Study on Zero Energy Cool Chamber (ZECC) for Storage of Mango

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Abstract: The zero energy cool chamber (ZECC) is used as storage for the extension of the shelf life of stored fruits and vegetables. However, there are limited researches on the use of ZECC for storage of mangos in Nepal. Therefore, the present study was conducted to qualify the quality and storability of mangos in different storage structures such as ZECC, room, and freeze conditions. We measured the physiological loss of water (PLW), TSS, and vitamin C of mango under different storage conditions. This study was conducted at Agricultural Engineering Division, Khumaltar, Lalitpur, Nepal. Mangos were purchased from local market. They were stored in three different storages such as in ZECC, room condition, and freeze conditions. The results showed that on eighth days of storage the highest PLW (%) was recorded for the room storage and the lowest was recorded for ZECC condition. The TSS and vitamin C significantly increased on the eighth day of storage compared to the first day for all types of storage. On the tenth day of storage, vitamin C was decreased compared to the eighth day in both ZECC and freeze conditions. The PLW was higher in freeze storage condition compared to that of ZECC condition. We concluded that mangos stored in ZECC can be stored until the eighth days of storage after considering both quality and PLW. Our result suggested that ZECC can maintain mango's quality and extend its shelf life therefore it can be used as a temporary storage structure for fruits like mangos.

Keywords: ZECC, PLW, TSS, Vitamin C, Mango

1. Introduction

Mango (*Mangifera indica L.*) is originated from eastern India, Assam and Burma [1]. It is one of the important tropical fruits of Nepal which is cultivated in 9% of the total fruit cultivated area [2]. Mango is cultivated in about 14 thousand hectares with an average annual production of 100 thousand tons [3]. The local cultivars of mango are Sindhure, Kali, Supare, and Lohare from the lower hills, and Chinia, Sipiya, Chausa, and Safeda from the Terai and hills region [4]. To meet the consumers' demand the production of mango is increasing day by day [5]. After harvesting, the storage of mango is a major problem due to lack of purchase capacity of farmers of an expensive cooling system in a country like Nepal. Besides, there is a lack of electricity in rural areas.

Zero Energy Cool Chamber (ZECC) can be a possible solution for storage as it does not requires electricity. Also, they are eco-friendly and require low cost for its construction [6, 7, 8]. ZECC is a simple type of storage structure which is used to store fruits and vegetables and consists of outer and inner brick walls with a gap between two walls which is generally filled with sand. Water is sprinkled on the sand for the cooling purposes [7]. Ganesan *et al*., (2004) [9] reported that the shelf life of eggplants was enhanced up to nine days by storing them in ZECC storage. Similarly, several other researchers reported that storing fruits and vegetables in ZECC increases their shelf life. For example, Narayan *et al*., (2002) [10] conducted research on banana; Prabha *et al*., (2006) [11] conducted research on lemon; Singh *et al*., (2010)

[12] conducted research on aonla fruit; Islam *et al*., (2012, 2013) [6, 7] conducted research on tomato; Murugan *et al*., (2011) [13] conducted research on grapes; Sharma *et al*., (2010) [14] conducted research on apple in ZECC conditions. All of them confirmed that the storage of fruits and vegetables in ZECC condition increases their shelf life. Dirpan *et al*., (2017) [15] reported that ZECC with watering 20 liters of water per day decreases temperature and increases relative humidity inside ZECC which helps to maintain the quality and storability of fruits and vegetables inside the ZECC. There is limited research on the quality and storability of mangos stored in the ZECC storage condition. Therefore, this study was conducted to qualify the quality and storability of mango inside the ZECC.

2. Material and Methods

2.1. Experimental design

This research was conducted at Agricultural Engineering Division, Nepal Agricultural Research Council, Khumaltar from June to July 2019. Zero Energy Cool Chamber (ZECC) was constructed by materials such as bricks, sand, bamboo, straw, gunny bag, etc. The double wall was erected and leaving a gap of 7.5 cm between two walls. The gap between the two walls was filled with river sand. House was constructed with bamboo and wheat straw to protect the ZECC from rainfall and sunlight. Mango was collected from the local market. Mango was washed with tap water to remove field heat soon after sorting for uniform size and undamaged product. About fifteen kilograms of mango with no fungal infection were selected, labeled and weighed initially. Finally, mangoes were stored into three different storage conditions such as ZECC, room, and freeze conditions.

