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Vegetable Preservation by Evaporation Cooling Process

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ABSTRACT

Horticultural produce are stored at lower temperature because of their highly perishable nature. There are many methods to cool the environment. Hence, preserving these types of foods in their fresh form demands that the chemical, bio-chemical and physiological changes are restricted to a minimum by close control of space temperature and humidity. The high cost involved in developing cold storage or controlled atmosphere storage is a pressing problem in several developing countries. Evaporative cooling is a well-known system to be an efficient and economical means for reducing the temperature and increasing the relative humidity in an enclosure and this effect has been extensively tried for increasing the shelf life of horticultural produce in some tropical and subtropical countries. Zero energy cooling system could be used effectively for short-duration storage of fruits and vegetables even in hilly region. It not only reduces the storage temperature also increases the relative humidity of the storage which is essential for maintaining the freshness of the commodities. In summer season when the life time of vegetables reduce then it is possible to increase the life time by reducing the temperature and increasing the heat. By using coconut pad the temperature reduces up to 10˚C and total temperature drops up to 40 %.

Keywords: Evaporative cooling system, Zero energy, Factors affecting, Design consideration.

1. Introduction

Fruits and vegetables are vital agricultural products for human consumption all over the world. They are rich in vitamins and minerals such as carotene (provitamin A), ascorbic acid, ribo flavin, iron, iodine, calcium etc. Deficiency of these nutrients can lead to widespread of decreases and on the long run lead to death .Vegetables are also rich in fibers which are essential for good digestion. Results from global burden of disease project for year 2000 show that up to 2.7 million death worldwide and 1.8 percent of total global disease may be attributed to inadequate consumption of fruits and vegetables [1] .

However these produce are not only seasonal but highly perishable. The essence of storage is of great importance because not all the harvested vegetables or crops in general will be used after the harvest so , measures of preserving the vegetables before it exceeds its shelf life is of great importance .

Evaporative cooling has been found to be an efficient and economical means of reducing temperatures and increasing humidity in an enclosure where the humidity is comparatively low. Minimizing deteriorative reactions in fruits and vegetables in fruits and vegetables enhances their shelf lives, implying that the produce will be available for longer periods; this would reduce fluctuation in market supply and prices.

Nitipong studied the cooling pads made of rice husk and recycled HDPE by using two sieve size of 0.5 m * 0.5 m. to dovetail into and then filling them with the rice husk and recycled HDPE [2].

Approximately 23–35% of the horticulture produce goes waste due to improper post-harvest operations and due to lack of enough storage facilities [3].

A zero-energy cool chamber was developed using locally available materials in New Delhi, India [4]. The chamber is designed for on-farm use, operates by evaporative cooling, and is constructed from double brick with sand-filled cavity walls. The shelf life of tropicalfruits held in the chamber was increased by 2 to 14 days (15–27% increase) as compared to storage at room temperature, and the physiological loss in weight was lower. The chambers were shown to be suitable for short-term storage of fruits and vegetables.

One adaptation on the basic pot design is the janata cooler, developed by the food and nutrition board of India [5]. Mohammed Abbah, a teacher in Nigeria, developed a small scale storage pot-in-pot system that uses two pots of slightlydifferent size [6]. The smaller pot is placed inside the large pot and the space betweenis filled with sand.

2. Methodology

A GP sheet of 37 inch long and 24 inch wide was taken . It has well heat conductivity and heat transfer properties which helps to keep the storage system cool. Then the entire sheet was pierced in equidistance. It was done for promoting diffusion from the outside to the inside of the system. Then the rectangular GP sheet was converted into cylindrical shape. The pad materials were added with the outside of the cylindrical GP sheet. Two types of pad was used the thickness of the pad was 0.6 inch.

A water reservoir was kept up to the system and the water could come with the contact of the pad materials. the part of pipe which has contact with the pad was pierced in successively larger diameter so that the water distribution becomes uniform throughout the pad materials because the water pressure is higher at starting and lower at the terminal.

The water flow is controlled by a tap which is connected with the bottom of the reservoir. The water flow speed may be varied according to necessity. The cylinder is kept vertically on a tray. The excess amount of water which comes through the pad materials is stored there.

