EFFORT TO ENHANCE STORABILITY OF NEPALI SWEET ORANGE (*Citrus sinensis*) UNDER DIFFERENT STORAGE CONDITIONS

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ABSTRACT

Nepali sweet orange (Citrus sinensis) cultivars are grown in mid hills and are considered to be exquisite in taste. It is mostly harvested during December-January that fetches poor market price. Farmers try to delay picking by retaining fruit on tree compromising tree health and production for next season. Further in some places farmers try to store in normal room and cellar storage facility with considerable amount of post-harvest loss. Recently cool bot storage facility has been introduced to storage horticulture commodities. Thus an experiment was set to study the effect of various storage structure on shelf life of sweet orange at National Citrus Research Program, Dhankuta, Nepal. Four types of storage facilities (zero energy, cellar, cool bot and normal room) were used to store sweet orange fruit over 90 days. Freshly picked Dhankuta Local sweet orange fruit with small pedicel intact were used for this study in RCB design with four treatments replicated four times. Physiological loss in weight (PLW), fruit rot percent, juice recovery percent, TSS and TA were recorded at weekly interval. The result revealed that there was no significant difference in chemical quality parameters (TSS and TA) due to storage method. However, juice recovery and PLW was better in cool bot and cellar stored fruit with ≤ 15% fruit rot when waxed fruit were stored at 10-12°C with more than 85% RH. In a constant supply of electricity, cool bot storage could be better option compared to other storage facilities for sweet orange storage up to three months.

Keywords: *cellar, cool bot, post-harvest loss, zero energy*

INTRODUCTION

Sweet orange fruit is grown throughout mid hills (800-1600 m) of Nepal and most of the genotypes grown are landraces with harvesting time during December to January (Acharya et al., 2019; NCRP 2018). There are many traditionally grown sweet orange landrace in central to eastern Nepal. The current sweet orange area (6446 ha) produces 43061 mt fruit with productivity of 10.14 mt/ha (MoALD 2019). Due to short harvesting window, there is always market glut with nominal selling price of the fresh fruit resulting lower income to the orchardist. In the past, Nepal government has promoted cellar house to promote storage in season and marketing during off-season for better price but this structure has its own limitation as need to be constructed above 1300 m-asl towards northern facing slope and every orchardist cannot have such kind of advantage. There were reports of post-harvest loss up to 25% inside cellar storage (Bhattari et al., 2013; Bhusal, 2002; & PHLRD, 2005).

Cool bot machine for fresh produce storage is comparatively a recent introduction in Nepal. Orchardist are willing to build and store their citrus fruit inside cool bot house as it breaks the altitude and aspect barrier of cellar storage construction. The two pre-requisites for the cool bot installation are: air tight room and electricity facility where in farmer can install a 1-1.5 ton capacity air condition with cool bot machine. The cool bot machine hacks the 16^{o}C limit of air-condition system and brings down temperature to 8-12^{o}C needed for sweet orange storage. The temperature drop inside the room to desire level depends on air volume inside the structure and capacity of the air-condition system. There is still issue of green and blue mold development inside storage room caused by *Panicillium digitatum* and *Panicillium italicum* (Smilanick et al., 2008). Hence to test the ability of a cool bot chamber for storability of Dhankuta local sweet orange a study was carried out in year 2020 at NCRP, Dhankuta.

MATERIALS AND METHODS

Storage condition and sample preparation

An experiment was set up using four storage facilities: zero energy chamber, cellar room, normal room and cool bot room storage at an elevation of 1300 m-asl. Cool bot room (1.8 m x 1.8 m x 2.5 m) equipped with 1 mt capacity air-condition and one cool bot machine purchased from R and D Solution, Kathmandu. Sweet orange cv. Dhankuta Local fruit harvested with small pedicel intact using clipper as suggested by Rokaya et al (2020) from National Citrus Research Program, Dhankuta experiment block were used for this study. Aforementioned four storage treatments were imposed to selected fruit lot of same size and uniform maturity stage. Sixty fruits were allocated for each treatment in RCB design and replicated four times. The fruit were first treated with bee wax emulsion (10%) prepared with oleic acid and tri-ethanolamide as suggested by Lahlali et al. (2014) and Rokaya et al. (2016). Fruit were stored on cast iron shelves and without staking in cellar and cool bot facilities whereas plastic crates and plastic trays were used in zero energy and normal room condition, respectively. It was not possible to spread the fruit over the ground due to space limitation in zero energy chamber and cleanliness issue in normal room condition. The data on physiological loss in weight (PLW), percent fruit rot, juice recovery percent, TSS and TA were recorded at weekly interval. Three fruits were randomly chosen for destructive sampling at each week while recording fruit quality parameters. The trial was conducted from 19th January to 16th April 2020. The fruit rot was measured as damage of the fruit caused by blue mold. The juice recovery was measured with measuring cylinder of the squeezed juice and expressed in percentage compared with whole fruit weight. The TSS and TA was measured with digital Acid Brix meter (from Atago Japan Cat No 7101, https://bit.ly/3fO9CZG). The reading was taken in duplicate from each fruit for both TSS and TA.

