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Comparison of Two Storage Structures for the Storage of Sweet Potato Tuberous Roots in the Coastal Savannah Zone of Ghana

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ABSTRACT

The storage of sweet potato (*Ipomoea batatas* L.) is confronted with a myriad of post harvest challenges resulting in heavy losses during marketing and storage in tropical Africa. In this study two storage structures were evaluated and compared for the storage of two sweet potato varieties. A completely randomized design (CRD) was used and the roots were stored for twelve (12) weeks in both storage structures. The two storage structures improved the shelf life of sweet potato over 8 weeks. However after 10 weeks of storage, the Purpose Built Evaporative Cooling Barn (PBECB) stored sweet potato roots better than Modified Pit Storage Structure (MPSS). The roots stored in the PBECB showed 66% wholesomeness, 53% weevil damage, 3.8% shrinkage, 30% weight loss, 58% sprouting and 52% decay compared with 60% wholesomeness, 53% weevil damage, 4.1% shrinkage, 38% weight loss, 74% sprouting and 60% decay of roots stored in the MPSS. TIS 2 sweet potato variety stored better than Ukerewe variety in both structures. TIS 2 sweet potato stored for 3 months in the PBECB with 76% wholesomeness, 12% weight loss, 29% decay and 3.4% shrinkage.
Keywords: Sweet potato, Purposed Built Evaporative Cooling Barn, Modified Pit Storage Structure.

INTRODUCTION

Sweet potato (*Ipomoea batatas* Lam.) is a herbaceous perennial and the edible portion is the tuberous root though the young leaves and shoots are eaten as well (Woolfe, 1992). The crop is now cultivated throughout the tropics and subtropics; it is ranked seventh among the most important crops worldwide (Scott, 1992; Zhitian *et al.,* 2001). The ranking differs from country to country; in China it is ranked fourth as a food crop after rice, wheat and maize (Li *et al.,* 1992) while in Sierra Leone, it is ranked third after rice and cassava (IAR, 2009).

In Ghana and other parts of tropical developing countries, sweet potato tuberous roots have storage duration of only up to three (3) weeks (Rees *et al.,* 2003; Teye, 2010). However, under controlled atmosphere (Temperature range of. 13-15^{o}C and RH of 90%) the roots can be stored up to a year (Woolfe, 1992; Rees *et al.,* 2003).

Despite the immense economic prospects that could be derived from its production and marketing, sweet potatoes is highly perishable. Its perishability arises mainly because of the thin delicate skin which easily gets damaged during harvesting and post harvest handling. This is also coupled with unfavourable environmental conditions and weevil damage in storage. Currently, the cultivation of sweet potato is being encouraged in Ghana. However, during the glut season, farmers find it difficult to store because they lack appropriate storage structures which are able to reduce weevil damage, and curb deterioration in store. Hence, this research seeks to evaluate and compare two storage structures for the storage of two sweet potato varieties.

MATERIALS AND METHODS

Study Area

The study was carried out at the Technology Village of the School of Agriculture, University of Cape Coast from March 2009 to April 2010. The experimental area falls within the Coastal Savannah zone of Ghana. It is between latitude 05^{0} 03'N and 05^{0} N and longitude 01^{0} 13'W and is characterized by an annual rainfall of about 750mm to 1200mm (Boamah, 2008). There are two main seasons in the area: wet season and dry season. The wet season is divided into major and minor seasons. The major season starts from May to July and peaks in June while the minor season begins from September to November and peaks at October. The main dry season in the area is from December to February. Temperatures throughout the year are usually high, with the maximum usually between 30–36^{0}C and minimum between 22–26^{0}C (Ayittah, 1996). The relative humidity in the area ranges from 65-70% (Meteorological Station Cape Coast, 2002).

Storage Structures

- **Purpose Built Evaporative Cooling Barn (PBECB)**

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The Purpose Built Evaporative Cooling Barn had a concrete foundation, two layers of block wall at the base, and plastered with a 10mm concrete plaster, making it a composite wall. It has a wooden columns, beams, and frames, and walled with jute sacks. The jute sacks were fastened to the wooden columns and beams with thread and nails. In all, 50 jute sacks were used, each with an area of $0.9m^2$. The roof was double-pitched, with 45^0 slope to facilitate easy run-off of condensed water and was covered with spear grass thatch. A bamboo water trough was to collect water and 3in PVC pipe was fixed above the structure to provide a means of wetting the jute sacks for evaporative cooling. The floor and basement were made of concrete mix in a ratio (1:3:5) with 31kg of water per bag of cement. The completed Purposed Built Evaporative Cooling Barn is shown in plate 1.

