighteen fruit at a time.

Environmental parameters:

The environmental parameters such as temperature, relative humidity were measured for each hour of the experiment.

Cost estimation:

The cost estimation of best suited evaporative cooling chamber was found out by taking into account construction cost with material.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Quality parameters :

The quality parameters included physical as well as the chemical quality parameter.

Physical quality parameters:

The physical quality parameter included the colour index, softness index, physiological loss in weight.

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 (T_2) treatment colour was changed slowly from pink to dark red followed by in treatment T_1 and T_0. The tomatoes were edible and good condition in T_2 treatment up to 27 days followed by treatment T_1 (21 days) and treatment T_0 (12 days). Fig.1 shows nearly linear relationship up to 3 - 4 days of storage.

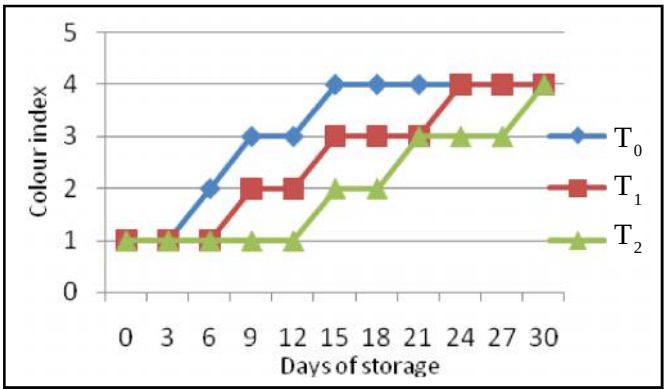

Fig. 1 : Effect of increased days of storage on the colour of the tomato

Softness index:

The data relevant to softness index of tomato vegetable are presented in Fig. 2. The score for softness index was given on the basis of sensory evaluation. It was observed that in T_2 treatment, softness index was changed slowly from slightly softened to fully softened followed by in treatment T_1, and T_0.The tomato vegetable was edible and in good condition in T_2 treatment (27 days) depending upon softness index marks, followed by treatment T_1 (21 days), treatment T_0 (12 days).Fig.2 shows nearly linear relationship up to three to four days of storage.

Physiological loss in weight (PLW):

The data related to physiological loss in weight of tomato vegetable are presented in Fig. 3.The data

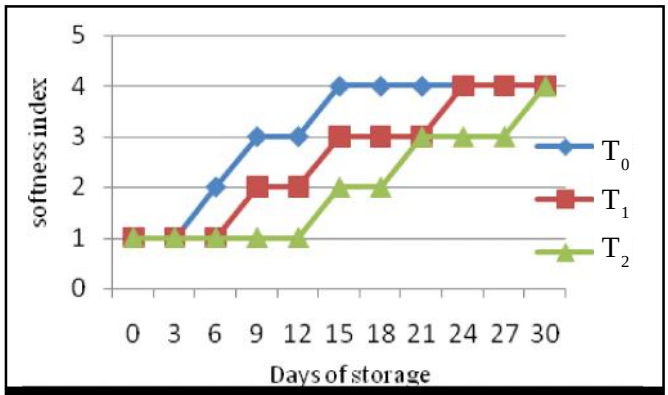

Fig. 2 : Effect of increased days of storage on the softness of tomato

obtained from present study on physiological loss in weight indicated that physiological loss in weight was maximum in T_0 treatment followed by treatment T_1 and T_2. The tomato fruits were edible and in good condition in T_2 treatment up to 27 days of storage with physiological loss in weight 9.99 per cent followed by treatment T_1 21 days (9.05 per cent), and treatment T_0 12 days (9.01 per cent).Fig.3 shows relationship between storage period physiological loss in weight and was indicated that and physiological loss in weight increased with storage period.