Storage room temperature and relative humidity

The cool bot and cellar room temperature were kept between 11-14^{o}C with relative humidity of more than 85% while the normal room condition was with temperature 18-25^{o}C and relative humidity between 65-85% (Figure 1). These data were recorded around 11 am each day using digital sensor. There was intermittent electricity failure at 33 days and 71 days afterwards of storage resulting drop of relative humidity near to 60% in cool bot storage. The PLW was recorded as loss in weight fruit of during storage as compared with previous reading of the same and expressed as percentage.

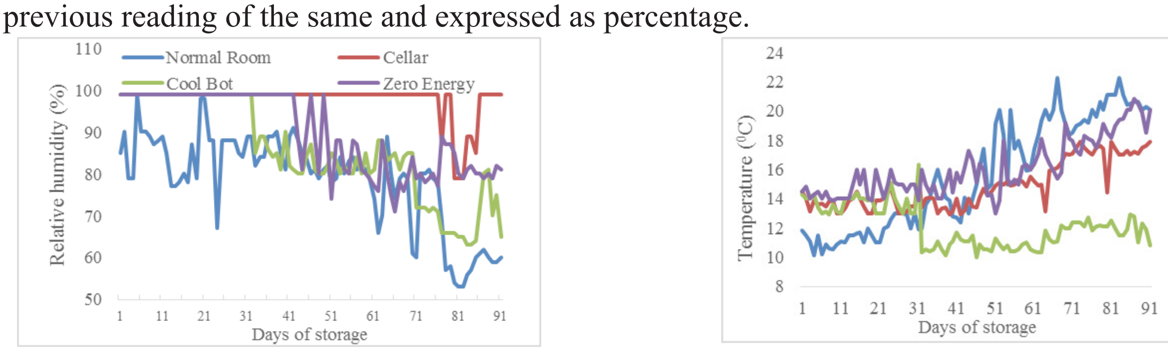

Figure 1. The relative humidity and temperature at different storage condition

The data were analyzed using R software (v 4.0.0) with add on packages tidyverse (1.3.0) and car (3.7-0) and graph were prepared using packages ggplot2 (v 3.3.0) and ggpubr (v 0.4.0). The correlogram plot was created using R package corrplot (0.84). The average value of all quality parameters for different storage method was calculated and their correlation with each other was obtained, tested for significance and plotted with color coding for positive and negative association as a correlogram.

RESULTS AND DISCUSSION

Fruit rot (%)

The fruit rot due to blue mold in different storage condition was non-significantly different throughout the storage period (Figure 2). The average rot percent was below 6% till seventy days of storage and by the end of the experiment it went up to 15% in zero energy chamber. The higher blue mold induced fruit loss during last 20 days of experiment was with the onset of summer season in naturally ventilated room and zero energy chamber while that was due to electricity failure for few hours to days in cool bot room. In this experiment there was less than 25% fruit loss due to blue mold in all storage system as compared to >25% in same cellar storage condition in year 2019 (NCRP, 2019). This could be partly attributed to waxing of fruit. The storage loss was as minimum as 6% to maximum of 25% in this storage study was similar to the findings of Rokaya et al. (2016) under their cellar storage study of mandarin fruit. There was up to 30% loss in the under cellar storage due to rotting at Dhankuta condition in the year 2017 (NCRP, 2018).

