ADVANCES IN YAM STORAGE RESEARCH IN NIGERIA

S.A. Adesuyi*

SUMMARY

A concise review of research findings from the Nigerian Stored Products Research Institute indicates in particular the importance of avoiding physical damage to yams during harvest and post harvest handling, and the great potential value, from a technical viewpoint, of the use of γ-radiation for sprout control, which effectively prolongs storage life maintaining excellent quality.

RESUME

Un apercu concis des résultats de recherche obtenus par l'Institut Nigérian de Recherche sur les Produits en Stockage met en relief le fait qu'il est important de ne pas blesser l'igname pendant et après la récolte, de même que la grande valeur potentielle, du point de vue technique, de l'utilisation de radiation — γ pour le contrôle des bourgeons, ce qui assure à l'igname une longue durée de conservation et une qualité excellente.

RESUMEN

Una revisión concisa sobre los aportes de la investigación del Instituto para la Investigación de Productos Almacenados de Nigeria, indica — en particular — la importancia de evitar daños físicos al ñame durante el manejo en la cosecha y en postcosecha, y el gran valor potencial, desde un punto de vista técnico del uso de radiación γ para el control de retoños el cual, efectivamente, prolonga el tiempo de almacenamiento manteniendo una calidad excelente.

*Nigerian Stored Products Research Institute, Federal Ministry of Trade, P.M.B. 5044, Ibadan, Nigeria.

INTRODUCTION

Yams are the most important of any farm crop produced for home consumption in the internal economy of Nigeria, and they also earn foreign exchange[5]. The principal species is the white Guinea yam, *Dioscorea rotundata* Poir. Other species cultivated being the yellow Guinea yam, *D. cayenensis*, the Water yam, *D. alata* L., the Chinese yam, *D. esculenta* (Lond.) Burk and the Bitter or Cluster yam, *D. dumetorum* (Kunth) Pax. Nigeria is the world's largest producer of yams, producing 12.1 million long tons in 1970/71[4], while global production has been estimated at 20-25 million tons per annum.[12]

Only one crop is grown per year, and it is therefore necessary to store yams for six months or longer. The yam barn is the most widely used structure for yam storage in West Africa. This consists of a vertical or nearly vertical wooden framework, to which the yams are tied individually by means of string or local cordage.

Very substantial losses in weight and quality occur during storage in the yam barn. Weight losses of 10—15 percent in the first three months, approaching 50 percent after six months' storage have been reported[11, 12]. The factors responsible are as follows:

1. Physical losses, i.e. mechanical damage and dessication.
2. Metabolic losses due to respiration.
3. Losses due to microbiological attack.
4. Losses due to insect and nematode attack.
5. Losses caused by rodents and other mammals.

It has been found that smaller yam tubers are less susceptible to mechanical damage than larger tubers. In 1960 Coursey and Walker found that yams maintained a fairly constant moisture content at Port Harcourt during storage, losing only 4 percent moisture during 22 weeks storage, but in the drier climate of Ibadan, 24 weeks storage resulted in a moisture loss of 20 percent.

Work on the respiration of stored yams showed that the principal sources of weight loss in yams during storage could be attributed to the respiratory activity of the living tuber[9,14,16].

Storage rots caused by microorganisms are the second most important factor responsible for losses and deterioration. Weight losses are greatly increased when rotting of the tubers occurred, and several microorganisms have been isolated from rotten yams[9,10,16,22].

Storage at low temperatures had been investigated in the hope of reducing the rate of respiration and controlling the microorganisms causing decay. However, yams suffer from chilling damage at temperatures of 10° C or below which are therefore unsuitable for their storage.[13]

The use of maleic hydrazide as a chemical sprout inhibitor at different concentrations was tried[18] without any conclusive results, although it has been reported[8] that methyl (alpha naphthyl) acetate (MENA) incorporated on paper carriers reduced sprouting in *D. alata*, while maleic hydrazide (MH-30), tetrachloronitrobenzene, pentachloronitrobenzene, and isopropyl phenyl carbamate failed to prolong the dormancy of *D. alata*.

Fungicides had been tried to control rotting of stored yams[9]; limewash proved to be more satisfactory for the first 10-12 weeks of storage, then borax or copper treatments tested on *D. cayenensis* and *D. rotundata*.

Walker[27] found that hermetic storage was unsuitable for yams. It has been claimed[26] that clamp storage was better than barn storage for yams but Olorunda and Adesuyi[24] found the reverse.

Attention has been paid to the two factors of sprouting and microbiological rot in relation to yam storage, during renewed research in the past four years in Nigeria. A report of the findings is presented here. *D. rotundata* has been used for most of these investigations.

REVIEW OF RECENT RESEARCH FINDINGS

Sprouting

Sprouting has been found to have many adverse effects in stored yams.

