

Research Article

Underground Storage of *Tacca involucrata* Tubers

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Abstract: *Taccainvolucrata* tubers are not currently stored but processed in-situ and this has limited the commercial production and processing of this wild crop. The increasing research into the potential qualities of its starch for use in the food and pharmaceutical industries informed this investigation to determine the storability of the tubers in underground pits. Three identical pits were dug and provided with one, two and no vent. Two hundred clean *T. involucrata* tubers weighing 22 kg were stored in each pit and monitored for six months. The temperature and relative humidity were monitored three times daily at 6 h intervals from 6 am to 6 pm using a digital thermo-hygrometer while weight loss, sprout index and rot incidence were examined monthly. Air temperatures varied from 28.4-32.9°C, 28.2-32.9°C and 28.2-32.5°C in zero-vent, one-vent and two-vent pits respectively as against 30.1-33.7°C in the surrounding. Weight losses of 12.9, 9.2 and 9.0% were recorded at 4 months while sprout indexes of 7.1, 3.0 and 12.0% were, respectively obtained for zero-vent, one-vent and two-vent pits at 3 months of storage. Thereafter, sprout index >80% was observed in all the pits. Rot incidences of 4, 3 and 0% for zero-vent, one-vent and two-vent pits respectively were observed after the 6 months storage period. The study revealed a three-month storability of *T. involucrata* tubers in pits. This is a promising approach, economical and will make *T. involucrata* available for a longer period after its season for the small scale processors in the locality while awaiting full commercialization.

Keywords: Pit, rot incidence, sprouting index, *Tacca involucrata*, temperature, weight loss

INTRODUCTION

The *Tacca involucrata* is a deciduous plant with a subterranean thin skinned potato-like tuber. Its synonyms are *T. leontapetaloides*, *T. hawaiiensis*, *T. oceanica* and *T. pinnatifida*. Its common names include Polynesian arrowroot, African arrowroot lily, Bat flower and White bat plant. The plant is native to the tropical regions of Africa, Southeast Asia, Northern Australia and the Pacific Islands. In Nigeria, the plant is widely distributed in the rain forest and the savannah regions of the country. It is known as *gbatche* in the North Central, *amura* in the North East, *giginyar birii* in the North West and *aduro-susu* in the South West (Zaku *et al.*, 2009; Raji and Ahemen, 2011).

Raw *T. involucrata* tubers and starch have been used for the treatment of vomiting and diarrhea in traditional Hawaiian communities (Krauss, 1998). Amongst the Tiv people of North Central Nigeria, the starch is used in preparing a variety of puddings and sauces (Ahemen and Raji, 2008). The suitability of *T. involucrata* starch for various uses in the food and pharmaceutical industry has been widely reported

(Spennemann, 1998; Attama and Adikwu, 1999; Kunle *et al.*, 2003; Ofoefule *et al.*, 2004; Adebisi *et al.*, 2011; Igbabul *et al.*, 2012; Jiang *et al.*, 2014).

Many conventional tuber crops have been successfully stored in underground pits, or trenches. Westby (2002) reported the storage of cassava freshly harvested cassava tubers in pits containing sand/soil at 15% moisture content. After two months of storage 80-85% tubers were recovered undamaged while starch content losses of 15-20% were recorded in the tubers. Opara (1999) reported the use of traditional underground structures for short term storage of yam such as pits, ditches and clamps, as well as an improved pit structure that is not only well ventilated, water proof and stronger than the traditional shelters but one that enables low temperatures, high relative humidity and consequently low storage losses and delayed sprouting. Nwakonobi *et al.* (2012) reported the storage of yam in pits installed with PVC vents for air exchange and ventilation. After eight weeks of storage temperature in the pits ranged between 30-38°C, 34-40°C and 36-42°C for the two-vent, one-vent and zero-vent pits respectively; while the relative humidities were 84, 76

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and 70% for the three pits, respectively. The report stated that while sprout indexes of 46.2, 53.8 and 76.9%, respectively were recorded for two-vent, one-vent and zero-vent pits, cumulative weight losses of 44.8, 69.5 and 79.2% were recorded respectively during the same period. Obetta *et al.* (2007) evaluated the storage of cocoyam (taro) in ventilated underground pits for a period of eight weeks with mean temperatures and relative humidity of 28.6°C and 83%, 29.6°C and 82.5% and 30.9°C and 72% for two-vent, one-vent and zero-vent pits respectively. Cumulative weight loss over the storage period was reported as 38.5, 63.9 and 76.9% for two-vent, one-vent and zero-vent pits respectively; while 34, 37.7 and 47% were recorded as sprout indexes respectively.