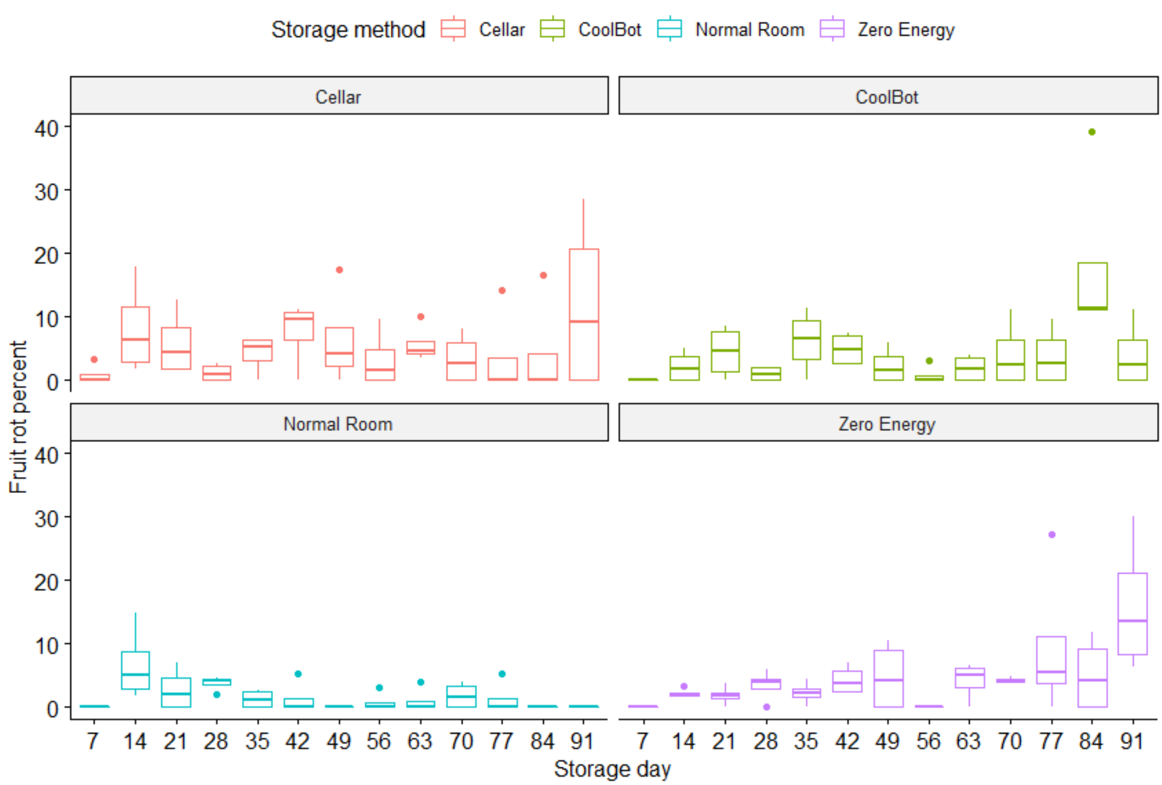

Figure 2. Change in fruit rot (%) due to blue mold over storage period of three months

Physiological loss in weight (%)

The effect of storage condition on PLW was non-significant during the storage period when analyzed at weekly interval. The physiological loss in weight was not more than one percent till 56 days after storage on all storage facilities except in normal room condition wherein it reached 12% in 49 days (Figure 3.). This finding was in agreement with the finding of the mandarin storage study by Rokaya *et al.* (2020). The PLW was below 5 percent till 70 days in other storage conditions with exception of cellar storage then after and reached more than 10% after that time in this study. Later after 77 days of storage the loss was higher than 10% in cool bot due to electricity failure during that time and similar trend was found in cellar storage too. The highest weight loss of up to 19% was recorded in cellar storage at weekly interval which was followed by 15.5% in cool bot facility, 12% in normal room and 8% in zero energy chamber. There was increasing trend of PLW as storage day advances. This result was also in agreement with the findings of PHLRD (2005) and Rokaya et al. (2020).

