

## Indigenous Knowledge Systems for Storage of Yams in Nigeria: Problems and Prospects

<sup>1</sup>Ofor, M.O., <sup>2</sup>Oparaeke, A.M. and <sup>1</sup>Ibeawuchi, I.I.

<sup>1</sup>Department of Crop Science and Technology

Federal University of Technology, Owerri

<sup>2</sup>Department of Crop Protection

Ahmadu Bello University, Zaria

[mariofor2002@yahoo.com](mailto:mariofor2002@yahoo.com) ii [ibeawuchi@yahoo.co.uk](mailto:ibeawuchi@yahoo.co.uk)

### Abstract

Diverse indigenous knowledge systems of storage have been used by most cultures over time to preserve their produce after harvest. For Nigeria, in the tropical region of the world, yams can be stored in trench silos dug in the fields; left in the ridges after maturity; stored in a yam barn or on a platform. They can also be stored under a conical protective roof made from maize or millet stalk; or left in heaps on the ground. Problems associated with these indigenous storage systems, which lead to heavy postharvest losses include: rotting; respiration and temperature; sprouting while in storage; and pests like insects, nematodes and animals. Prospects for improvement of the indigenous systems of storage include low-cost storage techniques like proper selection of crop for storage; curing of yams; provision of adequate ventilation using night time air to reduce transpiration to the barest minimum; construction of shelves for storage of yam tubers to enable regular inspection and prevent damage; as well as construction of a well ventilated shed over the shelves to give adequate protection from rain and sunlight. Ventilated pit storage with improved temperature ranges of 21°C to 24°C and relative humidity from 83.9% to 93%, are expensive when compared with those of the traditional barns, but caused significant reduction of storage losses. Advanced storage methods include the use of refrigerated structures at about 15°C in combination with the use of fungicides. However, the high capital cost and the need for a technical support makes this method not feasible. The use of Gamma radiation to inhibit sprouting is also a promising alternative method of yam storage. [Researcher. 2010;2(1):51-56] (ISSN:1553-9865)

**Keywords:** Indigenous, storage systems, yams, Nigeria, problems, prospects.

### Introduction

Indigenous knowledge can be described as knowledge which has been accumulated by a people over generations by observation, experimentation, and by handing on old people's experience and wisdom in any particular area of human endeavour. Efforts at improving agricultural production have always been concentrated on increasing production through the breeding of high-yielding varieties with little emphasis on the conservation of what is produced.

According to Ohiagu (1987), since all that is produced cannot be consumed immediately, there is always the need for adequate and efficient storage facilities to save the excess crop that is produced from deterioration and waste. Storage serves a tripod objective in any human society. These are to ensure steady availability of produce and stable prices of produce, thereby reducing the seasonal fluctuations of market prices; to enable farmers and producers sell off their produce at strategic times for best market prices; and to eliminate or reduce quantitative and qualitative losses, thereby ensuring that healthy seeds are available for use in the next planting season.

Diverse indigenous storage systems exist for the array of crops found in Nigeria. Most tropical

crops have a limited postharvest shelf life, thus the storage method has to be adapted to adequately reduce any loss in flavour, texture, taste, colour as well as nutritional constituents. In Nigeria, indigenous knowledge systems exist for the storage of most of the food produced in most parts of the country. This discourse reviews some indigenous storage systems available for yams in Nigeria; the problems associated with the methods and prospects for improvements.

### Indigenous Storage Methods of Roots and Tubers

Root crops rank second, in comparison to cereals in importance as a global source of food carbohydrates (Cooke *et al.*, 1988). Root and tubers are stored in different ways depending on the customs and practices of the various tribes which grow them. In Nigeria, this group of crops are mainly grown in regions of the country where the rainfall has a longer duration like in the South-east, South-west, South-south and the Middle Belt.

In the humid tropics, the importance of these groups of food which relates to their agronomic advantages is quite significant. However, a key limitation is their bulky nature and relatively poor storage quality (Kay, 1987). The associated high

transport and marketing margins in urban markets in the developing world is of special interest.

