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

Anand Mishra[1*], Sanjeet Kumar Jha[2], and Pravin Ojha[3]

*Corresponding author's Email: anandhansy@yahoo.com
[1, 2]Agricultural Engineering Division, Khumaltar, Lalitpur, Nepal
[3]Food Research Division, Khumaltar, Lalitpur, Nepal

DOI: 10.29322/IJSRP.10.01.2020.p9767
http://dx.doi.org/10.29322/IJSRP.10.01.2020.p9767

Abstract: Two-third of the population of Nepal depends on agriculture which shares about 31% of gross domestic product. Although there is huge potential of vegetable cultivation in Nepal, however post-harvest losses of vegetable negatively affect the economy of Nepalese agriculture. The vegetables are vulnerable to high temperature. The adoption of newer storage techniques is necessary to prevent waste of fresh vegetables. The zero energy cool chamber (ZECC) is an ecofriendly system with low cost of construction. The present study was conducted to qualify the quality and storability of vegetables (pointed gourd and okra) in different storage conditions such as in ZECC, room, and freeze conditions. We measured the physiological loss of water (PLW) and vitamin C of vegetables under different storage conditions. The study was conducted at Agricultural Engineering Division, Khumaltar, Lalitpur, Nepal. Pointed gourd and okra were purchased from the local market. They were stored in three different storages conditions such as in ZECC, room condition, and freeze conditions. The results showed that the highest PLW (%) was recorded on fifth days of storage for the room storage and the lowest was recorded for ZECC condition. The vitamin C significantly increased on the fifth day of storage compared to the first day for all types of storage. On the seventh day of storage, vitamin C was decreased compared to the fifth day in both ZECC and freeze conditions. The PLW was higher in freeze storage condition compared to that of ZECC condition. We concluded that pointed gourd and okra stored in ZECC can be stored until fifth day of storage after considering both quality and PLW. Our result suggested that ZECC can be used as a storage structure for vegetables such as pointed gourd and okra.

Keywords: ZECC, PLW, Vitamin C, Pointed gourd, Okra

1. Introduction

Nepal is the sixth leading producer of fresh vegetables after China, India, Vietnam, Philippines, and Myanmar in 2016 [1]. Farmers are attracted to vegetable farming in Nepal [2]. Two-third of the population in Nepal depends on agriculture which shares about 31% of gross domestic product [3, 4]. Farmers can generate cash by cultivation vegetable crops even in a small plot of land in a short period and can improve their livelihood [5]. Although there is huge potential of vegetable cultivation in Nepal, however post-harvest losses of vegetable negatively affect the economy of Nepalese agriculture. (Gautam and Bhattarai, 2006) [6] reported that the post-harvest loss of fruit and vegetable in Nepal is about 20-50 percent. After harvest of vegetable, it is stored and transported under various environmental conditions before it reaches the retailer market. Post-harvest losses during handling, transportation, storage, and distribution are the major losses for perishable vegetable marketing. Turan (2008) [7] reported that improper harvesting and post-harvest practices cause the spoilage of vegetables which reduces the quality of vegetables such as deterioration in appearance, taste, and nutritional value before reaching the market. The vegetables are vulnerable to high temperature. The adoption of newer storage techniques is necessary to prevent waste of fresh vegetables.

The zero energy cool chamber (ZECC) is an ecofriendly system with low cost of construction. It also saves energy as it does not need electricity for its operation. It is constructed with locally available materials therefore these structures can be easily constructed in rural areas [8]. The evaporative cooling is suitable for storage of fruit and vegetables compared to refrigerators [9, 10]. ZECC can be used as short-term on-farm storage of perishable agricultural commodities as well as for pre-cooling of fruits and vegetables before transit and storage in cold storage [11]. Temperature and relative humidity in the storage chamber are important environmental factors affecting the ripening process of fruits and the final quality [12, 13]. Ganesan *et al*., (2004) [14] and Rajeswari *et al*., (2011) [15] reported that the storage of fruits and vegetables inside ZECC could reduce the water loss. In a semi-arid region, it is viable to use ZECC storage to retain freshness longer during storage. There are limited researches on the quality and storability of vegetables (pointed gourd and okra) stored in the ZECC storage condition. Therefore, this study was conducted to qualify the quality and storability of vegetables (pointed gourd and okra) inside the ZECC. We measured PLW and vitamin C for the fulfillment of our objectives.