- **Modified Pit Storage Structure (MPSS)**

The Modified Pit Storage Structure was constructed by digging a pit of dimension 1.5m wide, 3m long and 1m deep. It was then lined with bricks and a 3-inch PVC pipe was erected from the base of the pit to the surface for ventilation. Also, a suck-way stocked with stones was created beneath the pit and occasionally moistened with water through the 3 inches PVC pipe to improve relative humidity and temperature. The pit was then covered with welded mesh and net to prevent insect pest from entering structure. Finally, an over head mono-pitch shade of 2m above ground was constructed to prevent rain water from entering the storage structure. The completed Modified Pit Storage Structure is shown in plate 2.

Plate 1: Completed PBECB

Plate 2: Completed MPSS

Comparing the two storage structures

Two varieties of sweet potatoes namely TIS 2 and Ukerewe were obtained from the School of Agriculture research farm. The two varieties were then cured separately at 32^oC and 90% relative humidity and bagged into mini sacks (10 roots each). The mini sacks with the roots were stored in the structures on the shelves. The arrangement was done using completely randomized design (CRD) with three replications. The sacks in each structure on each shelf were randomly sampled for destructive analysis every two weeks for 3 months. Daily temperature and relative humidity of the inside and outside air stream of the storage structures were measured with a digital thermo-hydrograph. A Psychometric software (CYTPsyChart) was used to generate the other properties of the air streams in both structures.

Data collection

The following parameters were recorded for both structures during each sampling period: weight loss, shrinkage, weevil damage, decay, rate of sprouting, and wholesomeness. Weight loss was calculated by subtracting the final weight from the initial weight at every sampling time. Shrinkage of the roots was determined by measuring the diameter of the root with a calliper at the start of the research and also at every 2 weeks interval. The diameter measuring point at the start was marked with a permanent marker and this served as a reference point for subsequent measurements. The differences in the initial and final diameter were used to determine the shrinkage. A tuberous root showing the presence of *Cylas sp* or tunnels created by the weevils is recorded as damaged and weevil damage recorded (Nicole, 1997). The incidence of decay was assessed using the percentage surface of the roots showing deterioration. Roots showing extensive rot (> 50% surface) were removed from the sack. The sprouting index was calculated using the ratio of the occurrence of sprouting to the total number of roots. Sweet potatoes that showed at least 20% deterioration are considered unwholesome and the percentage wholesomeness was found from the total number of roots. Other investigators (Mutandwa & Gadzirayi, 2007; Rees *et al.,* 2003) used similar approaches to assess root decay and percentage wholesomeness. The results were subjected to analysis of variance using GenStat statistical software to investigate significant differences in the parameters studied.