An exhaust fan is added on the top of the cylinder. Its Speed is varied and the reading of temperature is taken for different temperature. It extracts the outside fresh air and a little water from the outside to the inside. The outside fresh air is used to cool the vegetables and the water is used the increase the humidity of the system. The food chamber becomes humid and dark so several algae and microorganism may grow up which spoils the vegetables. To overcome this problem a 25 watt electric bulb is used.

Fig.1: Cylindrical GP sheet

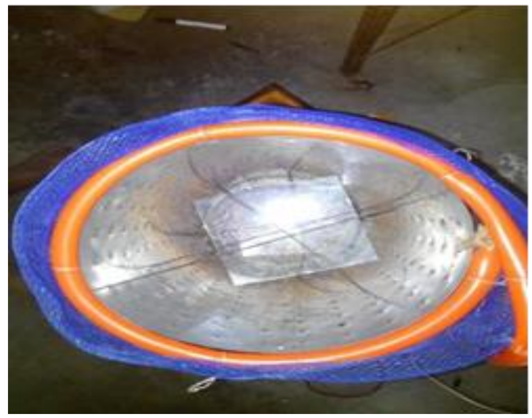

Fig.2: Top view of cooler

Fig.3: Piercing pipe for water distribution

Fig.4: Evaporative cooling refrigerator

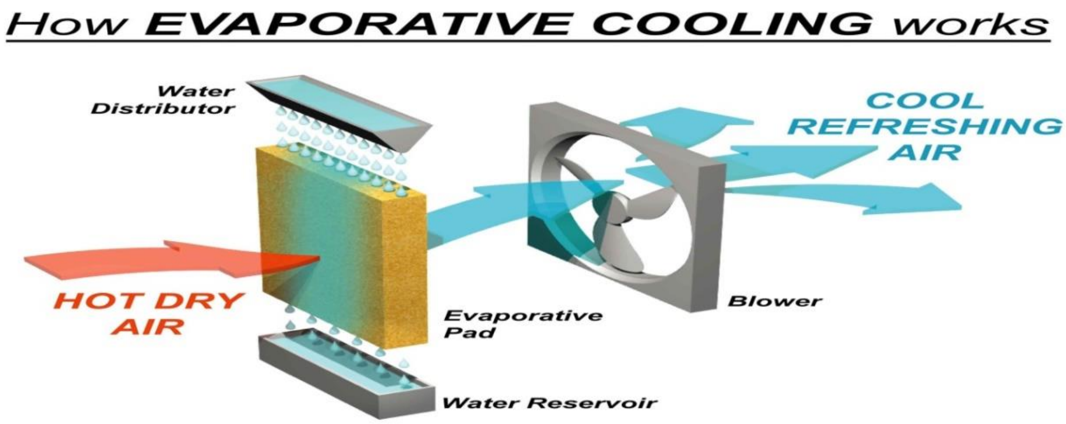

Fig.5: Evaporating cooling

3. Equipment Used

The GP sheet was used for producing the frame of the cooler. The exhaust fan was used for exchanging the inside air with the environment and the tachometer was used to measure the rpm of the exhaust fan.

➢ GP sheet	➢ Exhaust fan (30 W ,2000 Hz)
➢ Exhaust fan	➢ Water reservoir
➢ Thermometer	➢ Piping system
➢ Tachometer	➢ An electric bulb
➢ Coconut fiber pad	➢ Watch
➢ Glass plate	

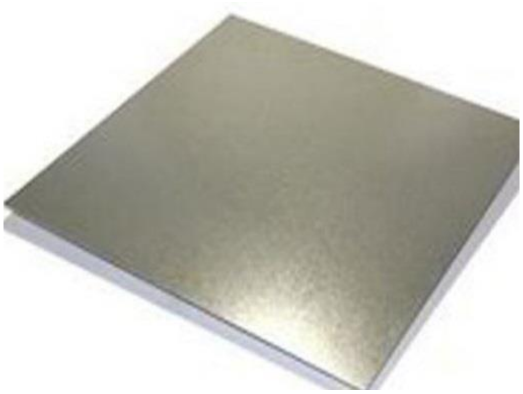

FIG.6: GP Sheet

FIG.7: Exhaust fan (30 W, 2000 Hz)