Despite the increasing discovery of the importance of *T. involucrata* starch in the food and pharmaceutical industries, the tubers are not yet stored but processed *in-situ*, hence its non-availability off harvest seasons. This has hampered commercial production and processing of the tuber into starch. The study therefore was designed to investigate the storability of the tuber in underground pits-since the farmers in Nigeria are used to leaving tubers underground until when needed for processing-with the aim of ensuring its availability off harvest season and hence encourage commercial production, storage and processing of the tuber into starch.

MATERIALS AND METHODS

This study was carried out on the experimental site of Agricultural Engineering Department, Akperan Orshi College of Agriculture Yandev, Benue State in North Central Nigeria from December 2011 to May 2012.

The pit structure: Three identical pits were dug and built at the experimental site (Fig. 1). The pit walls were built with burnt bricks-because of their very low thermal conductivity and water permeability-and well plastered with cement mortar. The pit base was laid with concrete and the top covered with concrete slab. The solid structure was necessary for durability of service and to prevent rodent attack on stored produce and seepage of water into the storage chamber (Igbeka, 1985; Opara, 1999). The depth×length×width of each pit was 1.2 m×0.8 m×0.7 m. This is within the range of pit dimensions reported by Opara (1999) for yam pit storage and Obetta *et al.* (2007) for cocoyam pit storage. The brick wall was 0.15 m thick while the base concrete and the top concrete slabs were both 0.1 m thick. The diameter of PVC pipes used as air vents and as probe head insertion pipes was 0.038 m. The upper end of the probe head insertion pipes were tightly fitted with wooden corks, which were only removed when inserting the probe head of the thermo-hygrometer for measurements; whereas those of the vents were covered with nylon net to screen off flies and other insects from entering the pits.

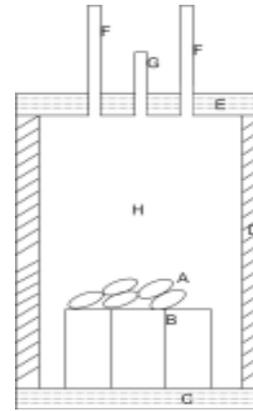


Fig. 1: Cross section of the pit. A: Tubers; B: Platform; C: Concrete floor; D: Brick wall; E: Concrete slab; F: Air vent; G: Probe head insertion pipe; H: Storage chamber

The experimental procedure: Clean *Tacca involucrata* tubers free from cuts and rot were obtained from the wild in Tse-Ikyor, Mbater district of Logo Local Government Area of Benue State, Nigeria and cured.

Two hundred (200) cured tubers weighing 22 kg were spread on wooden platforms and carefully lowered into each pit. A total of 600 tubers weighing 66 kg were stored in the 3 pits. The following parameters were measured for a period of 6 months: temperature and relative humidity, sprouting index, weight loss and rot incidence.

The pit and ambient air temperatures and relative humidity were taken three times (6.00AM, 12.00Noon, 6.00PM) daily using a Testo 625 Digital thermo-hygrometer as described by Osunde and Orhevba (2009). The probe head of the digital thermo-hygrometer was inserted into the storage chamber via a PVC pipe. The digital thermo-hygrometer displayed both the dry bulb temperature and the relative humidity of the air in the chamber at the same time.

At the end of each month of storage, tubers were carefully observed for first occurrence of sprouts and for tubers wholly or partially infected by wet or dry rot. Rotted tubers were removed from the lot immediately. Sprouting index or percentage (SP) was calculated as a ratio of the number of tubers which by physical inspection have started developing sprouts >3 mm lengths (N_s) to the total number of tubers stored (N_t) expressed in percentage (Struika *et al.*, 2006; Obetta *et al.*, 2007)(Fig. 1):

$$SP = \frac{N_s}{N_t} \times 100 \quad (1)$$

Rot Incidence (RI) was calculated as the percentage number of tubers affected by either dry or wet rot at a particular time (N_r) to the total number of

tubers stored in the structure (N_t) expressed as a percentage (Nwakonobi *et al.*, 2012):

$$RI = \frac{N_r}{N_t} \times 100(2)$$

The method reported by Osunde and Orhevba (2009) and Roy *et al.* (2006) was used in evaluating the weight loss of tubers in the pits. Tubers in each of the pits were weighed monthly using an electronic weighing balance with 0.01 g accuracy. The initial weight was taken before loading the tubers into the pits. The tuber Weight Loss (WL) was obtained as the ratio of the difference between initial weight of the tubers (W_i) and the weight of the tubers after time, t in storage (W_t) expressed as a percentage of the initial weight:

$$WL(\%) = \frac{W_i - W_t}{W_i} \times 100 \quad (3)$$

RESULTS AND DISCUSSION

The mean monthly data for the 6 months of storage are presented in Table 1 to 4. The mean monthly relative humidity in all the pits was 100% throughout the storage months.