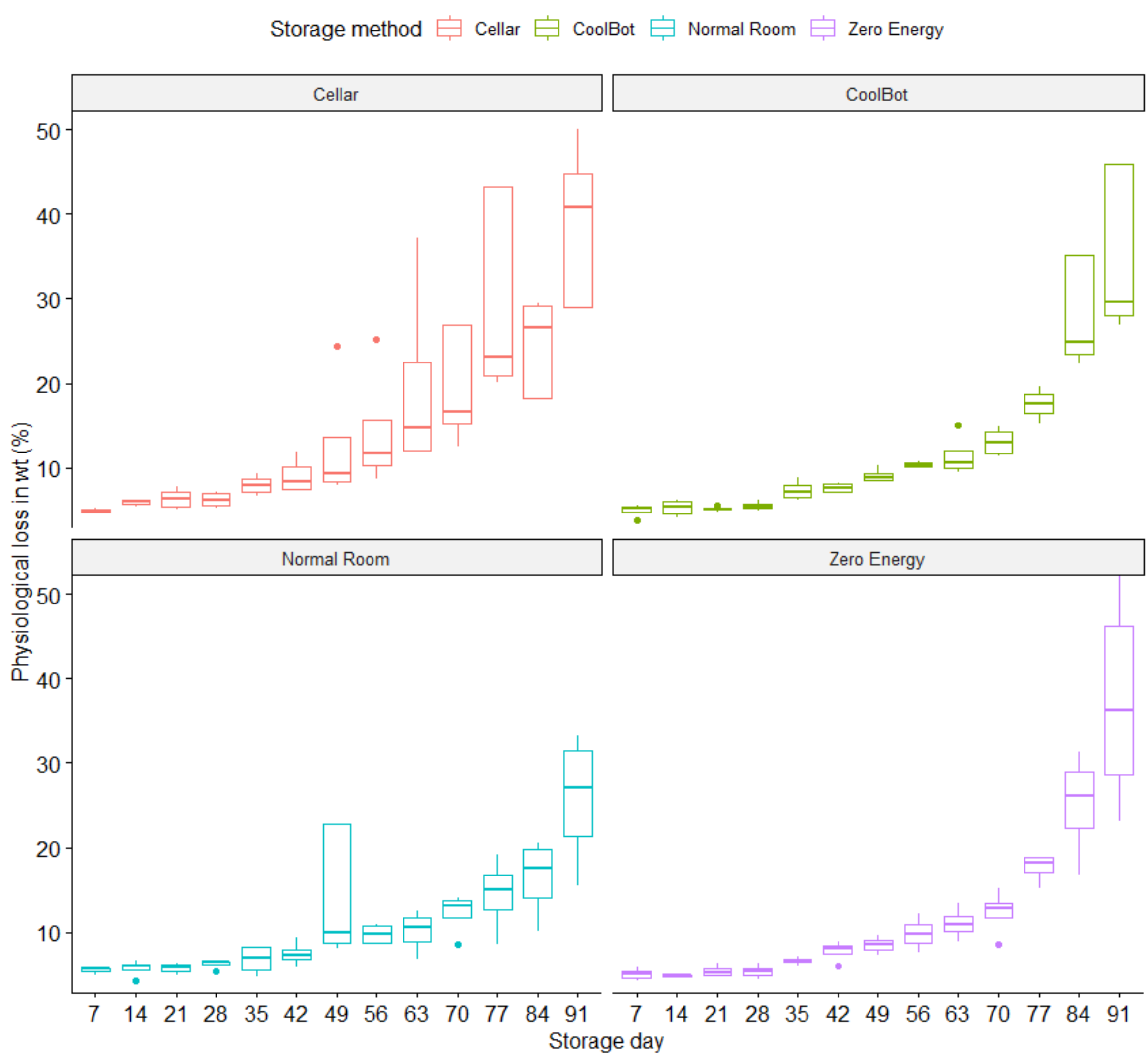

Figure 3. Change in physiological loss in weight (%) over storage period of three months

Juice content (%)

The juice content was ranged between as low as 30% to as high as 51% during experimental period (Figure 4). The lowest content of juice was found around 28% in normal storage to as high as 61% in zero energy chamber. The juice content was not much affected by storage condition during earlier stage as there was negligible water loss from the fruit as represented by PLW (Figure 3) while it was significantly differed from 63-77 days of storage and later there was no effect of storage. During the latter stage the higher average juice content was found in cool bot followed by cellar storage. This trend could be attributed the way of PLW changes during earlier and later days of storage (Figure 3) as juice recovery is positively linked to PLW (Figure 6). Further such pattern of PLW change associated with change in juice content was also confirmed by Rokaya *et al.* (2020).

