COMPARATIVE ANALYSIS OF HYBRID UNDERGROUND Pit STORAGE STRUCTURE FOR YAM AND SWEET POTATO TUBERS

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Abstract: Storage of crop as post-harvest operation is very important, in order to reduce wastage during the season of the crop, maintain the quality of the crop, to meet up with demand in times of scarcity and reduce price cost. This can be achieved with the design and construction of a good storage structure. In order to improve one of the storage structures used for yam and sweet potato tuber crops, underground pit storage structure was modified by hybridizing the bottom and side wall lining using closed-cell foam and sawdust material at ratio 50:50 in terms of thickness. Twenty tubers of yam and sweet potato were stored in the hybrid underground pit structure. The lowest and highest temperatures of the underground pit were 20 and 23°C, while the lowest and highest temperatures of the ambient environment were 27.9 and 29.8°C. The lowest relative humidity in the hybrid underground pit and ambient environment were 70.6% and 57.3%, while the highest were 86 and 79.6% respectively.

It was discovered that at the end of eight week of storage, the weight loss in the tubers of yam and sweet potato was 10.5 and 22.5%, while the sprouting rates were 15 and 20%, percentages of rottenness were 10.5 and 15% respectively.

It can be concluded that the hybrid underground pit storage structure improved the storage period of yam and sweet potato but can prolong the storage and life span of yam tuber than sweet potato.

Key words: Hybrid Underground Storage Structure, Closed-Cell foam, Sawdust, Yam, Sweet Potato.

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INTRODUCTION

One of the post-harvest operation is storage, but some problems like loss of quality and quantity of tuber crops are the challenges of farmers. Wastage is unavoidable at post-harvest stage because all the harvested crops cannot be suddenly consumed. Hence, the supply of tuber crops diminishes from time of harvest. According to [1], moisture, temperature, relative humidity, relative humidity and soil type are some factors that can initiate the growth of microorganisms causing spoilage of yam under storage. In addition, water table height can also influence spoilage of tuber in case of storage in underground pit.

According to [2] and [3], Yam is better stored in environment that can inhibit sprouting (breakage of dormancy), reduce dryness of the tuber, and prevent rottenness and storage life span of up to seven (7) months.

Therefore, to increase the quality and quantity of tuber crops available at off season, tuber crops are preserved in storage structures like underground pits, underground ditches, mud structures, thatched huts, cribs, leaving the tubers on the bare ground, platform, tree shade, and barns. Most of these storage structures are used by peasant farmers, although they have their demerits, for example, underground structure and mud structures are prone to flooding, high moisture content that can cause fungi infections and decay; so, structures made with palm fronds and other fire prone materials used by peasant farmers are not reliable. The use of shelters that are durable, well ventilated, insect and rodent proof are not financially affordable by some peasant farmers [4]. Hence, there is need to improve on the affordable storage structures like underground pit as yam and sweet potato storage structures for the peasant farmers who are the main tuber crop farmers.

Sweet potato is a tuber crop that is easy to plant, affordable with many health benefits, such as; good source of fiber, prevents cancer, good for heart, contains vitamins (E, B6, C), relieves stress, good for baking, good for livestock feeds and regulates blood sugar. These benefits in addition to population increase has increased the demand for sweet potato beyond supply, hence, it has opened opportunity for potato farmers to increase their commercial farming of sweet potato. The other tuber crop under discussion is yam; yam is also a tuber crop of the species of Discorea spp. It is a worldwide acceptable tuber crop with different varieties depending on the region. It is grown in Africa and many continents in the world. It is a source of carbohydrate and also protein to some extent in the world [5]. According to [6], in terms of nutritional content, carbohydrate content of yam is 80 – 90%, protein content is 5 – 8% and mineral content of 3.5%.

There has been different study of underground storage structure, but there is lack of knowledge in hybrid form of its bottom and wall layers with closed cell foam and sawdust as lining materials.