RESULTS AND DISCUSSION

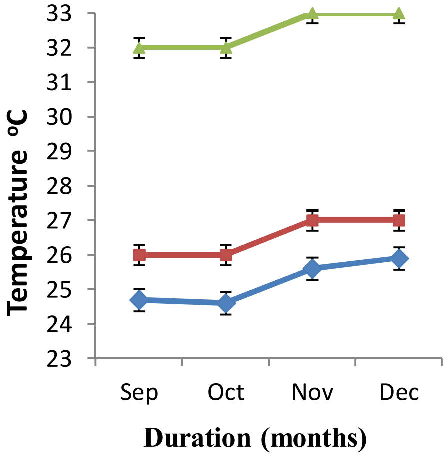


Fig. 3 Maximum temperature in storage structures

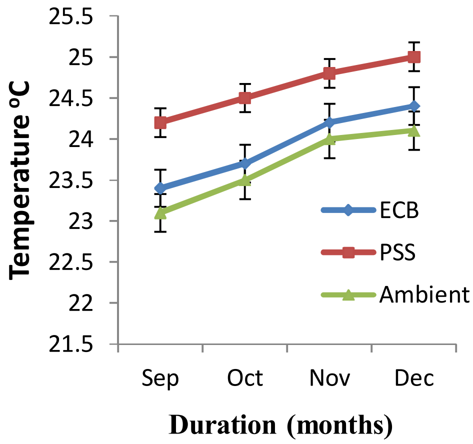


Fig. 4 Minimum temperature in storage structures

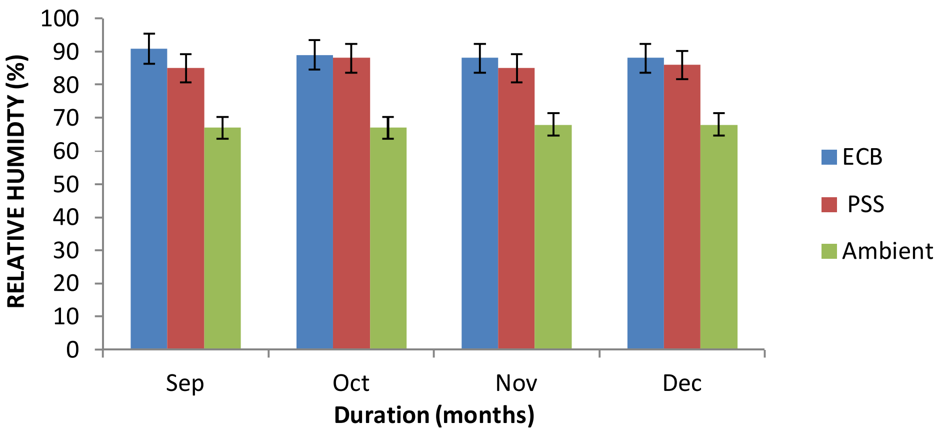


Fig. 5 Relative humidity in storage structures and of ambient air

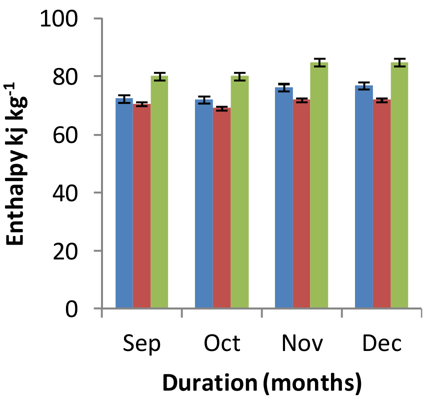


Fig. 6 Enthalpy in storage structures

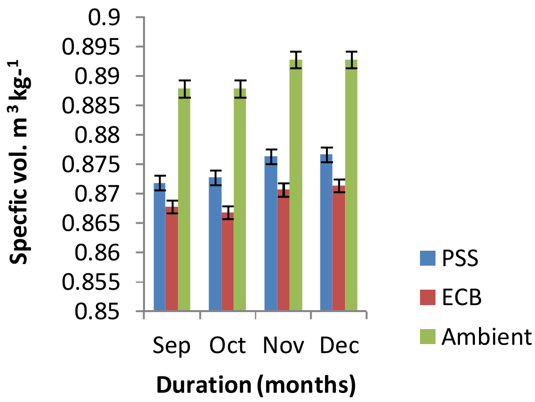


Fig. 7 Specific volume in storage structures

Psychrometric properties in structures and of ambient air

Temperature and relative humidity

From figures 3 & 4 the ambient temperature was relatively higher than the temperature in the two storage structures. On the contrary in figure 5, the relative humidity in the two storage structures was higher than that of the ambient air; because in the two storage structures, water was used for evaporative cooling thus reducing the heat energy coming into the structure. For the Evaporative Cooling Barn (ECB), the jute sack wall was occasionally moistened to reduce temperature. The wet jute sack acted as a cladded wall to reduce the temperature hot air entering the storage structure. In the case of the Pit Storage Structure (PSS), the suck-away beneath the shelves was moistened daily to increase the relative humidity and temperature. Comparatively, the two storage structures had a lower temperature and relative humidity than ambient condition. To a large extent the structures improved environmental conditions and maintained a fairly good relative humidity and temperature.

Enthalpy and specific volume of air

From figure 6 & 7, the enthalpy and specific volume for the ambient air and the storage structures were different. This is because the cooling process in the storage structures was adiabatic processes. The high ambient sensible heat blown through the wet pad was converted to latent heat of vaporization and resulted in a depression in the internal enthalpy of air in the storage structures. Furthermore, heat generated by respiration of the sweet potatoes was too small to raise the enthalpy to the level of the ambient enthalpy. The specific volume of the ambient air was higher than the specific volume of the two storage structures, with that of the Pit Storage Structure being higher than that of the Evaporative Cooling Barn. These differences were due to their enthalpy, dry bulb and wet bulb temperatures.