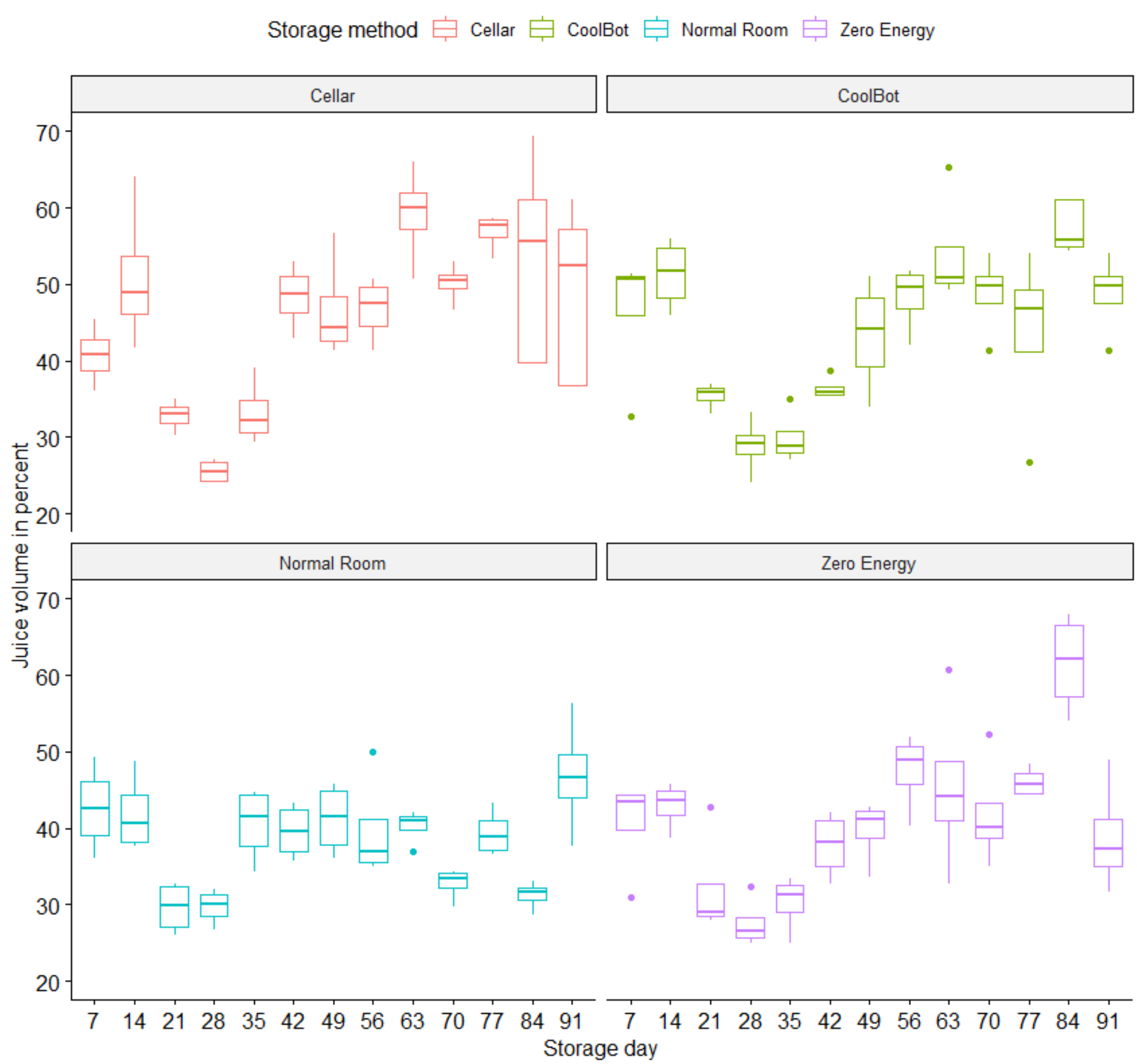

Figure 4. Change in individual fruit juice content (%) over storage period of three months

Titratable acidity (%)

The titratable acidity was ranged between 1-2% during the storage period (Figure 5). The significant effect of storage condition on TA was shown on 28, 35, 63 and 77 days after storage. However, during early and mid-experimental period there was no storage effect evident. This could be linked to no significant change in juice recovery percent and PLW as both have significant negative correlation with TA value (Figure 6). There was no abrupt or steady decline in TA during storage period and similar trend has been reported by Rokaya et al. (2020) while storing mandarin in cellar storage.

