Evaluation of Ventilated Underground Pit Structures for Yam 
\textit{(Dioscorea Spp) Storage} 

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Abstract: Underground pit structures are commonly employed by farmers for on farm storage of yam 
\textit{(Dioscorea spp)} in Nigeria and other parts of developing world. This traditional storage structure is used 
without provision for adequate air exchange or ventilation. This study investigated the performance of yams 
stored in underground pit structures provided with air vents. Three experimental pits of similar dimensions were 
constructed with Pit 1 installed with one PVC vent; Pit 2 had two PVC vents and Pit 3 without vent which 
served as control. 20 Kg weight of yams was loaded in each pit measuring 1.0 m in diameter and 0.65 m in 
depth. The results of the study show that a lowest temperature range of 30-38ºC was maintained in pit 1 
(improved) temperature range of 34-40ºC in Pit 2 (semi-improved) while temperature in pit 3 range from 36-
42ºC. The relative humidity obtained were 84, 76 and 70% in pit 1, 2 and 3 respectively. The sprouting indexes 
obtained within 8 weeks storage period were 46.2, 53.8 and 76.9 for pit 1, 2 and 3, respectively. The cumulative 
weight loss obtained in pit 1, 2 and 3 were 44.8, 69.5 and 79.2%, respectively for the 8 weeks storage period. 
Increased in storage period for yams is possible with adequate ventilation in underground pit structure.

Key words: Air-vent, Nigeria, pit air - thermal properties, sprouting index, underground structure, yam storage

INTRODUCTION

Yam is an important crop in many parts of the 
tropical and subtropical regions where it is a major part of 
the diet. About 96% of the world production is from 
Africa, with Nigeria alone accounting for nearly 71-75% 
of the total world production (Opara, 1999; FAO, 2005). 
The World annual production was estimated to be 25 
reported that the estimated world production of yam is 
3.136 million metric tonnes and West Africa accounts for 
90-95% of total production (Acquah and Nganje, 1991). 
In the south pacific, yam is a significant food crop 
accounting for over 20, 8.1 and 4.6% of the total dietary 
calorie intake in the kingdom of Tonga, Solomon Islands 
and Papua new Guinea, respectively (Opara, 1999). In 
addition to its importance as food source, yam also plays 
a significant role in the socio cultural lives of some 
producing regions, for example, through the famous yam 
festivals in West Africa.

Like most tubers, the storage of yam (dioscorea) has 
remained a problem among peasant yam producers which 
constitute about 70% of farming population in Nigeria. 
Losses in tuber weight of about 10 to 12% occurred in the 
first 3 months and 30 and 60% after 6 months during 
storage in traditional or improved barns (Ezeike, 1993; 
Opara, 1999). Weight losses of 33 to 67% after 6 months 
storage period have been reported by Coursey (1967). 
These losses arise from physical damage and attack by 
fungi or bacteria as well as physiological factors 
(sprouting, dehydration and respiration). Autolytic 
process is reported as the most important factor that 
contributes to storage losses in yam (Opara, 1999). 
Autolytic processes give rise to chemical or biochemical 
changes in the tuber as a result of interaction amongst 
parts of the tuber or between it and environment. 
Infestation by insects and other arthropods can destroy all 
part of the produce and cause the partial or complete 
spoilage. Microbiological attack has deleterious effects on 
stored produce especially in warm tropical climates.

The three main requirements for yam storage have 
been presented to be aeration, reduction of temperature 
and regular inspection of produce to remove sprout. 
Optimum conditions of 15 or 16ºC at 70 to 80% relative 
humidity have been recommended for cured tubers 
(Martin, 1984; McGregor, 1987). Kay (1973) reported 
that the trifida began to sprout within 3 weeks at a storage 
condition of 20 to 29ºC and 46 to 62% relative humidity.

A number of storage structures are used by farmers in 
yam producing regions. These include the traditional yam 
barn (Ezeike, 1985; Bencini, 1991; Chukwu and Ifenkwe, 
2001). The use of the open sided shelves store was
recommended by the Nigerian stored products research institute (NISPRI, 1982). This is to enable careful handling and easy inspection in comparison with tying tubers to poles, which can cause physical damage and rotting (Bencini, 1991). Yams are also stored in raised platforms in shed (Opara, 1999). Other traditional storage structures included underground structures such as pits, ditches and clamps (Opara, 1999). The use of underground storage for other tubers such as cocoyams (Taro) has been reported by Obetta et al. (2007). Improved traditional shelter for yam has been reported by (Ezeike, 1985; Akoroda and Hahn, 1995; Osuji, 1987). Although the environmental regime for cold storage of yam have been established, the use of refrigerated storage is not wide spread (Opara, 1999). Successful use of gamma radiation to inhibit sprouting has been reported by several researchers (Adesuji, 1976, 1982; Olaifa, 1994; Ukpabi et al., 1994). Afolabi et al. (1997) reported that coating of yam tubers with termitaria soil reduces weight loss and rotting during storage. Okoedo-Okojie and Onemolease (2009) reported the major constraints limiting farmers’ adoption of modern yam storage technologies in Edo State, Nigeria which include; cost, non-availability, and ignorance of technology existence.

For yam to keep well in storage there must be use of sound and healthy tubers, proper curing, combined with fungicide - treatment, adequate ventilation and protection from direct sunlight and rain (Opara, 1999).

For an underground pit structure, the soil profile needed is that of free draining sandy soil in higher elevated area of the land. This study improves on the traditional pit structure through the provision of chimney for air escape and evaluates the storage performance in terms of thermal factors, weight loss and yam sprouting index.

