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PERFORMANCE EVALUATION OF DEVELOPED EVAPORATIVE COOLING STORAGE STRUCTURE FOR TOMATO

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Abstract: 25 kg storage capacity of evaporative cooling chamber was developed with the help of galvanised mild steel, wire mesh and locally available materials like a small pieces of burnt bricks + coarse sand for storage of freshly harvested tomato. The effect of temperature and relative humidity inside evaporative cooling storage structure was observed with the significant difference in temperature drop and respective differential change in % relative humidity, the average temperature drop maintained at 8 to 9 ^{o}C and relative humidity at 84.18% for 10 days period storage study. The overall average cooling efficiency was found 89.97%. The trend of weight loss of tomato varies from 25 Kg to 18 Kg (28%). The testing samples stored in the evaporative cooling structure retained its original colour up to 8 days but later turned pale yellowish and the firmness was maintained at the 9th day then reduction was shown up to 30% out of the total sample stored. Total soluble solid content was found 3.65°Brix on 10 day. So that the Evaporative cooling chamber can be used to store the fruits and vegetables for a desirable period of time with minimum significant loss and will be beneficial for maintain a regular market flow for a marginal farmer.
Keywords: Evaporative cooling, Tomato, Weight loss, colour, firmness, temperature.

INTRODUCTION

With considering the various losses found in vegetables after harvesting for waiting to transport in weekly market in ruler area, evaporative cooling chamber was design and develop working on evaporative cooling principle that could be utilized to extend the shelf-life of the fruits and vegetables like tomatoes at their minimal storage temperature. Due to which farmers can avoid the clutches of the middlemen and will not be forced to make any distress sale. In India 90% of horticultural produce is sold in fresh form. Due to the presence of middle men, the price of horticultural raw material is 60-100% higher in *mandis* than in growing areas. By avoiding middle men the poor farmers can be able to get remunerative price of their produce. As the Evaporative cooling chamber extend the shelf-life of the produce; farmer can get the premium price for his produce in weekly *bazaar,* because with the help of the ZECC he can sell his commodity by keeping its quality same after 10-15 days late than the other farmer. The present study was therefore planned to develop and evaluate performance of an evaporative cooling system that could be utilized to preserve tomatoes.

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MATERIALS & METHODS

Constructional feature:

The zero energy cooling chambers consists of the cabinet to cool the material, the transmitting porous medium commonly known as a “cooling pad” which plays an important role to control the atmospheric condition inside cooling chamber of the storage structure and provided water reservoir in the input and output section to maintain the inflow and outflow of the water as per the requirement. The cooling system has rectangular shaped with total storage space of 0.184 m^3, made of galvanized mild steel, attached with the rectangular wire mesh for the incorporation of cooling pad of 0.05m thickness and water reservoir with storage capacity of 0.0174m^3 (17.45 lit) is linked to the cooling system at the top through a P.V.C. Pipe supplying water with a uniform drip system to keep the cooling pad continuously wet and for outflow one water reservoir is given to drain the outflow of the system. The basic principle relies on cooling by evaporation, when the system is set in operation, the dry air passes over the wet surface of cooling pad and evaporated away the soaked water from the cooling pad. When water evaporates, it draws energy from surroundings which produce considerable cooling effect in the storage chamber.

Selection of cooling media:

Evaporative cooling occurs when air that is not too humid passes over a wet surface. When rate of evaporation is faster, then cooling effect is greater. The selection of cooling pad was made by the small pieces of burned bricks mix with the coursed sand to maintain the porosity required for the water absorption, retention and evaporation rate. Evaporative cooling efficiency is dependent on the conditions of the air and it is necessary to determine the weather conditions that may be encountered.

Application of water:

Water is applied continuously to cooling pads of cooling chamber through drip system. For applying the water to the cooling pads; the LLDPE laterals are used and the water is supplied from the elevated reservoir having capacity 15-17 liter and water channeled out from the cooling pad drain into the bottom reservoir with outlet.

Quality analysis:

The quality parameters *viz.,* physiological loss in weight, change in colour, firmness, total soluble solids (TSS) and environmental parameters like temperature, relative humidity were tested during the experimental investigation.

Physiological loss in weight:

The physical parameter viz. Physiological Loss in Weight (PLW) is given by following formula by weighing the tomato fruit before and after the storage,

$$\text{PLW}\ (\%) = \frac{w_1 - w_2}{w_1} \times 100$$

Where,

W_1= Weight of tomato fruit before storage, kg W_2= Weight of tomato fruit after storage, kg

Change in colour:

The colour changes tested during the course of study up to 10 days inside the cool chamber and at ambient condition under daily observation.

Firmness: The firmness was tested with the freshness of the fruits by observing the surrounded skin of the fruits in terms of its softness during the storage period.

Total Soluble Solid (TSS):

Total Soluble Solid (TSS) of the stored fruits measured by using Erma Hand refract meter preparing the pulp of the stored fruits on 1^{st} day and after 10^{th} day of the experiment.