Closed cell foam is a dense foam made from polyurethane material. It has higher R-values and insulation than other types of foam. It has high resistance to water penetration to avoid moisture build-up, because moisture can cause bacterial and mold growth. The ability of closed cell foam in controlling temperature and relative humidity prevents the growth of mold. Its use will prevent extreme rise in temperature and relative humidity. Closed cell foam is highly dense, strong, flexible plastic rubber material possessing internal pores or cells. The internal cells are very close but not interconnected together.
The closed cells contain trapped gas at the production stage, which is helpful in increasing the insulation capacity of the foam material. In addition, it is resistant to water leakage and serves as moisture barrier.

Sawdust is a by-product of sawing or milling of wood or tree. It contains moisture content of 10.8, porosity of 84% and water retention of 50%. It has been used as blotting material because of its absorptive nature, as hand cleaner when mixed with dish detergent, wood filler by mixing it with adhesives and as compost. It has also been used as a fuel source because of its firing capacity, and also as an insulating material. Sawdust has been used for treating of inorganic metal impurities from waste water [7]; feasibility of using sawdust for supercapacitor application [8]; use of sawdust as bedding materials [9] and in vermicompost [10].

The lining materials of the wall and bottom consisting of closed cell foam and sawdust are at synergic ratio 50:50 with respect to thickness.

Despite the remarkable progress made in increasing food production at the global level, approximately half of the population in developing countries does not have access to adequate food supplies. There are many reasons for this, one of which is food losses occurring after harvest. Therefore, underground pits could increase the shelf life of agricultural products as well as save cost of food production.

In order to ensure constant availability of these tuber crops, storage is very important in a conducive environment. One of the storage facilities used for tuber crops is underground pit storage. The aim of this work is to perform a comparative analysis on the use of hybrid lining underground pit for storage of potato and cassava crop. In order to achieve this aim; measurement of temperature and relative humidity was done, degree of weight loss was determined, sprouting and rotting rate were observed.

**MATERIAL AND METHODS**

**Study Area:** The experiment was carried out at G2 western farm located at National Root Crop Research Institute, Umudike, during the dry season in 2021. Umudike is situated at 7°24′East, 5°29′North at an altitude of 120 m belonging to humid forest agro-ecological zone. It has an annual rainfall of 2,200 mm and average annual temperature of 31°C with dystric luvisol.

**Materials**


**Methods**

**Construction of Underground Storage Pit and Storage of the Tubers**

An underground pit was constructed with a rectangular shape of dimension 1.0m × 1.0m × 1.5m. The bottom and side walls were lined with sawdust and foam material with total of 60mm thickness at ratio 50:50. The lining materials of the wall and bottom consisting of closed cell foam and sawdust are at synergic ratio 50:50.
Twenty cassava tubers were put in the pit and the same number and process was done for potato and then covered with sawdust and thin layer of soil for evaluation of the storage structures. The tubers used in the research have been allowed to stay for three days before storing, cleaned and free from injury and sprout.

The lining materials of the underground pits were evenly distributed on the study site and the research was carried out at the period when the water table is low. The storage and research were carried out within eight (8) weeks.

Parameters for Assessment

The parameters used for assessing the tubers for underground pit storages structures were temperature, relative humidity, weight loss, sprouting index and rate of rottenness.

Temperature: It was carried out by reading the degree of hotness or coldness of the two underground storage structures daily and their ambient environment for the period of eight (8) weeks of storage with the use of thermometer.

Relative Humidity: The use of hygrometer and psychometric chart were used to determine the moisture contents of the environments of the storage structures and the ambient environment on a daily basis after reading the temperatures respectively.

Weight Loss: The stored cassava and potato tubers were weighed on a daily basis using the weighing balance and the average was recorded as the weight. The change of weight indicates the rate of moisture loss in the tubers. The weight loss, due to different factors, was calculated using the thousand tuber mass (TTM) method developed by [11] in equation 1.

\[
\% \text{ weight loss} = \left(\frac{M - M_x}{M}\right) \times 100
\]

Where,

- \(M\) = Thousand Tuber Mass (TTM) at the beginning of the study and
- \(M_x\) = The TTM of stored tuber for \(x\) duration.