**MATERIALS AND METHODS**

This study was conducted at the experimental farm of the Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi, Benue State, Nigeria in 2010.

**The material used:** Freshly harvested yam tubers that were free of any form of infestation and physical damage were obtained from local farmers. Three underground pits of similar dimensions (1.0 m in diameter and 0.65 m deep) constructed at the experimental farm of the Department of Agricultural and Environmental Engineering, University of Agriculture Makurdi, Benue state, Nigeria were used for the investigations.

**The underground pit structure:** Three Pits namely 1, 2 and 3 were dug carefully in an area with a silty-sand soil profile which allows free drainage. These three circular pit
storage structures were uniform in size with a radius of 0.5 m and a depth of 0.65 m and were located in an elevated area to avoid high water table. Each of the pits was treated with reliable pesticides to guard against infestation by pests such as termites. Water proof material was used as wall lining in the pits to prevent moisture migration into the pits. Pit covers were constructed which had provision for installation of wet bulbs and dry bulbs thermometers used for measuring the wet and dry bulb temperatures of the pits. Pit 1 (improved) was installed with two PVC vents; Pit 2 (semi-improved) was provided with one vent while Pit 3 which served as control pit was without vent. The PVC vents served as mediums for air exchange and ventilation. Wooden platforms were placed on the floor of all the three pits where the yam tubers were placed to avoid direct contact of yam tubers with the soil to prevent sprouting.

The initial weights of yam tubers before loading into the pits were taken using a weighing balance, reading to 0.01 g. Each pit was loaded with 13 tubers of yam which weighed 20 kg. A total of 39 yam tubers weighing 60 kg were stored in these three pits. The experiment set-up for underground pit storage is as shown in Fig. 1.

These pit structures with yam tubers stored in them were monitored for eight weeks to evaluate the efficiency of the underground pit storage. Parameters monitored were dry bulb temperature and wet bulb temperature. These two parameters were used to determine the relative humidity from a psychometric chart. The measured temperatures (pit air wet-and dry-bulb temperatures) were collected twice daily; at noon and evening at 6:00 pm (G.M.T.) for a period of two months. The thermometers used were installed permanently throughout the storage period. The average data per week for the pit air thermal properties for the storage period of 8 weeks was as shown on Table 1.

Apart from the thermal properties, the weight of the stored yams was also measured on weekly basis using the weighing balance to monitor weight change. The sprouting index of the stored yams was also calculated on weekly basis using the expression given as:

\[ \text{Sprouting Index, } I = \frac{\text{Number of tubers}}{\text{Total number of tubes}} \times 100 \]  

The data obtained for weight loss and the cumulative values are as shown on Table 2 while the sprouting index values obtained are as shown on Table 3. The sprouting of tubers was first observed during monitoring at week 5, 4, and 3 in Pit 1, 2 and 3, respectively.
RESULTS AND DISCUSSION

The variation of the relative humidity over the storage duration period for the three pits is shown in Fig. 3. It was observed that the relative humidity value obtained was 84% and highest in pit 1, 76% in pit 2 and lowest value of 70% obtained in pit 3. Figure 4 showed the pit air temperature over the 8 weeks storage duration for the three pits. The air temperature level attained in pit 3 is capable of causing dehydration of yam tubers as a result of relatively low generated ambient air vapour pressure which created higher moisture exchange driving potential in this pit than pit 2 and pit 3. Soil in underground pit is always in a moist condition and the air in close contact is therefore laden with moisture resulting in its high relative humidity. The variation of pit air temperature over the storage period is as shown in Fig. 4. Pit 1 recorded a temperature range of 30 to 38ºC within the storage periods of 8 weeks. Pit 2 maintained 34 to 40ºC range of temperature while pit 3 recorded the highest temperature level ranging from 36 to 42ºC within the same storage duration period.

The percentage weight loss was also observed to be increasing with the storage time in all the three pits (see Fig. 5). The total percentage weight loss of 44.8, 69.5 and 79.2% were recorded in Pit 1, 2 and 3, respectively within the 8 weeks of storage. It was however observed that weight loss in yam tubers stored in underground pit with no provision for air exchange is enormous, 79.2% compared with that stored in pits installed with air vents which is 44.8% at the end of 2 months storage.

The sprouting indices obtained in the three pits were plotted against storage time as shown in Fig. 5. This was also observed to be increasing with storage time with the highest value of 76.9% recorded in pit 3 at 8th week while the lowest value of 46.2% was recorded in pit 1 at the same period. The zero values observed in the first four weeks of storage in pit 1 indicate that sprouting only set in after five weeks of storage while in Pit 2 and 3 it was noticed at four weeks and three weeks, respectively.

Sprouting activity was less in Pit 1 where the temperature range was relatively low and highest in Pit 3 where the temperature was highest.

CONCLUSION

The various parameters evaluated in the three pits were pit air temperatures, relative humidity, percentage weight loss and the sprouting index. The lowest air temperature was obtained in pit 1 which had two vents, followed by pit 2 and highest, pit 3 in that order. This behavior was attributed to insufficient air flow particularly the pit 2 and pit 3. The sprouting pattern and the percentage weight loss were also affected in the same way with pit 1 maintaining the lowest value, while pit 2 recorded higher values and pit 3 recorded the highest of the three pits. The variations in the pit air temperature affected the storage durability of the product as observed in pit 3 with the highest air temperature.

REFERENCES