### **Indigenous or Traditional Storage Systems for Fresh Yam**

A number of storage methods are used by farmers in West Africa. According to FAO (1998), a simple method mixes the tubers with wood ash, heaping and covering them with soil, possibly topped with dry grass as a form of mulch. Similarly, they may be stored on the floor or on shelves in shed or huts sometimes built for the purpose. Types of storage structures are influenced by factors like climate, purpose for the yam tubers in storage and socio-cultural aspects of storage. However, the storage structure can also be influenced by the type of building materials available, the resources of the farmer in particular and the availability of labour (FAO, 1990).

During the storage of yams, the tubers must be kept dry and away from the soil; and also protected from the strong rays of the sun. Generally, yams are stored based on their expected utilisation. This may be as seed yam or for consumption. In parts of Calabar, South-eastern Nigeria, yams are harvested in September or October and hung up to dry for about three months. Thereafter, the seed yams are put inside a sheltered shed and covered with a layer of plantain or other leaves, with the upper portion pointing upwards. By January, the sprouts generally appear and this method helps the yams to sprout, after which they are planted out at the end of January or February.

### **Storage in Trench Silos**

In yam fields that are located far from human settlements, the farmers construct silos in or on the sides of the fields. This practice saves labour which is scarce during the harvest period and also to save labour necessary for transportation during harvest. This type of storage which is mainly practiced in regions with pronounced dry season is carried out by excavating a pit whose size is proportionate to the expected yam harvest.

The pit is lined with straw or similar material. The tubers are then stored in the layer of straw either horizontally or on top of and beside each other, with the tip facing downwards vertically. The trench silo can be built underground or with a part of the store above the ground. It is usually covered with straw or similar material but in most cases, a layer of earth is also added.

Problems associated with this storage system are basically lack of ventilation and direct contact of the tubers with one another. This causes the stored produce to become heated up and thus the

formation of rot. The closed structure of the trench silo also does not permit regular checking of the stored produce. In addition, the silo offers good refuge for rodents, with a corresponding damage to the stored produce.

### **Leaving Yam tubers in the ridges after maturity**

Yams reach maturity, frequently at the beginning of the dry season, when vegetative growth stops, the leaves turn yellow and most of the dry matter of the yam vine is translocated into the tuber which then enters a resting or dormant stage (FAO, 1998). This stage of physiological maturity normally takes place some 8 to 11 months after planting and the yams are then ready for harvesting.

In some communities, the tuber can be left in the ridges for up to 4 months as a form of storage, depending on the yam variety. This storage method normally does not require any cost in erecting a store. There is however no protection from pests (insects like termites, nematodes, rodents). Also, the farm cannot be used for other purposes while the storage period lasts.

### **Storage of Fresh Yam Tubers in the Yam Barn**

Yam barns are a common type of yam store used in Nigeria. The barn is usually built on open ground but is usually, at least partially, shaded. There are many variations in the type of structure but basically it consists of walls of vertical timbers, each 5-10 cm in diameter, 2 to 3 metres high and set about one meter apart. The vertical timbers are often made of sawn trees which, if left unbarked, will take root when set in the ground (Bencini 1991; Ezeike 1995).

According to FAO (1998), it is considered this will reduce the risk of attack by termite or rotting of the timber at ground level. (The grown timbers will also help to provide shade.) In between the vertical timber are cross members of lighter section timber, bamboo or similar material. The barns are covered with a straw roof and enclosed within a fence or a wall for security. Inside the barn the tubers may be tied individually to the vertical timbers or otherwise arranged to allow maximum air circulation. The maximum storage life of yams in the barn is six months. Losses are reported to be 10% to 15% during the first three months and up to 30% to 50% after six months.

Barns are effective for yam storage during the dry season, but once the rainy season starts, tubers stored in barns tend to deteriorate rapidly, with the constantly moist environment enhancing the rotting of the tubers and the framework of the barn. Also, with each rain, diseases are spread from rotted tubers to neighbouring healthy yams especially those in the lower tiers. For this reason, farmers who use

barns keep their yams until the early part of the rainy season, while the remaining yams earmarked for consumption are moved indoors and stored on the floor or on shelves. Here they are safe from the rains and also pilferage, which is common during the months of yam scarcity following the planting season. The construction of yam barns for use over several years also requires high input costs (wood for construction).