Sprouting Index: The use of visual observation was carried out every day to checkmate sprouting or any growth protruding in the tubers.

The Sprouting was calculated by taking the percentage of the number of sprouted tubers from the total number of tubers in each storage structures. Thus the sprouting was determined from the expression according to [12] and [2] in equation 2:

\[
\text{Sprouting Index} = \frac{\text{Number of Sprouted Tubers}}{\text{Total number of Tubers}} \times 100
\]

Rate of rottenness: Observation of discolouration of the surface of the yam tubers and potatoes were checked on a weekly basis for eight weeks of storage. The part of each yam and potato showing discoloration was measured using measuring tape at the end of each week. The rate of rottenness was measured using equation 3:

\[
\text{Rate of rottenness} = \frac{\text{Length of surface discoloration}}{\text{Total length of the Tuber Crop}} \times 100
\]
Sample Collection: Samples required for the experiment were gotten from National Rot Crop Research Institute Umudike, Abia State.

Reading Pattern: The samples were weighed before storage and values for Temperature and Relative Humidity were measured before storage. The number of crops stored in each pit and appearance were noted.

Data/Statistical Analysis: Simple statistical analysis of mean and standard deviation were used in computation of results [13].

\[
\text{Mean} = \frac{\sum x}{n}; \quad \text{S.D} = \sqrt{\frac{\sum (x - \bar{x})^2}{n}};
\]

Where: \( x \) = Temperature and humidity values;
\( n \) = Number of weeks;
\( \bar{x} \) = Mean and
\( \text{S.D} \) = Standard deviation

In addition, comparative analysis of the results between cassava and potato tubers were discussed.

RESULTS AND DISCUSSION

![Figure 1. Temperature in the Structure against Storage Period](image)

The highest and lowest temperatures were 29.8 and 20.0°C in the underground storage structure, while the highest and lowest temperatures of the ambient environment were 29.8 and 27.9 °C respectively. It was observed that the temperatures of the underground pit structure were lower than the surrounding temperatures during the storage period as shown in figure 1. This could be as a result of the hybrid nature of the bottom and lining walls respectively, since sawdust and closed cell foam are not good conductors of heat, hence they prevented rise in temperature of the underground pit.
The increase in temperature of the surrounding soil of the pit that can cause high heat was blocked by the wall, hence the hybrid lining wall serves as a lagging material preventing heat and temperature from the surrounding soil to the storage environment. Rise in temperature can increase the rate of transpiration of crop during storage, resulting in increase in sprout rate and weight loss respectively.

![Relative Humidity Against Storage Period](image)

The underground pit had average relative humidity a little higher than the ambient environment all through the storage period. During the first week, the underground structure had a higher RH than the ambient environment by 6.9%, while at the 8th day of storage, the widest difference of 13.3% between the underground structure and the ambient environment was observed. The lowest difference was at 5th week with a slight difference of 2.2% between the underground storage structure and the environment. The slight difference in the RH between the two environment helps in reducing the rottenness and sprout rate of the tubers. The hybrid lining was helpful to maintain good RH for the storage of the tuber crops, as the soil moisture could not gain access to the pit environment because of the reduced penetration from the sawdust and very low porosity and permeability of the closed cell foam.
Figure 3. Weight Loss against Storage Period of Yam and Potato

The weight loss experienced at first week was 1% for yam with no weight loss experienced by the potato tuber crops. The rate of weight loss till fifth week was almost equal with a slight difference within the range of 0.5 to 1% as seen in figure 3. At 6 to 8\textsuperscript{th} week of storage, the rate of weight losses in the sweet potato were as twice as the yam weight loss. The highest weight loss was experienced at 8\textsuperscript{th} week of storage with 10.5\% for the tubers of yam and 22.5\% for the potatoes. This might be caused by slight increase in sprouting rate and rottenness.