FIG.8: Thermometer

FIG.9: Tachometer

4. Results and Discussions

Only the products which quality were high, free from damage and contained proper nutritive value was stored . But it was not possible to maintain the temperature lower than the recommended temperature. The storage was overloaded so air could not flow throughout the vegetables. There was some lacking in proper ventilation system. As a result proper moisture was not maintained. When some items were spoiled then there was not any outdoor area for cleaning the storage. This polluted the total system and remaining fresh products had to replace which was really unexpected. After all different types of vegetables should not be stored.

Primary air outlet temperature was recorded in each test and its maximum and minimum values are shown in table. It varies between 31˚C to 37 ˚C for coconut fiber pad in April, and between 20 to 25 ˚C for nylon pad materials . It is thus possible to reduce the temperature of incoming air below its WBT by the use of pad materials. Such operation will be beneficial in post-harvest preservation.

Saturation efficiency values for different combinations are shown in table appendix. The general trend is that saturation efficiency decreases with decrease in atmospheric humidity. The maximum values are obtained for minimum mass flow rates and vice versa .At higher fan speed air spends lesser time inside the cooling pad thereby getting lesser cooling effect. Efficiency decreases at higher mass flow rates and efficiency values are lower because of indirect cooling process. IEC efficiency values range between 83.3 % and 68 %.

The value of evaporative effectiveness for different combinations is obtained between 4.43 and 12.68. The maximum cooling effect takes place when fan speed is at full speed because of maximum mass flow rate. The major power consumption of the unit is fan and bulb. The fan is kept continuous running when the weather is humid and low temperature conditions. So it requires more power under the conditions of low temperature and high humidity. When the weather is dry and temperature is high then it is unnecessary and keeps the fan always running. So this cooler is most suitable in summer than the winter. From the appendix it is shown that no significant temperature drops takes place in winter.

The actual flow rates of water for coconut fiber pad and nylon pads are pump are 2.95×10^{-5} kg/sec and 1.62 $\times10^{-5}$ kg/sec respectively. The water recirculation process was absent so it consumes much more water than the actual requirements. If a pump is used for recirculation purpose then the cost increases more than double when the cooler is too much larger than pump may be used.

The economics of using evaporative cooling are surprising to most people. An 85% reduction in energy used compared to a conventional refrigeration system. The operating cost of heat evaporative refrigerator is 90% less than the normal refrigeration system.

The purchasing cost of conventional refrigeration is up to 40 thousands taka where anevaporative cooling requires only 3 thousands taka.

Table 1: Reading for day 01 : 29-10-18 (Using nylon pad)

No of observation	Time duration in hour	Wet bulb temperature , ℃	Cooler Dry bulb temperature , ℃	Atmospheric dry bulb temperature,℃	Atmospheric dry bulb temperature, ℃
01	06:00 am	23	25	27	82
02	10:00 am	21	24	28	78
03	02:00 pm	22	24	29	84
04	06:00 pm	22	23	29	81
05	10:00 pm	21	23	28	86
06	02:00 am	20	22	27	79

Table 2: Reading for day 02 : 30-10-18 (Using nylon pad)

No of observation	Time duration in hour	Wet bulb temperature , ℃	Cooler Dry bulb temperature , ℃	Atmospheric dry bulb temperature,℃	Relative humidity , RH%
01	06:00 am	22	24	27	84
02	10:00 am	21	25	28	77
03	02:00 pm	19	26	28	75
04	06:00 pm	19.5	25	29	79
05	10:00 pm	20	25	28	81
06	02:00 am	20.5	23	26	83

Table 3: Reading for day 03: 31-10-18 (Using nylon pad)

No of observation	Time duration in hour	Wet bulb temperature , °C	Cooler Dry bulb temperature , °C	Atmospheric dry bulb temperature,°C	Relative humidity , RH%
01	06:00 am	20	25	27	64
02	10:00 am	19.5	24	28	74
03	02:00 pm	19	24	29	78
04	06:00 pm	19	23	29	82
05	10:00 pm	20	23	28	85
06	02:00 am	20	22	27	80