### **Platform Storage**

Yams are sometimes stored on raised platforms constructed on the field. The tubers may be placed vertically or horizontally but it is important that no tuber is placed on top of another. As with barn storage, shading, ventilation and inspection are essential in platform storage.

With this method, ventilation and inspection are usually more difficult for the farmer to carryout, especially if the tubers are placed vertically and the situation is certainly aggravated if the tubers are stacked several layers deep. Also, like barn storage, outdoor platform storage is discontinued when the rainy season begins. Sometimes indoor platform storage is used.

### **Storage under Conical Protective Roof**

This type of storage is often erected under a shady evergreen tree. It consists of a conical protective roof made of maize or millet stalk which can be lengthened. The tubers are placed on top of each other under this protection. This method requires no financial investment as the raw materials (maize or millet stalk) are sourced from the farmer's field (FAO, 1990). Additional work in-put is also limited. The shady tree makes temperature fluctuation throughout the day milder in the night. Protective roof allows sufficient ventilation.

Problems arise with the possible entry of insect pests and rodents. In addition, there is also the risk of wild and domestic animals damaging the roof construction while in search of food, causing damage by feeding on the tubers which can lead to rot as the tubers are piled up on top of each other. Also, since the roof completely covers the tubers, it prevents regular visual checking of the stored produce.

### **Storage of Yam Tubers in Heaps on the Ground**

Yam tubers can be stored, piled up on a carpet of dried yam climbers, in a heap. This normally happens under a tree providing shade and the heap is covered with maize or millet stalks or similar materials (FAO, 1990). The shade of the tree somewhat balances out the temperature fluctuations occurring throughout the day, providing protection against the overheating of the produce.

This storage in poorly ventilated structures cannot allow the produce to be checked regularly. This promotes the spread of rot which means that storage duration is strictly limited. The stored produce is also damaged by rodents which can hide themselves very well in the heap.

### **Problems of the Indigenous Storage Systems**

The major problems associated with the indigenous storage systems are the postharvest losses arising from the methods. The sources of storage losses include:

**Rotting:** Rotting is due mostly to the effect of fungi and bacteria. The importance of microbial rotting in causing storage losses lies in the entry of pathogens which occurs through wounds or cuts and natural openings on the surface of the tubers (Ogundana, 1971). Although great variations have been observed between varieties, loss in weight of 10-20 per cent after only three months' storage, and 30-60 per cent after six months are not unusual even for sound tubers, and even greater losses have been observed to occur if infection by rotting organisms occur (Booth, 1974).

**Respiration and Temperature:** Losses due to respiration are high in the tropics as a result of uncontrolled temperature conditions, just as it has been established that the rate of respiration is dependent upon temperature (Booth, 1974). Roots and tubers are living organisms and as such, they respire. For respiration to occur freely a supply of oxygen is needed and the resulting carbon dioxide and heat have to be removed from the products' environment. A limited supply of oxygen and inadequate removal of carbon dioxide may lead to effective asphyxiation and the death of product tissue (FAO, 1998).

Excessively high temperatures may induce black heart, a disorder caused by the asphyxiation of the central cells (Booth and Proctor, 1972); and it is thought to occur in yams, where it has been shown that the internal temperature of tubers exposed to the sun may reach 45-50<sup>0</sup>C (Coursey, 1967). The respiration rate of yam tubers during storage have been observed to decrease with decreasing temperature over the range 30 to 50<sup>0</sup>C (Coursey *et al.*, 1966).

**Sprouting:** A physiological cause of storage losses in yams is sprouting. This is the conversion of edible tuber material to inedible sprout and is considered a postharvest loss. Coursey (1961) showed that while sprouting of yams stored in different regions of Nigeria was very variable, it could reach 100% after

4 months' storage. Sprouting usually increases with increasing storage temperature up to a certain maximum (Booth, 1974). The storage life of yam tubers is finally terminated by the breakage of dormancy, and subsequent sprouting (Coursey, 1981). Traditional practice normally involves breaking off the emergent sprouts when they are twenty or thirty mm long, unless the tubers are needed for planting. Further sprout development is delayed; the shelf life is extended by a few weeks and respiratory weight loss is reduced.