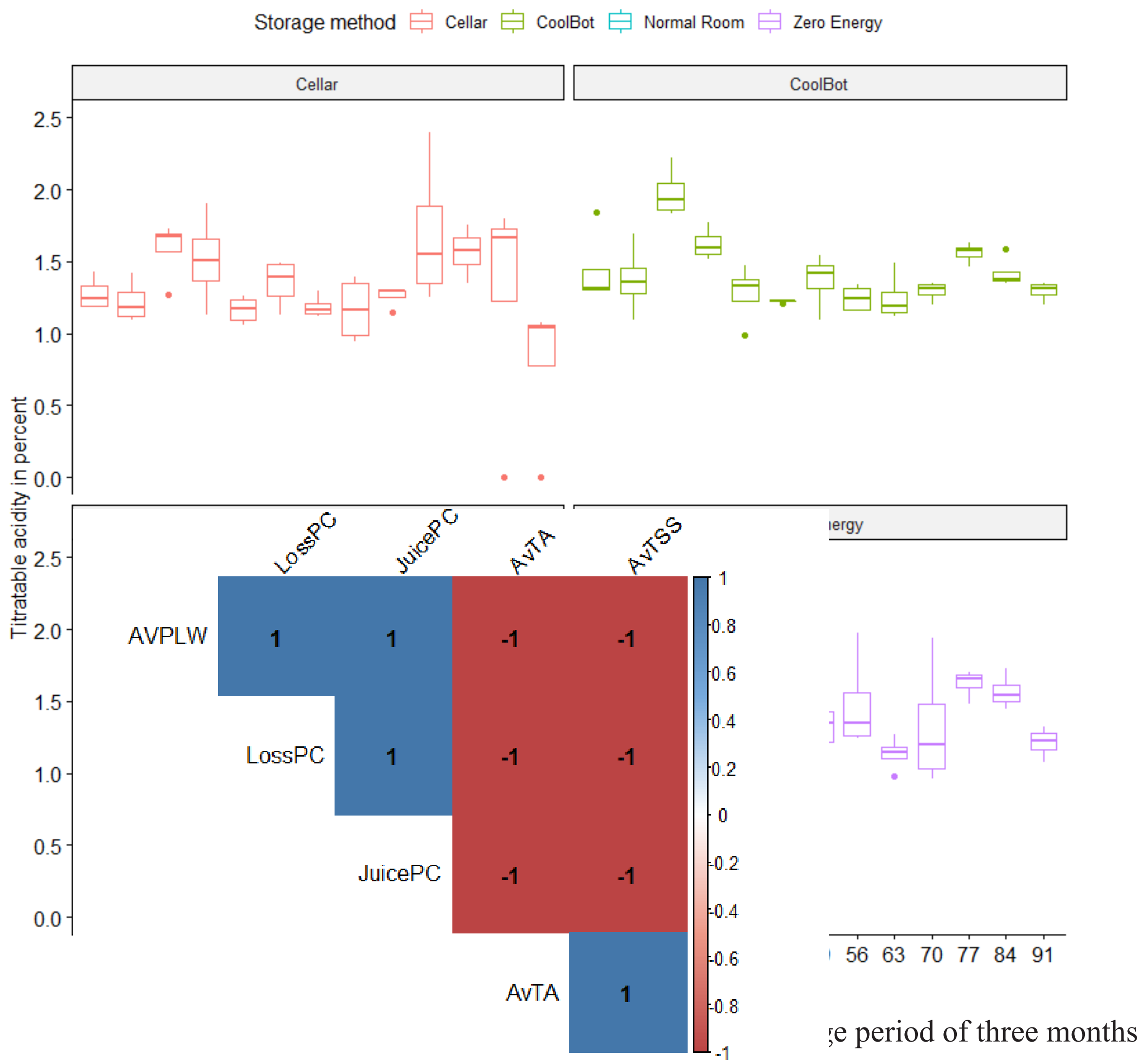

Figure 6. Correlogram of AVPLW (average physiological loss in weight), LossPC (fruit rot percent due to blue mold), JuicePC (Juice recovery percent), AvTA (Average titratable acidity) and AvTSS (average total soluble solid).

The red color indicates significant negative and blue color indicates significant positive correlation between parameters.

TSS (%)

Average TSS content was ranged 8-11% during the storage period of the fruit (Figure 7). The effect of storage condition on TSS was found statistically significant on earlier four week and at 70 and 77 days of storage. This kind of change could be linked to similar trend on change in juice recovery and PLW as these values found showing negative but significant correlation with TSS (Fig 6). The highest TSS content was always recorded from fruit stored under normal room condition (>10%) and the lowest from zero energy chamber (9-9.5%). There was no sharp increase in TSS evident during the experimental period in all type of storage condition. A similar trend in TSS was recorded by NCRP (2019) and Rokaya et al. (2016 & 2020) in their mandarin storage study under cellar and normal room storage.