2. Material and Methods

2.1. Construction of Zero energy cool chambers (ZECC)

ZECC was made from locally available raw materials such as bricks, sand, bamboo, dry grass, jute bags etc. The chamber is an above-ground double-walled structure made up of bricks. The cavity of the double wall is filled with riverbed sand. ZECC had a maximum efficiency during the summer season. The rise in relative humidity (90% or more) and fall in temperature from the ambient condition could be achieved by watering the chamber twice a day. The photographic view of ZECC constructed at Agricultural Engineering Division is shown in Fig. 1.

Fig. 1: Photographic view of Zero energy cool chamber (ZECC) constructed at Agricultural Engineering Division, Khumaltar.

2.2. Experimental design

This research was conducted at Agricultural Engineering Division, Nepal Agricultural Research Council, Khumaltar from June to July 2019. Pointed gourd and okra were collected from the local market. About five kilograms of pointed gourd and okra each with no fungal infection were selected, labeled and weighed initially. Finally, they were stored in three different storage conditions such as ZECC, room, and freeze conditions.

2.3. Information about storage container

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

2.4. Effects of storage types on quality of vegetables

2.4.1. Effects of storage types on physiological loss in weight (PLW) of vegetable

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.

2.4.2. Effects of storage types on vitamin C of vegetable

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

2.5. 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 the experiment is shown in Table 1. The room temperature ranges from 29.4 to 31.5 ° C. However the ZECC temperature ranges from 23.4 to 25.0 ° C.

Table 1: Room and ZECC temperature during experiment

Month	Day	Room temperature (° C)	ZECC temperature (° C)
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 pointed gourd and okra

The physiological loss in weight (PLW) of pointed gourd stored inside ZECC, room, and freeze conditions are shown in Fig. 2. We found significant differences in PLW (%) of pointed gourd stored in the ZECC compared to room storage condition. The PLW of pointed gourd stored inside the ZECC were lower than those stored in room and freeze conditions. On the fifth day of storage of pointed gourd, the highest PLW was recorded for room storage conditions followed by freeze storage condition. The lowest PLW was discovered for pointed gourd stored in ZECC condition. On the seventh day, the PLW was 10.60% and 30.54% for pointed gourd stored in freeze and ZECC conditions, respectively. 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.

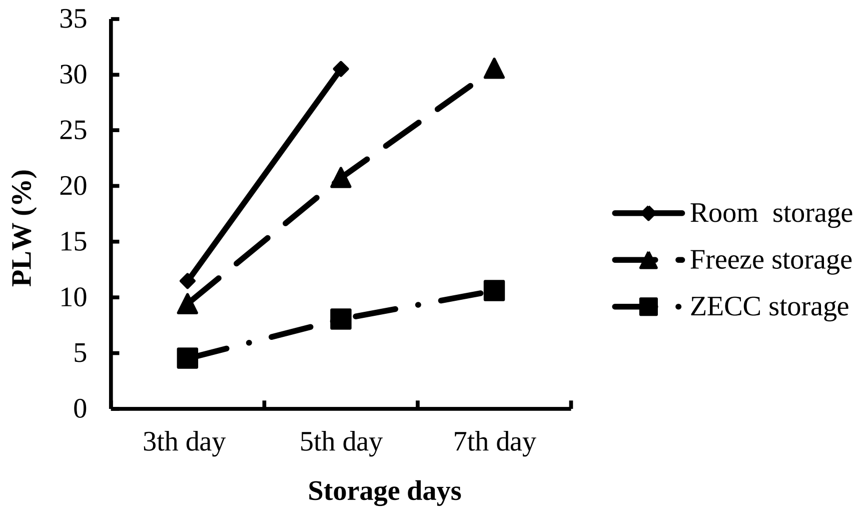

Fig. 2: Effects of storage types on physiological loss in weight (PLW) of pointed gourd with storage days.