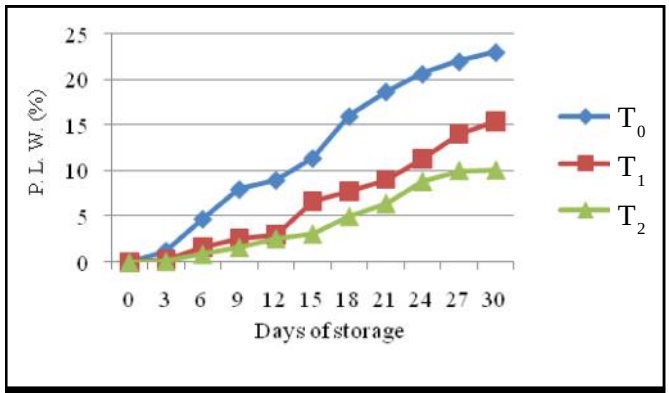

Fig. 3 : Effect of increased days of storage on the per cent loss in weight

Chemical quality parameters:

The chemical parameters included moisture content, total soluble solid and acidity.

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 $T_1$and T_2. The tomato was edible and in good condition in T_2 treatment up to 27 days of storage with moisture content (95.96 per cent) followed by treatment T_1 21 days (95.30 per cent),

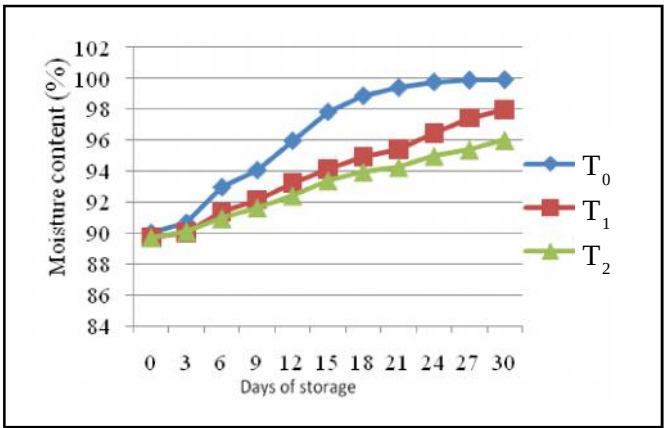

Fig. 4 : Effect of increase days of storage on the moisture content

treatment T_0 in between 12 days (95.41 per cent). Fig. 4 indicates that there was increase in moisture content with advancement of storage period of preserve.

Total soluble solid:

The data related to total soluble solid of tomato vegetable are presented in Fig. 5. The data obtained from present study on total soluble solids were indicated that total soluble solid was maximum in T_0 treatment followed by treatment $T_1$and T_2. The tomato vegetable was edible and in good condition in T_2 treatment up to 27 days of storage with total soluble solid 5.4^0 Brix followed by treatment T_1 21 days(5.2 º Brix), treatment T_0 12 days (4.9 º Brix).

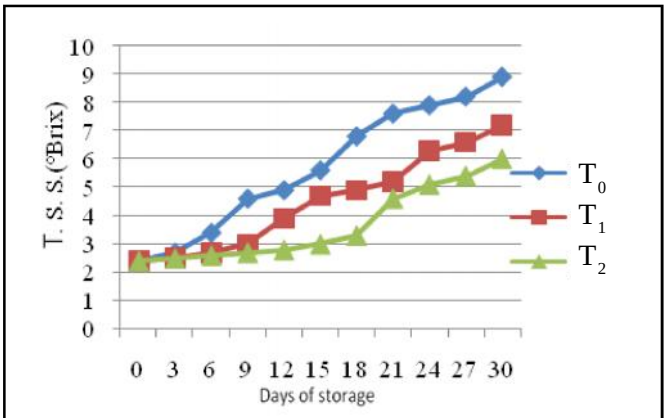

Fig. 5 : Effect of increased days of storage on the T.S.S. content of tomato

Acidity:

The perusal of data regarding the acidity of tomato during different storage conditions illustrated in Fig. 6. The data obtained from present study on acidity indicated that acidity was maximum in T_2 treatment followed by treatment T_1 and T_0.The tomato were edible and in good condition in T_2 treatment up to 27 days of storage with acidity 0.106 per cent followed by treatment T_1 21 days (0.101 per cent), and treatment T_0 12 days (0.104 per cent). Fig.6 indicates that there was decrease in acidity with advancement of storage period.