Figure 4. Sprouting Rate against Storage Period
Dormancy is necessary to maintain the quantity and quality of stored produce, but before this dormancy can be maintained for a long time, the environmental condition must be at a level that is not favorable for sprouting to take place. The prevention of high rise in temperature inside the underground pit by the hybrid lining wall prevented sprouting of yam for the first five weeks of storage while dormancy was maintained in potato for three weeks. The maintenance of low temperatures below the environmental temperature all through the storage period prevent high rise of heat, which kept the sprouting rate of yam and sweet potato to be low with maximum sprouting rate of 10% and 15% as shown in figure 4.

![Figure 5. Rottenness against Storage Period](image)

There was no record of deterioration of the crops till the end of second week. However, rottenness was discovered a little at the end of the third week in the yam and potato by 0.6 and 0.8% respectively. Rottenness increased as the storage period increased, but at a very slow rate. The highest rates of rottenness were 6.2 and 7.0% in the yam and sweet potato respectively. This showed that the hybrid lining of the bottom and side walls of the underground pit storage prevented conducive environment that can make microorganisms causing deterioration of crop during storage to thrive very well.

**CONCLUSIONS**

The use of underground pit storage structures designed with good materials in hybrid lining form is effective to a good period of time in keeping storage crop at the environmental requirements favourable for the storage of such crop. The research findings with 6.2% and 7% of rottenness of yam and potato, and also highest sprouting rate of 10% and 15% for yam and sweet potato respectively, has proven that hybrid lining of the bottom and side walls of underground pit with sawdust and closed-cell foam material can prolong the storage of yam and sweet potatoes beyond eight (8) weeks. The research showed that underground pit storage is a good storage structures for yam and sweet potato tuber crops and also for curing if the tubers will still be transferred to another storage structure, but the findings showed that underground pit storage is a better storage structure for yam than sweet potato.
REFERENCES


KOMPARATIVNA ANALIZA HIBRIDNE PODZEMNE KONSTRUKCIJE SKLADIŠTA ZA ĆUVANJE YAMA I SLATKOG KROMPIRA

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Abstrakt: Skladištenje poljoprivrednih proizvoda kao operacija posle žetve je veoma važno, da bi se smanjio gubitak tokom sezone, održao kvalitet proizvoda, zadovoljila potražnja u vremenu oskudice i tako uticalo na cenu proizvoda. Ovo se može postići projektovanjem i izgradnjom dobre strukture skladišta za ćuvanje.
U cilju poboljšanja jedne od skladišnih struktura koje se koriste za useve Yama i krtola slatkog krompira, struktura podzemnog skladišta forme jame (trap) je značajno modifikovana promenom obloge dna i bočnih zidova upotrebom strukturne pene sa zatvorenim tipom čelija i dodatkom piljevine u odnosu 50:50 na debljinu materijala. U hibridnoj podzemnoj strukturi jame (trap) usklađen je uzorak od dvadeset krtola jama i slatkog krompira. Najniža i najviša temperatura podzemnog skladišta iznosila je 20°C i 23°C. Najniža i najviša temperatura ambijentalne sredine 27,9°C i 29,8°C. Najniža relativna vlažnost u hibridnoj podzemnoj jami i ambijentalnoj sredini iznosila je 70,6% i 57,3%, dok je najviša iznosila 86% i 79,6% respektivno. Utvrđen je na kraju osmonedeljnog skladištenja gubitak mase u krtolama Yama i slatkog krompira od 10,5% i 22,5%, dok su stope nicanja bile 15% i 20%. Pojava truleži je registrovana kod Yam useva sa 10,5% odnosno 15% kod krtola slatkog kromira. Može se zaključiti da je hibridna struktura podzemnog skladištenja tipa jame (trap) poboljšala dužinu perioda skladištenja Yama i slatkog krompira, ali više može produžiti skladištenje i životni vek krtola Yama, u odnosu na krtole slatkog krompira.

**Ključne reči:** Hibridna podzemna skladišta, pena sa zatvorenim čeliijama, piljevina, Yam, slatki krompir.

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