2.2. Information about storage container

Three perforated crates made from high-density polyethylene were used to store mango. Mangos were placed inside the perforated plastic crates and stored inside ZECC, freeze and room conditions for evaluation of its quality.

2.3. Effects of storage types on quality of mango

2.3.1. Effects of storage types on physiological loss in weight (PLW) of mango

The physiological loss in weight was measured using an electric balance with an accuracy of 0.01 g. The PLW was measured by using the following formula:

Physiological loss in weight (PLW), % = $(X_1\text{-}X) \times 100$ ……. (1)

where, X_1 = Initial weight (g) X = Weight (g) at the end of storage time.

2.3.2 Effects of storage types on total soluble solids (TSS) of mango

The TSS was measured by using Abbe refractometer with a measurement accuracy of ° Brix ±0.1%, and three replicates of TSS samples.

2.3.3 Effects of storage types on vitamin C of mango

The vitamin-C content was determined by 2, 6-dichlorophenol-indophenol visual titration method [16]. Three replicates of vitamin C were taken.

2.4. Statistical analysis

The experiment was conducted in a completely randomized design with three replications. The data were analyzed using one-way ANOVA followed by Tukey's HSD test ($p < 0.05$). All analyses were done with STATISTIX 8 (Analytical Software, Tallahassee, FL, US).

3. Results and Discussion

3.1 Room and Zero Energy Cool Chamber (ZECC) temperature during experiment

Room and Zero Energy Cool Chamber (ZECC) temperature during experiment is shown in Table 1. The room temperature ranges from 29.4 to 31.7 ° C. However, the ZECC temperature ranges from 23.3 to 25.2 ° C.

Table 1: Room and ZECC temperature during experiment

Month	Day	Room temperature (° C)	ZECC temperature (° C)
June	23	29.4	23.3
June	24	30.6	23.9
June	25	31.7	25.2
June	26	30.5	24.4
June	27	29.5	24.5
June	28	30.3	24.2
June	29	29.6	23.5
June	30	29.4	23.4
July	1	31.5	25.0
July	2	31.3	24.7
July	3	30.5	24.4

3.2. Effects of storages types on physiological loss in weight (PLW) of mango

The physiological loss in weight (PLW) of mangos stored inside ZECC, room, and freeze conditions are shown in Fig. 1. We found significant differences in PLW (%) of mangos stored in the ZECC compared to mangos stored in room condition. The PLW of mangos stored inside the ZECC were lower than those stored in room and freeze conditions. On the eighth day of storage, the highest PLW was recorded for mangos stored in room conditions followed by freeze storage condition. The lowest PLW was discovered for mangos stored in ZECC condition. On the tenth day of storage, the PLW was 6.33% and 4.17% for mangos stored in freeze and ZECC conditions, respectively. On the tenth day of storage, the mangos stored in room condition almost decay therefore we did not consider the PLW. Our results were in agreement with Chien *et al*., (2007) [17] and Dirpan *et al*., (2018) [18] who reported that the mango with the higher moisture had lower PLW and vice versa.