Environmental parameters:

The environmental parameters like temperature and relative humidity is measured by the dry and wet bulb thermometer and digital hygrometer. The evaporative storage structure was evaluated on the temperature drop, change in relative humidity and cooling efficiency.

Cooling efficiency:

The cooling efficiency is calculated as follows:

$$\eta = (T_{db} - T_s) / T_{db} - T_w) \times 100$$

Where, T_{db} = dry bulb temperature, T_w = Wet bulb temperature, T_s = Storage temperature.

RESULTS & DISCUSSION

During research work, different tests were investigated for the execution of the project including the measurement of dry bulb temperature and % relative humidity at ambient condition and inside the storage structure at the regular interval of 2hrs. from 10.00 am to 6.00 pm in a day for the comparative analysis regarding the performance of the cooling chamber as per the set atmospheric condition and the quality parameters.

Performance evaluation of evaporative cooling storage structure:

The performance evaluation of the developed evaporative cooling chamber storage structure was carried in terms of temperature drop, change in the relative humidity as per the atmospheric condition and cooling efficiency shows the effectiveness of the cooling chamber. The testing was done by keeping freshly harvested tomato in full load condition for the observation and evaluation of different quality parameters in terms of physiological weight loss, change in colour, firmness, and total soluble solid and further cooling efficiency.

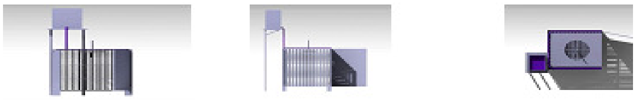

Fig.: 1 Different views of the Zero Energy Cooling Chamber

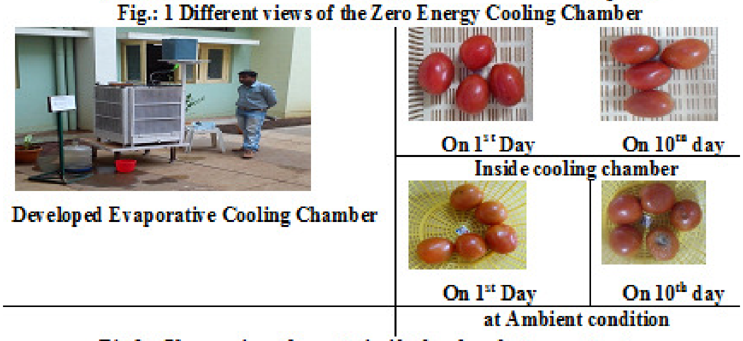

Fig 2.: Observation of tomato inside developed storage structure

During investigation, it was found that temperature and relative humidity inside evaporative cooling storage structure, highest temperature drop was found at noon time from 12.00 to 14.00 in each day observation and lowest at 10.00 am and in between 16.00 to 18.00 gradually decreased. In case of ambient condition, maximum temperature was found 35.6 ^{o}C and minimum temperature 29.8^{o}C. From this ambient set condition, the maximum temperature drop inside evaporative cooling storage structure was found on 4th day up to 11 ^{o}C in the range of 28 to 22 °C and minimum temperature drop on 1st day with 6^{o}C in the range of 31^{o}C to 28^{o}C with the average temperature drop 8 to 9 ^{o}C for 10 days storage period as shown in Table No.1.

The relative humidity inside the evaporative cooling storage structure was in the range of 81.6 to 87.2 % and average relative humidity for 10 days period up to 84.18% while in ambient condition the range was noted 66.2 to 77.2 % with the average relative humidity for 10 days period up to 73.08 %. This shows favourable condition for fruits and vegetable crop storage, as it requires high humidity. Cooling efficiency of evaporative cooling storage structure during storage of tomato, the cooling efficiency is the measure of effectiveness of cooling storage structure. The overall average cooling efficiency is of the evaporative cooling storage structure was found to be 89.97%.

Table 1: Comparative analysis of overall temperature (^oC) parameters

Comparative analysis of Dry bulb temperature (^oC) for 10 days storage period												
S. N.	**Temp. observation during ambient storage condition at regular interval of 2 hrs in a particular day**					**Avg. Temp.**	**Temp. observation inside the Evaporative Cooling Chamber at regular interval of 2 hrs in a particular day**					**Avg. Temp.**
	10.00	**12.00**	**14.00**	**16.00**	**18.00**		**10.00**	**12.00**	**14.00**	**16.00**	**18.00**	
1	32	38	37	35	31	**34.6**	30	31	28	26	28	**28.6**
2	33	36	37	35	32	**34.6**	30	26	24	22	22	**24.8**
3	30	33	36	35	32	**33.2**	28	23	21	22	23	**23.4**
4	28	34	36	35	31	**32.8**	25	23	21	22	22	**22.6**
5	32	38	40	39	32	**36.2**	28	26	24	24	26	**25.6**
6	31	36	38	39	34	**35.6**	28	26	24	23	22	**24.6**
7	26	29	32	31	31	**29.8**	25	22	23	23	21	**22.8**
8	32	34	37	36	32	**34.2**	24	27	26	24	22	**24.6**
9	31	34	37	36	29	**33.4**	25	26	23	23	24	**24.2**
10	32	37	40	39	36	**36.8**	28	24	23	22	24	**24.2**

Table 2: Comparative analysis of Relative humidity (%) parameters.