Percentage weight loss

Figures 1 and 2 shows the percentage weight losses of the two sweet potato varieties stored in the two storage structures. It was revealed that weight loss damage for Ukerewe in both storage structures was barely the same, with no significant differences between them. However, the PBECB stored TIS 2 sweet potato variety better than the MPSS. Also, at the end of 12 weeks of storage weight loss in the PBECB was 12% while that of the MPSS was 34%. Weight loss in both structures was inevitable as reported by Rees et al., (2003). However, it was minimized better in the PBECB than the MPSS hence it could be said that the PBECB had a lower physiological breakdown due to a more stable environmental state.

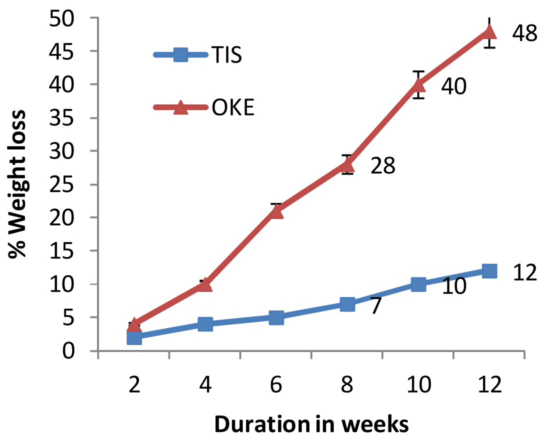


Fig. 3 Percentage weight loss in PBECB

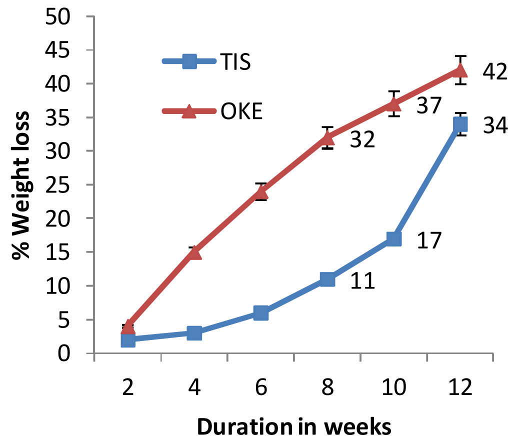


Fig. 4 Percentage weight loss in MPSS

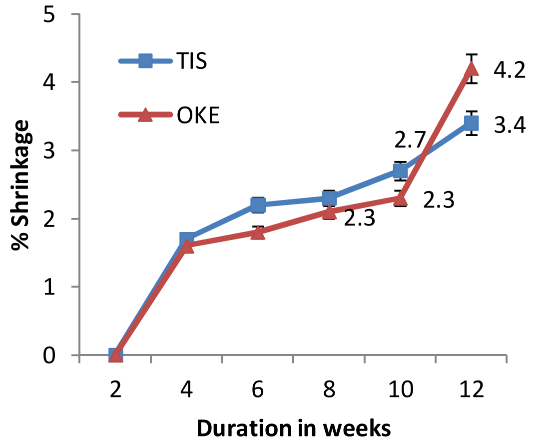


Fig. 3 Percentage shrinkage in PBECB

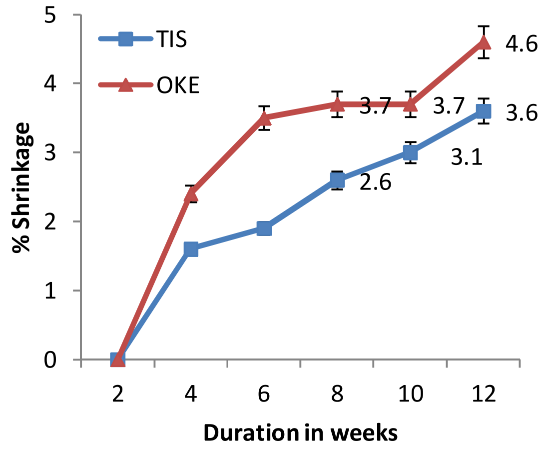


Fig. 4 Percentage shrinkage in MPSS

Figures 3 and 4 indicate that shrinkage in both storage structures was fairly the same statistically. However, at 10 weeks of storage percentage shrinkage in the PBECB was lower that is between 2.3 & 2.7 while in the MPSS it was also between 3.1 to 3.7. This further revealed that the PBECB was slightly better than the_MPSS.