**Pests:** Post-harvest and storage losses are caused by pests, which include: insects, nematodes and animals. Estimates of storage losses of roots and tubers due to insects are very scarce. Insects damage roots and tubers in two ways: by boring holes in the tubers, reducing the quantity and quality of the produce and sometimes the germination capacity; and by damage to the epidermis providing entry for moulds and bacteria to penetrate the tuber (FAO, 1998).

Quantitative pathogenic losses result from the rapid and extensive breakdown of host tissues by microorganisms; while qualitative pathogenic losses are typically the result of blemish or surface diseases which render the produce less attractive and so reduce its market value (Booth, 1974).

### **Prospects for Improvement in Indigenous Systems of Storage.**

The Successful storage of yams requires the use of sound and healthy tubers; proper curing, if possible combined with fungicide treatment; adequate ventilation to remove the heat generated by respiration of the tubers; regular inspection during storage and removal of rotting tubers and any sprouts that develop and; protection from direct sunlight and rain (FAO, 1998). Efforts at improved low-cost storage methods would require the following:

#### **Selection of Crop for Storage**

Yam farmers understand from tradition and upbringing that only sound, healthy tubers are suitable for storage. For this reason yams are harvested with great care but, because of the varying sizes and shapes of yam tubers, some damage inevitably occurs. Improved storage of fresh yam tubers begins during harvesting. Injuries should be avoided as much as possible as these constitute avenues for rot viruses. According to Nwankiti *et al.* (1989), harvesting, transport and storage have to be carried out with as much care as possible. When transporting over longer distances, the tubers should not be piled up too high or this will quickly lead to injury to the epidermis and the formation of bruises.

The farmers are known to reject unhealthy or damaged tubers which are then used for immediate consumption or processing (FAO, 1998). According to Coursey (1981), each bruise or abrasion is more likely to lead to decay in storage than a clean cut and it is traditional practice to cut away any bruised or decayed flesh and often to rub the clean wound with alkaline material such as lime, ground chalk or wood ash to inhibit microbiological infection.

#### **Curing of Yams**

Yam tubers need to be properly cured as soon as possible after harvest to promote the formation of a hard cork layer. Curing should be carried out near the place where the tubers will be stored to minimize handling after curing. The process is carried out for 4 to 7 days at temperatures of 32° to 40°C and a relative humidity of 85% to 95% (FAO, 1989). Farmers achieve these conditions in two ways:

**Above ground:** Here yams are carefully piled on the ground and covered by a layer of grass at least 15 cm thick and finally a canvas tarpaulin or jute bags are used to cover the whole pile (FAO, 1987). Plastic sheets should not be used and the curing pile should not be exposed to direct sunlight. The cover should be removed after 4 days (Knoth, 1993).

**Pit-curing:** This system is widely used in parts of Nigeria. It consists of a pit, approximately 2.5 x 1.5 x 1 metre with the bottom lined with sawdust or dry grass. The yam tubers are placed on this lining and then covered with a thin layer of soil. The treatment takes about two weeks after which the tubers can be removed for storage. According to trials in Nigeria, yam tubers treated for two weeks by this method showed only 40% rotted tubers after 4 months of storage, compared to 100% of untreated tubers (FAO, 1989). Studies considering the optimum duration of the curing period combined with an appropriate fungicide may further enhance this technology.

Both of these curing methods are dependent on high temperature and high relative humidity. These conditions also favour the development of fungi and bacteria. Based on this, Demeaux and Vivier (1984), advised that prior to curing, the tubers should be treated with lime wash or wood ash, or if available, an appropriate fungicide such as thiabendazole or benomyl. Subsequently, the tubers should be handled with care to avoid new injuries.

#### **Provision of Adequate Ventilation**

Successful storage of roots and tubers in any sort of structure depends very much on natural ventilation to remove respiration heat, to remove carbon dioxide, which in concentration can lead to

the breakdown of dormancy, and to keep the temperature of the crop as low as possible (FAO, 1998). Ventilation should therefore be with the coolest possible air. Night time ventilation is not only the coolest but has the highest relative humidity, so that water loss through transpiration is also held to a minimum (FAO, 1998).

Although the traditional storage in yam barns is very popular in West Africa, the yams are vulnerable to attack by rodents and other mammals and it is very tedious to have to tie each tuber individually to the framework. This also can restrict ventilation and accentuate any tendency to deterioration. Any improvement to the traditional structure attempts to overcome these deficiencies as well as improve weatherproofing and in exposed situations to provide better shading.