Comparative analysis of Relative Humidity (%) for 10 days storage period												
S. N.	**RH. observation during ambient storage condition at regular interval of 2 hrs in a particular day**					**Avg. RH.**	**RH. observation inside the Evaporative Cooling Chamber at regular interval of 2 hrs in a particular day**					**Avg. RH.**
	10.00	**12.00**	**14.00**	**16.00**	**18.00**		**10.00**	**12.00**	**14.00**	**16.00**	**18.00**	
1	71	64	65	66	65	66.2	85	82	82	81	82	82.4
2	73	68	66	69	71	69.4	82	85	90	91	88	87.2
3	76	73	69	67	71	71.2	84	85	89	85	86	85.8
4	78	76	72	72	76	74.8	80	83	84	83	82	82.4
5	79	76	75	73	74	75.4	85	88	88	84	81	85.2
6	74	72	70	70	72	71.6	79	82	83	83	81	81.6
7	83	76	74	76	77	77.2	81	83	84	84	82	82.8
8	83	77	73	72	73	75.6	85	83	84	86	86	84.8
9	73	71	70	69	68	70.2	86	87	88	89	89	87.8
10	82	80	78	77	79	79.2	82	81	83	83	80	81.8

Physiological weight loss in tomato storage in evaporative cooling storage structure:

The comparative analysis was studied in the progressive change in the physiological loss in weight of the tomato produce stored in both ambient condition and the evaporative cooling storage structure. Due to the change in temperature and relative humidity the evaporation was takes place in term of moisture migration from tomato produce to the surrounding for 10 days storage period. The physiological loss in weight of ambient condition and evaporative cooling storage structure both was shown in Fig. 1.

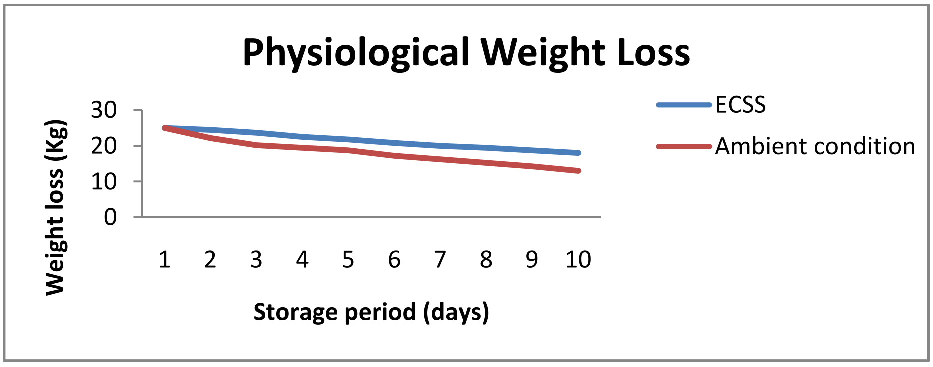

Fig 3: Behaviour of Physiological Weight Loss

It was observed that the trend of weight loss of tomato varies from 25 kg to 13 Kg when it is stored in ambient condition (52%) while the weight loss of tomato varies from 25 gm to 18 Kg when stored in evaporative cooling storage structure (28%). It was clear that the physiological loss increases with the increase in storage period, after 8th day there was decline in the quality of the stored tomato in ambient condition and found were spoiled on 10th day. During the evaporative cooling storage tomatoes were well preserved for 10 days with negligible spoilage occurred. Hence it was conclude that physiological loss in ambient condition was higher than tomato stored in evaporative cooling storage structure during the 10 days period.

Quality analysis Stored Products

Change in Colour:

The Change in colour noticed with the product stored in the ambient condition and evaporative cooling storage structure by visual appearance in which the tomatoes colour changed from the reddish colour to pale yellow and later on with the spotted black in both the condition. The tomato stored in the ambient condition started changing its colour on after 5th day during the course of work of daily observation in which the testing sample were yellowish and moisture uptake condition and get spoiled on 10th day and as to checked samples stored in the evaporative cooling structure retained its colour up to 8 days but later on pale yellow colour was found.

Firmness:

It was observed that the firmness of the tomato product was decreased day by day with little change but after 6th day the firmness get reduce in a faster rate in ambient conditions storage of 10 day which implies the maximum microbial activity due to high temperature, but in case of evaporative cooling storage structure the firmness was maintain up to the 9th day then reduction was found and goes on in increasing direction.

Total Soluble Solids:

The Total soluble solid content was found an average of 6.30 °Brix initially and decreased to 2.20 in ambient storage conditions on 7th day, the decreased to 3.65 on 10 day in evaporative cooling storage structure.

Conclusion

The overall average cooling efficiency was found to be 89.97 %. It was observed that the weight loss of tomato found 52% in ambient condition whereas 28% in evaporative cooling storage structure. It also found as tomatoes were well preserved for 10 days with negligible spoilage and retained its colour up to 8 days in evaporative cooling storage structure.

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