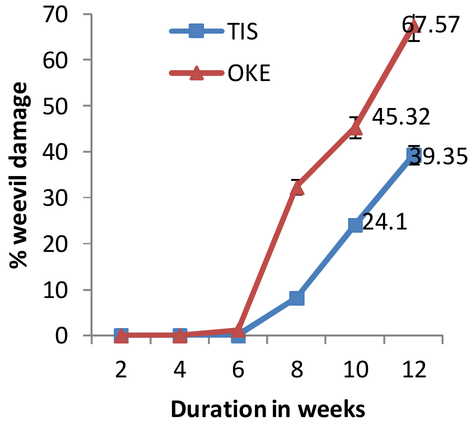


Fig. 5 Percentage weevil damage in PBECB

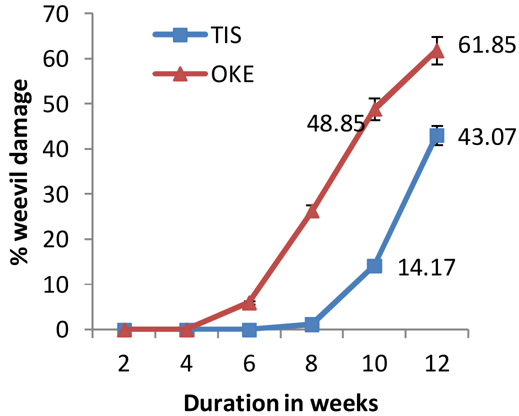


Fig. 6 Percentage weevil damage in MPSS

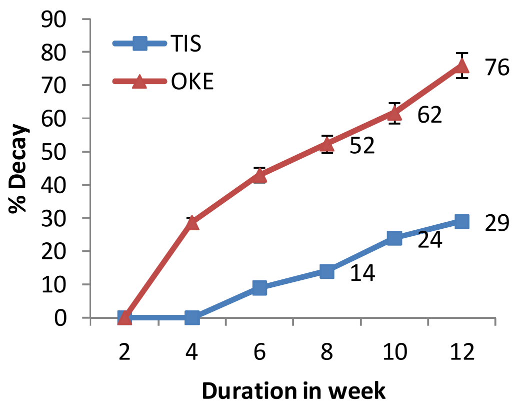


Fig. 7 Percentage decay in PBECB

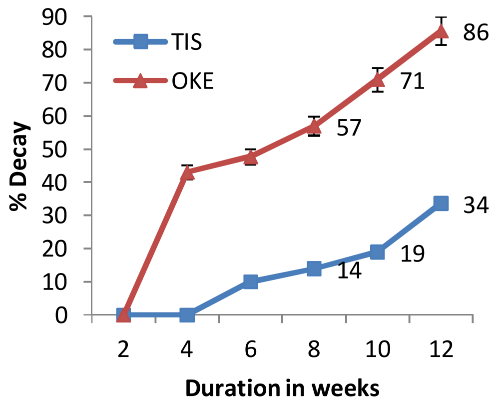


Fig. 8 Percentage decay in MPSS

Percentage weevil damage

Figure 5 & 6 above, showed that weevil damage started earlier in the MPSS than in the PBECB. Also at 8 weeks in storage, there was no weevil damage observed for TIS 2 in the MPSS while it was observed in the PBECB. Comparatively, there was no significant differences for weevil damage between the structures. But the varieties responded differently for the two storage structures. With TIS 2 having less weevil damage in the PBECB than in the MPSS.

Percentage decay in PBECB and MPSS

From figures 7 & 8, decay started concurrently in both storage structures at 2 and 4 weeks for Ukerewe and TIS 2 respectively. Generally, however, decay was more in the MPSS than the PBECB. At the end of 12 weeks of storage, the percentage decay in the PBECB was 29% for TIS 2 and 76% for Ukerewe compared with 34% for TIS 2 and 86% for Ukerewe in the MPSS.

Percentage sprouting in PBECB and MPSS

Figures 9 & 10 indicated that for the PBECB the percentage sprouting was higher for TIS 2 (78%) while the same was lower (67%) in the MPSS. This indicates that the two varieties behave differently in storage. It can be said that to reduce sprouting in storage TIS 2 should be stored in the MPSS while Ukerewe should be stored in the PBECB.