The physiological loss in weight (PLW) of okra stored inside ZECC, room, and freeze conditions are shown in Fig. 3. We found significant differences in PLW (%) of okra stored in the ZECC compared to okra stored in room condition. The PLW of okra stored inside the ZECC was lower than those stored in room and freeze conditions. On the fifth day of storage of okra, the highest PLW was recorded for okra stored in room conditions followed by freeze storage condition. The lowest PLW was discovered for okra stored in ZECC condition. On the seventh day of storage, the PLW were 22.89% and 43.17% for okra stored in freeze and ZECC conditions, respectively. 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.

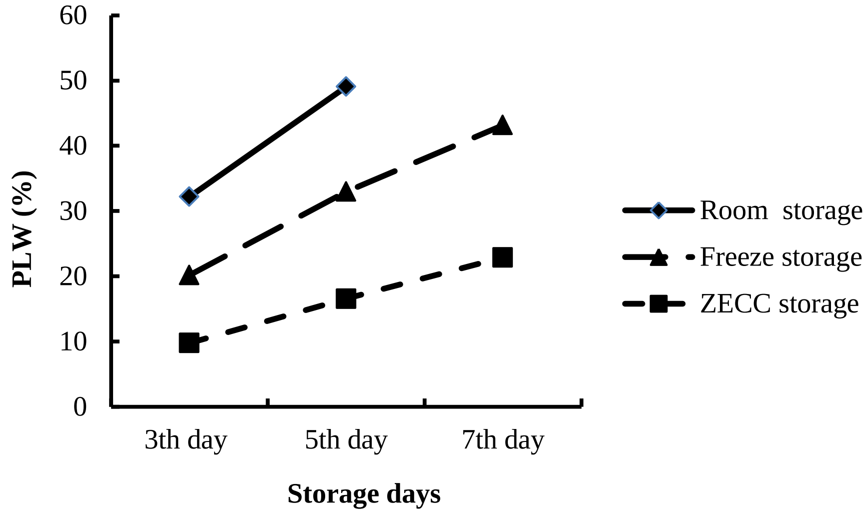

Fig. 3: Effects of storage types on physiological loss in weight (PLW) of okra with storage days.

3.3. Effects of storage types on vitamin C of pointed gourd and okra

The vitamin C of the pointed gourd in three different storage conditions is presented in Table 2. The range of vitamin C content was from 38.58 to 61.22 mg/100g. The vitamin C content on the first day was 45.15 mg/100g. The highest vitamin C (61.22 mg/100g) was found in ZECC treatment on the fifth day of storage; however, the lowest (39.71 mg/100g) was recorded in ZECC condition on the seventh day. In general, vitamin C content of the pointed gourd 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 pointed groud

Treatment	1st day	5th day	7th day
Room condition	45.15 ± 2.82	41.99±3.28 [b]	-
Freeze	-	50.66±3.93 [ab]	38.58±4.28 [a]
ZECC	-	61.22± 4.56 [a]	39.71±2.94 [a]

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

The vitamin C of the okra in three different storage conditions is presented in Table 3. The range of vitamin C content was from 20.02 to 67.87 mg/100g. The vitamin C content on the first day was 33.58 mg/100g. The highest vitamin C (67.87 mg/100g) was found in ZECC treatment on the fifth day of storage; however, the lowest (22.34 mg/100g) was recorded in ZECC condition on the seventh day. In general, vitamin C content of the okra stored in ZECC conditions was significantly higher compared to the room storage condition (Table 3). 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 3: Effects of storage on Vitamin C (mg/100 mg) content of okra

Treatment	1st day	5th day	7th day
Room condition	33.58±2.96	37.70±2.93 [b]	-
Freeze	-	48.28±3.69 [b]	20.02±0.94 [a]
ZECC	-	67.87±2.96 [a]	22.34±1.4 [a]

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

4. Conclusions

This study was conducted to qualify the quality and storability of vegetables (pointed gourd and okra) under ZECC, freeze, and room storage conditions. We concluded that storing vegetables in ZECC enhances the quality and storability of vegetables until the fifth day of storage. Therefore, we concluded that ZECC can be used for storage of vegetables such as pointed gourd and okra.

Acknowledgements

This study was financially supported by Nepal Agricultural Research Council (NARC). The authors would like to express sincere gratitude to all staff of Agricultural Engineering Division who directly or indirectly helped to conduct this experiment.

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