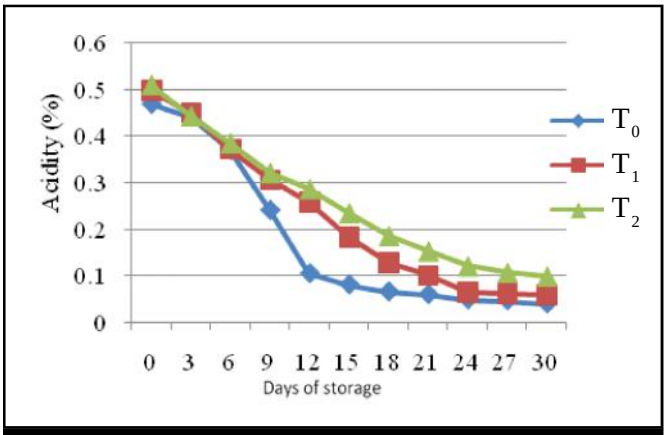

Fig. 6 : Effect of increased days of storage on the acidity of tomato

Cost estimation:

As far as storage of tomato was concerned evaporative cooling chamber with double cooling pad gave better results and increase shelf-life of tomato by fifteen days as compared to room temperature storage and about six days as compared to evaporative cooling chambers with single cooling pad (Table 1).

Hence, an evaporative cooling chamber with double cooling pad is best suited for present study. Therefore, an attempt was made to find out cost of double cooling pad evaporative cooling chamber.

Table 1 : Cost estimation:

Particulars	Requirement	Rate (Rs.)	Total cost (Rs.)
Bricks	333	3/brick	999
Cement	15 kg	5/kg	75
Piping	8.5 m	6/m	51
Water	4266	0.10/lit	426.6
Labour charges (job work)	100	100	100
Gunny bags	10	2.5/bag	25
Filling material	$0.44m^3$	$188/m^3$	83
Total	Rs.		1759.6/-

Total storage area was 0.472 cubic meters; hence cost of double cooling pad evaporative cooling chamber was estimated as Rs. 1759.6 /-.

The cost of single cooling pad ECC was worked out

as Rs. 970.43 for the same storage area. As compared to above the cost of double cooling pad ECC was high. But, inside environment parameters *i.e*. temperature and relative humidity gave better result than that of single cooling pad ECC which enhanced the storage life of tomato by six days than that of single cooling pad ECC. Nadre *et al*. (1999), Chopra *et al*. (2001) and Isaak *et al.* (2004) have also made some investigations on this aspect.

Conclusion:

– Evaporative cooling chamber with double cooling pad (treatment T_2) was better depending upon physical and chemical parameters of tomato vegetable stored followed by single cooling pad (treatment T_1) and room storage (treatment T_0).

– The shelf-life of tomato was 27 days in treatment T_2, followed by treatment T_1 (21 days), treatment T_0 (12 days) from above it can be concluded that shelf life of tomato in treatment T_2 was increased by fifteen days than that of room temperature storage.

– Evaporative cooling chamber with double cooling pad (treatment T_2) was better depending upon inside temperature and relative humidity of structure followed by single cooling pad(treatment T_1).

– As far as inside temperature and relative humidity was concerned, treatment T_2 and treatment T_1 should be used in ruler kitchens for the storage of milk and vegetable.

– As compared to single cooling pad ECC, double cooling pad ECC was permanent cement mortar structure which had the life span 10 to 15 years. This structure was used every season throughout the year for storage of various perishable commodities. For the construction of double cooling pad ECC initial investment was more as compared to single cooling pad ECC. But this drawback was overcome by increasing shelf-life of tomato by six days than single cooling pad ECC.

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REFERENCES

Chopra, S., Baboo, B., Alkesha Kudos, S.K. and Oberoi, H.S. (2001). Development of passive evaporative cooled room for on farm storage of fruits and vegetables. ACRECONF. pp 265-273.

Isaak, G.P., Kudachikar, V.B., Kulkarni, S.G., Vasantha, M.S., Keshva Prakash, M.N. and Ramana, K.V.R. (2004). Effect on modified atmosphere packaging on the shelf life of plantains under evaporative cooling storage condition. *J. Food Sci. & Technol*., **41** (6) : 646-651

Nadre, S.R., Harode, S.M. and Nadre, R.G. (1999). Study on low cost cooling system. *J. Maharashtra Agric. Univ.*, **24** (1) : 66-68.

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