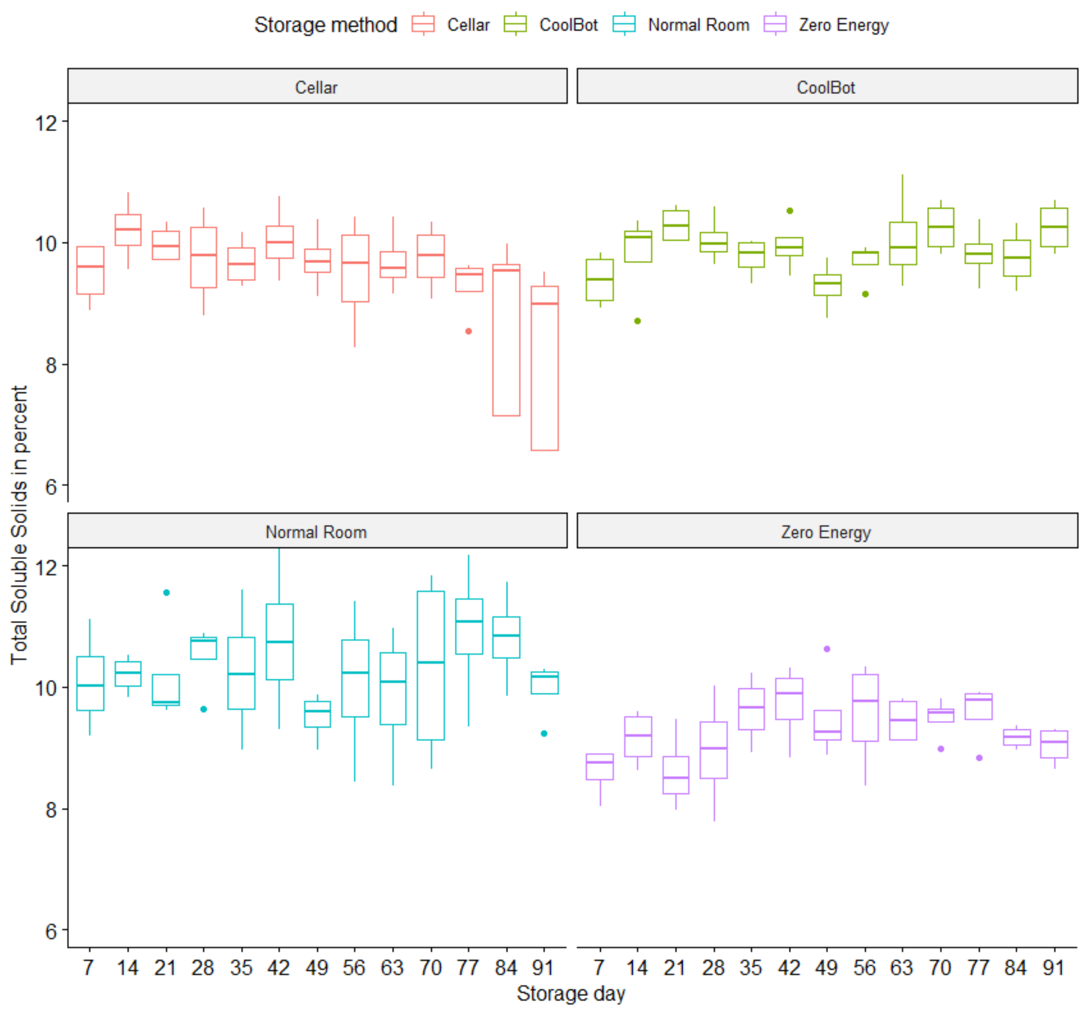

Figure 7. Change in total soluble solid content (%) over storage period of three months

CONCLUSION

Present study found all storage structure works well in winter season for up to 90 days of storage with less than 5% fruit rot and lower PLW with varying capacity of storage provided sweet orange fruit is waxed and stored under 15^{0}C and >80% RH at an elevation of 1300 m-asl. The cool bot storage technology is to be used in places where there is assure electricity throughout the storage period.

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