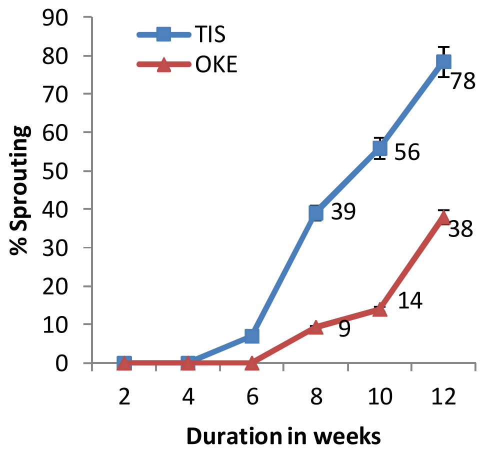


Fig. 9 Percentage sprouting in PBECB

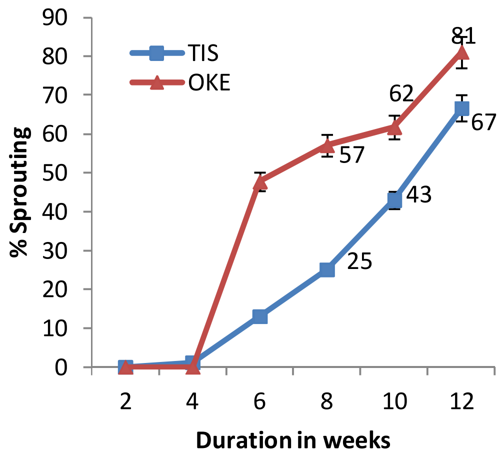
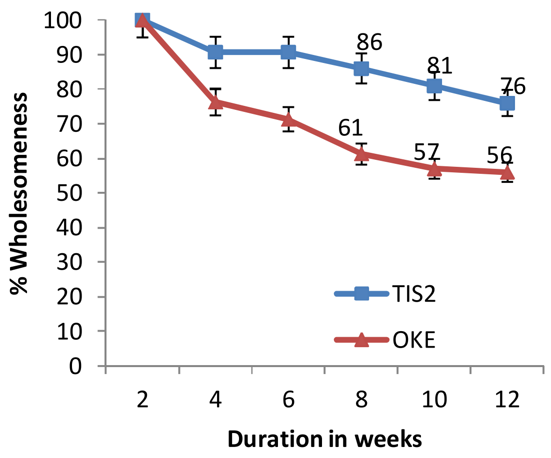


Fig. 10 Percentage sprouting in MPSS



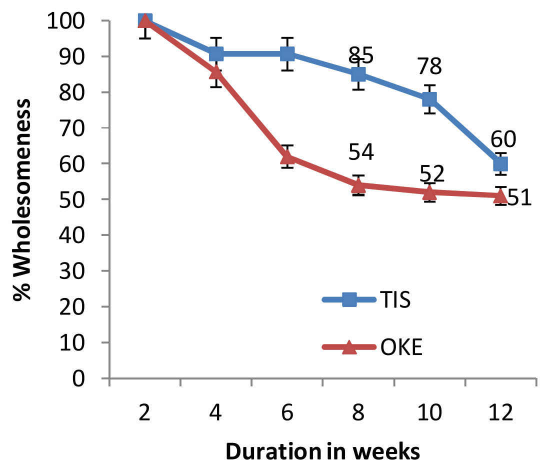


Fig. 11 Percentage wholesomeness in PBECB **Fig. 12 Percentage wholesomeness in MPSS**

Percentage wholesomeness in PBECB and MPSS

Figures 11 & 12 indicate that wholesomeness for both varieties was higher in the PBECB than in the MPSS. This means that the PBECB generally stored sweet potato better than the MPSS. At the end of 12 weeks of storage, TIS 2 was 76% wholesome in the PBECB while it was 60% in the MPSS.

CONCLUSION

The two storage structures improved sweet potato storage by reducing general deterioration. However, the Purposed Built Evaporative Cooling Barn (PBECB) was slightly better in reducing weight loss, weevil damage, shrinkage, decay and resulted in more wholesome roots than the Modified Pit Storage Structure (MPSS). However, the MPSS had slightly lower sprouting index compared to the PBECB.
Generally, at the end of 12 weeks of storage TIS 2 stored better than Ukerewe in both storage structures; it was also more resistant to weevil damage, decay, shrinkage, weight loss and had more wholesome roots in storage. It is possible to store TIS 2 sweet potato roots in both storage structures for 10 weeks at 78-81% wholesomeness.

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