A structure similar to the traditional yam barn except that the yam tubers are placed in single layers on shelves instead of being tied to the framework has been recommended by the Nigerian Stored Products Research Institute (NISPRI). This is a quick, simple operation which allows the yams to be handled more carefully so avoiding the tedium of tying the tubers to the framework and the damage which is associated with it. Regular inspection and the removal of rotting tubers are also simplified as a result of the shelving.

The recommendations also include that a well ventilated shed be constructed over the shelves to give adequate protection from rain and sunlight. Protection against rodents can be achieved by fixing a barrier of metal sheet or a wall about one metre high around the barn. Management of the store requires a weekly inspection, the disposal of rotting tubers and the removal of any sprouts on the tubers. According to NSPRI (1982), dipping of tubers in a solution fungicide, such as Benlate, Thiabendazole or Captan is recommended for the control of rot.

### Higher Cost Improved Yam Stores

**Ventilated pit store:** A ventilated pit store with dimensions- 2.9 m long, 1.3 m wide and 1.5 m deep, with a capacity of about 200 tubers placed on wooden shelves has been developed for the storage of fresh yams in Nigeria (Ezeike, 1995). It is covered by a cupola shaped galvanised sheet metal roof which protects it from sun and rain. To ensure adequate ventilation across the top of the crop, wire mesh was fitted on top of each long side wall up to the roof eaves on either side of the access door. An entry staircase leading down to the access door had a slopping corrugated aluminum roof which had to be removed to enter the pit. Vertical airflow within the store is encouraged by fitting in the centre of the roof structure a chimney 18cm diameter and 1.7m high

which is painted black to encourage convective air movement.

When compared with the traditional yam barn, temperatures in the pit remained constant over the range 21°C to 24°C. The barn and the ambient temperature were similar to each other but were consistently much higher than that in the pit. The humidity in the yam barn followed that of the ambient air and was quite low during the storage period. The mean weekly relative humidity of the pit was consistently high and ranged from 83.9% to 93%.

The comparatively favourable temperatures and relative humidity within the ventilated pit contributed to a significant reduction of storage losses. Efforts to encourage the adoption of this higher level of storage technology by farmers or traders in Nigeria need to be enhanced. There is however, no present study or any indication of the overall costs of storage (FAO, 1998).

**The thatched-roof pit:** A storage structure similar to the Nigerian ventilated pit but with a thatched roof has been tested in Benin (FAO, 1998). The results indicate that with the early variety *kpounan* the weight loss in the traditional system (tubers heaped inside a shed) could be reduced in the thatched-roof pit by 65% if yams were treated with a mixture of fungicides and insecticides (Fiagan, 1995).

### Advanced Storage Methods

More efficient storage methods are essential if large quantities of yams are to be collected at regional centres. Refrigerated storage at about 15°C in combination with the use of fungicides has been successful. The high capital cost involved with the widespread use of cold storage of yams; and the need for a technical support structure makes this method to be non-feasible (FAO, 1998). Gamma radiation to inhibit sprouting has also been successfully used to reduce weight losses and prevent sprouting of the tubers for up to 8 months (Adesuyi, 1982; Demeaux *et al.*, 1982).

### Conclusion

The negative storage properties of yam tubers mainly results from the high water content of the storage organs, with high losses frequently trailing their post-harvest behavioural pattern. Traditional storage systems for fresh products have been developed for yams in particular whose tubers have a natural storage quality due to their dormancy. These systems are all very simple in design and have often remained unchanged over a long period. Improvements to traditional storage systems for fresh yam tubers are possible. These must begin at the time

of harvesting when tubers should be handled carefully so that uninjured tubers can be put into storage. Small technical improvements to keep away pests, to improve the climate in storage and to facilitate regular control of the stored produce can contribute substantially to reducing losses.