The average monthly pit air temperatures for the storage are presented in Table 1. The air temperatures varied from 28.4-32.9°C with a mean of 30.5°C in zero-vent pit, 28.2-32.9 with a mean of 30.3°C in one-vent pit and 28.2-32.5°C with a mean of 30.2°C in the two-vent pit; as against 30.1-33.7°C with a mean of 31.5°C in the surrounding. The pit air temperatures showed a patterned decrease as the number of vents increased from zero-vent pit through one-vent pit to two-vent pit. The relatively higher temperatures in the zero-vent pit may be as a result of localized heat, since there was no exchange between the pit and the surroundings. This implies that further increase in the number of vents will greatly reduce air temperature in the concrete pits.

The air temperature values recorded in this study are lower than those reported by Nwakonobi *et al.* (2012) for yam; but within the range reported by Obetta *et al.* (2007) for cocoyam corms, both stored for 8 weeks in earthen pits in Makurdi, Benue State.

Knowledge of the air temperature trends in the storage chamber is needed in the analysis of studies associated with sprouting, weight loss and rot of *T. involucrata* tubers. High temperature increases metabolic activity that causes physiological changes in the tuber resulting to sprouting in the presence of moisture. The high temperatures recorded during the fourth month of storage (Fig. 2) coupled with the moisture saturated environment (100%RH) caused the dormancy of the tubers to be broken (Fig. 3). High temperatures encourage higher respiration and

Table 1: Pit air temperatures (°C) during the 6month storage

Month	1	2	3	4	5	6
0-Vent pit	28.4	28.8	31.3	32.9	31.4	30.0
1-Vent pit	28.2	28.6	31.1	32.8	31.2	29.9
2-Vent pit	28.2	28.4	31.0	32.9	31.1	29.7
Ambient	30.4	30.4	32.1	33.7	32.0	30.1

Table 2: Cumulative weight loss (%) during the 6month storage

Month	1	2	3	4	5	6
0-Vent pit	5.5	9.2	10.3	12.9	24.4	28.3
1-Vent pit	4.7	7.1	8.9	9.2	23.0	31.6
2-Vent pit	5.0	7.0	8.9	9.0	21.4	26.5

Table 3: Sprout index (%) of tubers during the 6month storage

Month	1	2	3	4	5	6
0-Vent pit	0	0	7.1	91.9	100	100
1-Vent pit	0	0	3.0	81.2	100	100
2-Vent pit	0	0	12.0	9.0	100	100

Table 4: Rot incidence (%) of tubers during the 6month storage

Month	1	2	3	4	5	6
0-Vent pit	0	1	1	1	1	4
1-Vent pit	0	0	1	1	1	3
2-Vent pit	0	0	0	0	0	0

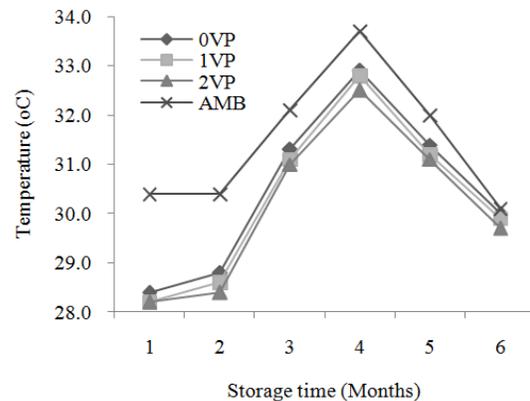


Fig. 2: Variation of pit air and the surrounding temperature against storage time; OVP: Zero-vent pit; 1VP: One vent pit; 2VP: Two vent pit; AMB: Ambient

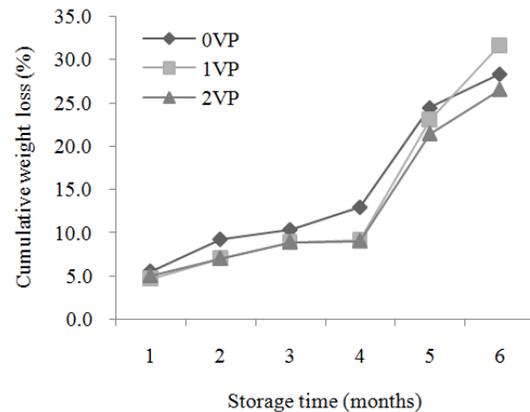


Fig. 3: Cumulative weight loss (%) against storage time; OVP: Zero vent pit; 1VP: One vent pit; 2VP: Two vent pit