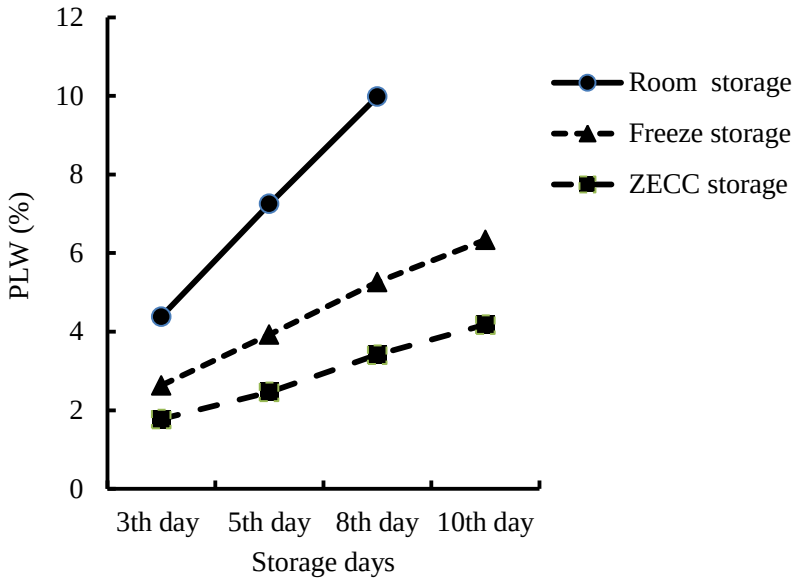

Fig. 1: Effects of storage types on physiological loss in weight (PLW) of mango with storage days.

3.3. Effects of storage types on vitamin C and total soluble solids (TSS) of mango

The vitamin C of the mango in three different storage conditions is presented in Table 2. The range of vitamin C content was from 37.12 to 95.88 mg/100g. The vitamin C content on the first day was 49.06 mg/100g which was similar to the previous study [19]. The highest vitamin C (95.88 mg/100g) was found in ZECC treatment on the eighth day of storage; however, the lowest (40.72 mg/100g) was recorded in ZECC condition on the tenth day. In general, vitamin C content of the mango stored in ZECC conditions was significantly higher compared to the room storage condition (Table 2). This might be due to the lower temperature and higher humidity conditions retards aging through reduced respiration rate and other undesirable metabolic changes [18].

Table 2: Effects of storage on Vitamin C (mg/100 mg) content of mango

Treatment	1st day	8th day	11th day
Room condition	49.06 ± 2.57	59.2±3.25 [b]	-
Freeze	-	82.93±3.54 [a]	37.12±3.44 [a]
ZECC	-	95.88± 4.39 [a]	40.72±4.02 [a]

Same letters are not significantly different ($p < 0.05$) by Tukey's HSD test.

The total soluble solids content (TSS) content in ZECC, freeze, and room storage condition is presented in Table 3. The TSS in this experiment ranges from 17 to 22 ° Brix (Table 3). There was no significant difference in TSS under ZECC, freeze, and room storage conditions on the fifth day of their storage. On the seventh day of storage, we also did not find any significant difference in TSS between ZECC and room storage conditions (Table 3).

Table 3: Effects of storage types on TSS (° Brix) content of mango

Treatment	1st day	5th day	7th day
Room condition	17.0±1.41	21±1.41 [a]	-
Freeze	-	21.5±0.7 [a]	22.0±1.41 [a]
ZECC	-	22.0± 2.83 [a]	20.0±2.83 [a]

Same letters are not significantly different ($p < 0.05$) by Tukey's HSD test.

4. Conclusions

In study we clarify the quality and storability of mango under ZECC, freeze, and room storage conditions. Results revealed that the storage and quality (vitamin C and ° Brix) of mango were increased in ZECC storage conditions until eighth day of storage. Therefore, we concluded that ZECC can be used as storage structure for storage of mango.