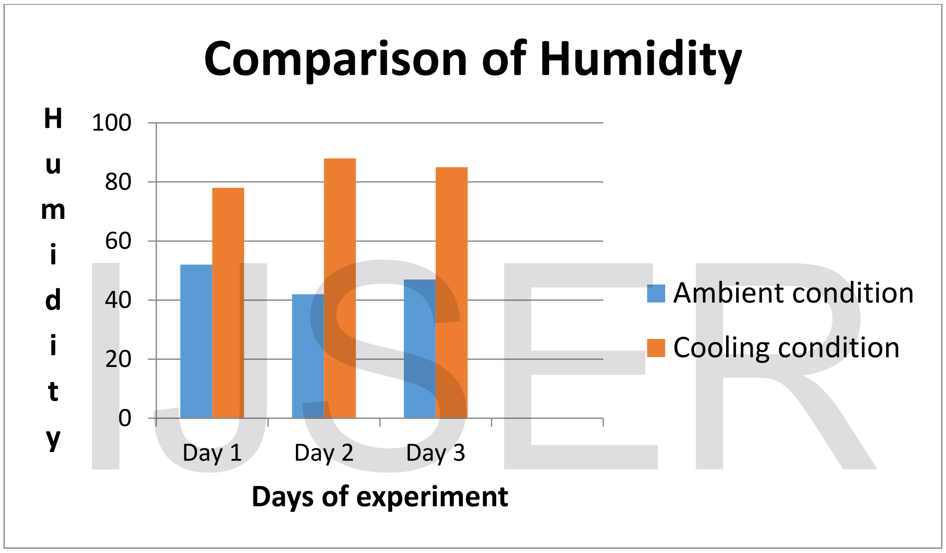

FIG.10: comparison of humidity at different condition

5. Applications

- Farmers can store their vegetable at the time of low price especially in post-harvest.
- Shopkeeper, retailer and supplier can preserve their unsold vegetable for a short time.
- In some cases it is also useable for domestic purposes instead of electric refrigerator.

5. Conclusions

Vegetable and fresh produce storage has proven to be a good application for evaporative cooling. To lengthen storage life, fresh produce needs to be stored in conditions of high humidity to reduce water loss which evaporative cooling can also achieve.

Evaporative cooling system has a very large potential to propitiate thermal comfort. Evaporative cooling system not only lowers the air temperature surrounding the produce, it also increases the moisture content of the air. Evaporative cooling system is well suited where; temperatures are high, humidity is low, water can be spared for this use, and air movement is available.

Zero Energy Cool Chamber could be used effectively for short-duration storage of fruits and vegetables even in hilly region. It not only reduces the storage temperature but also increases the relative humidity of the storage which is essential for maintaining the freshness of the commodities.

In summer season when the life time of vegetables reduce then it is possible to increase the life time by reducing the temperature and increasing the heat. By using coconut pad the temperature reduces up to 10˚C and total temperature drops up to 40 %.

6. References

[1] Anon (2010) Area & Production Estimates for Horticulture Crops for 09-10. National Horticultural Board (NHB), India. . (accessed 17 January, 2011).

[2] ASHRAE (1995) ASHRAE Handbook Application. American Society of Heating, refrigeration and Air-Conditioning Engineers, Inc. SI edn. Atlant. Cap 47. New York, USA

[3] Longmone AP. Evaporative cooling of good products by vacuum. Food Trade Rev (Pennwalt Ltd) 2003; 47:13–16.

[4] Fuglie K, Khatana V, Ilangantileke S, Singh JP, Kumar D, Scott GJ (1997) economics of potato storage in India. Social Science Department Working Paper No.1997–5. Int potato centre(CPI), Lima, Peru.

[5] Dadhich SM, Dadhich H, Verma RC. Comparative study on storage of fruits and vegetables in evaporative cool chamber and in ambient. Int J Food Eng. 2008;4(1):1–11.

[6] Das SK, Chandra P. Economic analysis of evaporatively cooled storage of horticultural produce. Agric Eng Today. 2001;25(3–4):1–9.