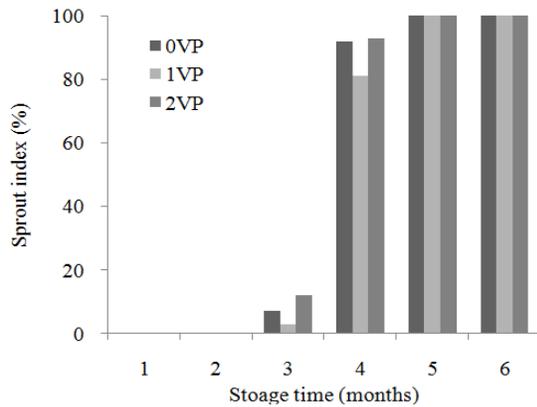


Fig. 4: Sprout index against time of storage (months); OVP: Zero-vent pit; 1VP: One vent pit; 2VP: Two vent pit

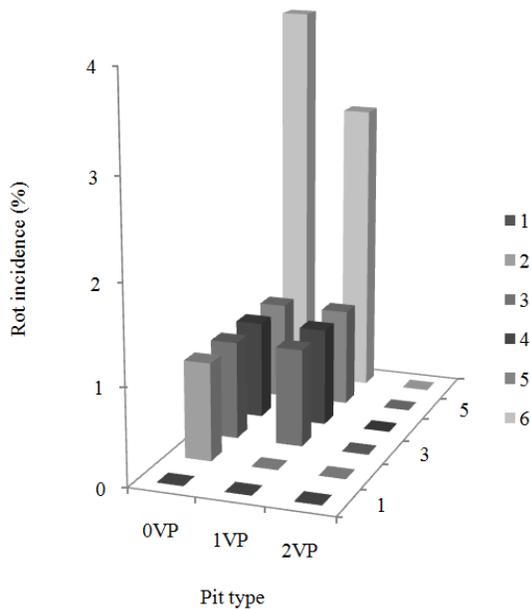


Fig. 5: Rot incidence against storage time (months); OVP: Zero vent pit; 1VP: One vent pit; 2VP: Two vent pit

evaporation rates. These result to a breaking down of starch in tubers into sugar, heat and water, which manifests in greater weight loss and rot of tubers. Where there is no air exchange like in the zero-vent pit, localized heat occurs.

Table 2 shows the cumulative weight loss in the pits during the period of storage. Weight loss followed similar trend with pit air temperatures, decreasing with increase in the number of vents. It was also observed that cumulative weight loss increased gradually in zero-vent pit from 5.5-12.9%; one-vent pit from 4.7-9.2% and two-vent pit from 5.0-9.0% between the first and the fourth month of storage. However, with the highest pit air temperatures during the fourth month that resulted to break of dormancy and consequent growth of sprouts, weight loss doubled in the 5th month to 24.4,

23.0 and 21.4% for zero-vent, one-vent and two-vent pits, respectively as seen in Fig. 2.

Table 3 shows that sprouting of *T. involucrata* tubers did not commence in the first two months which were months of harmattan in the region. However, sharp increase in pit air temperatures in the fourth storage month (Fig. 1) resulted in more than 80% of the tubers growing sprouts greater than 3 mm long (break of dormancy). No definite pattern was observed in relation to the effects of vents as seen in Fig. 4, mainly because air in all the pits was saturated with moisture. High temperatures in the presence of moisture encourage sprouting of tubers.

Table 4, after 6 months of storage, rot incidence was observed to be very minimal in all the pits: 4% in zero-vent pit, 3% in one-vent pit and 0% in two-vent pit. Figure 5, it can be seen that Rot incidence decreased with increase in the number of vents. *T. involucrata* tubers are living organisms which need a supply of oxygen and the removal of the resulting carbon dioxide and heat from the tuber's environment to respire freely. Limited supply of oxygen and inadequate removal of carbon dioxide must have been responsible for the asphyxiation and death of tissues in some tubers stored in the zero-vent and one-vent pits. The two-vent pit proved adequate in eliminating rot in *T. involucrata* storage.

CONCLUSION

- *Tacca involucrata* tubers were stored in 3 different types of pits for 6 months.
- Pit air temperatures decreased with increase in air vents inserted in the pits, been lowest in the two-vent pit followed by one-vent pit.
- Cumulative weight loss (%) and Rot incidence also decreased with increase in number of air vents for five months of the storage period.
- Sprouting index of >80% was recorded in all the pits in the fourth month of storage.
- Underground storage of *Tacca involucrata* tuber can be safely achieved in 3 months.

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