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References

1. Popenoe W. (1920). Manual of Tropical and Sub-Tropical Fruits. Hafner Press, Macmillan Publishing Co., New York, USA.
2. Gautam D. M. and Dhakal D. D. (1994). [Fruit and industrial crops] [In Nepali]. Pabitra Tatha Rupa Publication, Chitwan, Nepal. 324 p.
3. ASD [Agriculture Statistics Division] (2005). Statistical information on Nepalese agriculture. Agriculture Statistics Division, Ministry of Agriculture, Kathmandu, Nepal.
4. NARC [Nepal Agricultural Research Council]. (2003). Final Report of the IPGRI-ADB-TFT Project on Conservation and Use of Mango and Citrus Species Biodiversity in Nepal. Nepal Agricultural Research Council (NARC), Kathmandu, Nepal.
5. Jahurul, M. H. A., Zaidul, I. S. M., Ghafoor, K., Al-Juhaimi, F. Y., Nyam, K. L., Norulaini, N. A. N., and Mohd Omar, A. K. (2015). Mango (*Mangifera indica L.*) by products and their valuable components: A review. *Journal of Food Chemistry*.
6. Islam, M. P., Morimoto, T., and Hatou, K. (2012). Storage behavior of tomato inside a zero energy cool chamber. *Agricultural Engineering International: CIGR Journal*, **14** (4), 209–217.
7. Islam, M. P., Morimoto, T., and Hatou, K. (2013). Dynamic optimization of inside temperature of Zero Energy Cool Chamber for storing fruits and vegetables using neural networks and genetic algorithms. *Computers and Electronics in Agriculture*, **95**, 98–107.
8. Vala, K. V, Saiyed, F., and Joshi, D. C. (2014). Evaporative Cooled Storage Structures : An Indian Scenario. *Trends in Post-Harvest Technology*, **2** (3), 22–32.

9. Ganesan, M., Balasubramanian, K., and Bhavani, R. (2004). Studies on the application of different levels of water on Zero energy cool chamber with reference to the shelf-life of brinjal. *Journal of Indian Institute of Sciences*, **84**, 107–111.
10. Narayana, C., Mustafa, M., and Sathiamoorthy, S. (2002). Effect of packaging and storage on shelf-life and quality of banana cv. Karpuravalli. *Journal of Dairying, Foods and Home Sciences*, **59** (2), 113–117.
11. Prabha, A., H.R, S., A.K, G., and Ranjana, V. (2006). Changes in ascorbic acid content of lemon fruits stored in zero energy cool chamber and under ambient atmosphere. *Journal of Dairying, Foods and Home Sciences*, **25** (1), 73–75.
12. Singh, S., Singh, a. K., Joshi, H. K., Bagle, B. G., and More, T. A. (2010). Effect of zero energy cool chamber and post-harvest treatments on shelf-life of fruits under semi-arid environment of western India. Part 2. Indian gooseberry fruits. *Journal of Food Science and Technology*, **47** (4), 450–453.
13. Murugan, A., Ranjith, S. A. J. A., and Vidhya, S. (2011). Evaluation of self-life and organoleptic aspects of fruits stored in a modified traditional earthen pot cool chamber. *Indian Journal of Traditional Knowledge*, **10** (2), 375–379.
14. Sharma, R. R., Pal, R. K., Singh, D., Samuel, D. V. K., Kar, A., and Asrey, R. (2010). Storage life and fruit quality of individually shrink-wrapped apples in zero energy cool chamber. Indian *Journal of Agricultural Sciences*, **80** (4), 338–341.
15. Dirpan, A., Sapsal, M. T., Muhammad, A. K., Tahir, M. M., and Rahimuddin. (2017). Evaluation of temperature and relative humidity on two types of zero energy cool chamber (ZECC) in South Sulawesi, Indonesia. IOP Conference Series: *Earth and Environmental Science*, **101**, 012028.
16. Ranganna, S. 1997. Handbook of analysis and quality control for fruits and vegetable products. 2nd edn. New Delhi: *Tata McGrawhill Publishing Company Ltd.*
17. Chien, P. J., Sheu, F., and Yang, F. H. (2007). Effects of edible chitosan coating on quality and shelf life of sliced mango fruit. *Journal of Food Engineering*, **78** (1), 225–229.
18. Dirpan, A., Sapsal, M. T., Syarifuddin, A., Tahir, M. M., Ali, K. N. Y., and Muhammad, A. K. (2018). Quality and Storability of Mango During Zero Energy Cool Chamber (ZECC). *International Journal of Agriculture System*, **6** (2), 119-129.
19. Khader, S. E. S. A. (1990). Orchard application of paclobutrazol on ripening, quality and storage of mango fruits. *Scientia Horticulturae*, **41**(4), 329–335.