### References

1. Adesuyi, S.A. (1982). The application of advanced technology to the improvement of yam storage. In *Yams Ignames*. Oxford: Clarendon Press.
2. Bencini, M.C. (1991). Post-harvest and processing technologies of African staple foods: a
  - a. Technical Compendium. *Agriculture Services Bulletin* No. 89. FAO, Rome.
3. Booth, R.H. and Proctor, F.J. (1972). Considerations relevant to the storage of ware potatoes in the tropics. *Pans* 18, 409-432.
4. Booth, R.H. (1974). Post-harvest deterioration of tropical root crops: losses and their control. *Tropical Sci.* 16 (2), 49-63.
5. Cooke, R.D., Rickard, J.E. and Thompson, A.K. (1988). The storage of Tropical root and Tuber Crops - Cassava, Yam and edible Aroids. *Expl. Agric.*, Vol. 24, pp 457-470.
6. Coursey, D.G., Fellows, L.E. and Coulson, C.B. (1966). Respiration of yam tuber tissue. *Nature*. 210: 1292-1293.
7. Coursey, D.G. (1967). Postharvest problems of yams (*Dioscorea*). *Proc. 1<sup>st</sup> Int. Symp. Trop. Root Crops, Trinidad, 1967*, 2 (6), 28-34.
8. Coursey, D.G. (1981). Traditional post-harvest technology of tropical perishable staples. *Industry and Environment*. Jan./Feb./Mar., pp10-14.
9. Demeaux, M., Babacauh, K.D. & Vivier, P. (1982). Problèmes posés par la conservation des ignames en Côte d'Ivoire et essais de techniques pour les résoudre. In *Yams. Ignames*. Oxford: Clarendon Press.
10. Demeaux, M. and Vivier, P. (1984). Méthodes modernes de conservation des ignames. *L'Agronomie Tropicale*, Vol. 39, No. 2.
11. Ezeike G.O.I., (1995). Successful introduction of improved yam storage methods for Nigerian farmers. *Proceeding of the Workshop on the African Experience on Post-harvest Technology Development, Accra (Ghana), 4-8 July 1994*. Edited by FAO, Rome.
12. Fiagan Y.S., (1995). Amélioration du stockage et de la conservation. Des ignames. Evaluation technique et économique: Expérience du Bénin. *Proceeding of the Workshop on the African Experience on Post-harvest Technology Development, Accra (Ghana), 4-8 July 1994*. Edited by FAO, Rome.
13. Food and Agriculture Organization (FAO) (1987). Strategies and requirements for improved production of roots, tubers and plantains. Committee on Agriculture, 9th Session. 23 March - 1 April 1987.
14. Food and Agriculture Organization (FAO) (1990). Action Programme for the Prevention of Food Losses, Improving Post-Harvest Handling, Storage and Processing of Root and Tuber Crops, Rome.
15. Food and Agriculture Organization (FAO) (1998). Storage and Processing of Roots and Tubers in the Tropics. Calverley, D.J.B. (ed.).
16. Kay, C.E. (1987). Root Crops. *Crop and Product Digest No. 2*. Second edition. London. Tropical Development and Research Institute.
17. Knoth, J. (1993). Traditional storage of yams and cassava and its improvement. GTZ, Germany.
18. Nigerian Stored Products Research Institute, (1982). Yam Tubers and Dried Yam. NSPRI, Lagos, Nigeria.
19. Nwankiti, A. D. O. *et al.* (1989). Traditional and Some Improved Storage Methods for Root and Tuber Crops in Nigeria in: DEUTSCHE STIFTUNG F INTERNATIONALE ENTWICKLUNG (DSE) (edi.): *Roots, Tubers and Legumes, Bonn*, pp 51 -67.
20. Ohiagu, C.E. (1986). Storage of food Grains in the Savanna zones of Northern Nigeria. In: *Proceedings of International Drought Symposium on Food Grain Production in Semi-Arid Africa. Kenyatta Conference Centre, Nairobi, Kenya. 19<sup>th</sup> - 23<sup>rd</sup> May, 1986*. (Menyonga *et al*, eds.)

### Correspondence to:

Ofor, M.O., and Ibeawuchi, I.I.  
 Department of Crop Science and Technology  
 Federal University of Technology, Owerri  
[mariofor2002@yahoo.com](mailto:mariofor2002@yahoo.com)  
[ii\\_ibeawuchi@yahoo.co.uk](mailto:ii_ibeawuchi@yahoo.co.uk)

**Date 10/10/2009**