1. It reduces the food reserves in yams, through translocation of carbohydrate from the tuber into the sprouts.
2. It increases the rate of respiration and thus the rate of dry matter loss.
3. It causes an accelerated loss of moisture resulting in enhanced wilting. Adesuyi (unpublished work) reports that yams that sprouted lost 14 percent moisture content during six months' storage, 12 percent being in the last four months in which sprouting occurred; while yams that did not sprout lost only 6.5 percent moisture during the six months' storage.
4. It results in an enhanced loss of weight.
5. The vines produced during storage are a waste; vines of yams stored in the barn may be more than 180 cm long two months after sprouting, (i.e. about the fourth month of storage) and represent around 10 percent of the total weight.

6. It is associated with physiological rot in stored yam tubers. After some weeks the tubers become soft progressively from the bottom to the head, and become more susceptible to attack by microorganisms.
7. It reduces the quality and palatability of the tuber: the sprouting tuber is generally fibrous and bitter especially at the 'head' end.

Three methods for preventing sprouting in stored yam tubers of *D. rotundata* Gwaguzu have been investigated:

1. Storage at different temperatures, in rooms maintained at 15°C, 20°C, 25°C, and in the yam barn which was at ambient (27-35°C); only storage at 15°C was found to be effective in suppressing sprouting for six months.
2. Use of gamma radiation; tubers were irradiated to 2.5, 5.0, 7.5, 10.0, 12.5, or 15 krads four weeks after harvest, and stored with control tubers in a yam barn. Irradiation at 10 krad and higher doses effectively inhibited sprouting during six months storage, while 7.5 krad was found to be the critical dose for sprout inhibition.[3]
3. Use of chemical sprout inhibitors:
   (a) Maleic hydrazide, MH-30, and 1-naphthylacetic acid as a pre-harvest foliar spray at various concentrations up to 10 percent.
   (b) Aqueous solutions of MH-30, and 1-naphthylacetic acid as a dip at various concentrations.
   (c) Methyl ester of 1-naphthylacetic acid (MENA) and 2,3,5,6, tetrachloronitrobenzene (TCNB) applied by brushing on the head region, where sprouting usually begins.
   (d) Amyl and nonyl alcohols, to the vapours of which tubers were exposed in specially constructed air-tight cabinets for two weeks.

None of the chemical sprout inhibitors was found to be effective. The results of the successful methods of inhibiting sprouting in stored yam tubers for six months are presented in the Tables.

Radiation at doses of 15.0, 12.5, and 10.0 krads applied to yam tubers during dormancy and later stored in the yam barn, or alternatively storage of fresh tubers at 15°C, inhibited sprouting for six months as shown in Table 1. That there was a substantial reduction in weight loss in yams which did not sprout in storage is shown in Table 2. The weight loss in the controls, which sprouted, was approximately twice the weight loss in the treated tubers that did not sprout.

Table 3 shows that incidence of rot was reduced where sprouting was inhibited, presumably because there was no incidence of physiological rot. There was a high incidence of rot in one of the storage trials at 15°C when damaged samples were used, indicating that it is essential to store only sound tubers at this temperature.

Palatability and acceptability were very much enhanced in the treatments that inhibited sprouting as compared to the controls that sprouted in storage, as is shown in Table 4.

The successful inhibition of sprouting in stored yams for six months thus eliminated the adverse effects of sprouting enumerated earlier.

Decay

Two types of rot occur in stored yam tubers:

1. Physiological rot, which has already been mentioned in connection with sprouting.
2. Microbiological rot. This has the following effects on stored yams.
   (a) It increases the rate of loss in weight of stored yams.
   (b) It increases the rate of respiration and thus the rate of loss of dry matter.
   (c) It adversely affects viability of the tuber.
   (d) It can result in a total loss of the tuber.

Recent studies in Nigeria have led to the isolation of several fungi associated with storage rot of yams, *Aspergillus niger*, *Penicillium oxalicum*, *Fusarium moniliforme*, *F. poae*, *Trichoderma viride* and *Gliomastix convulata*[1,20]

The pathogens responsible for soft rot in stored yams entered the host tissue through wounds, and mycelial growths developed at natural openings such as scars left by rootlets and lacerations on the tubers. No fungal penetration appeared through the unwounded surfaces of the yam tubers[20]. This indicates that, apart from any natural openings, mechanical damage to tubers at harvesting, handling and transportation prior to storage provide the courts of infection. This in turn suggests that rotting in storage can be prevented by avoiding surface damage to the tubers during harvesting, handling and transportation prior to storage. Maximum attack by pathogens occurred at 90 percent R.H. and 26–30°C.

Anatomical studies on inoculated yam disks[20], revealed that the pathogens of yam causing storage rots penetrated the parenchyma cells of the tubers and established themselves within the cells. Infected cells were cleared of most of their starch grains and the cell walls disintegrated. The pathogens produced extracellular cellulolytic and pectic enzymes in culture.

Studies on yam nematodes[6] showed that the yam nematode, *Scutellonema bradys*, feeds on the peridermal and sub-peridermal cell layers of yam tubers causing destruction of the cells and the browning of cell walls, ultimately giving rise to a characteristic dark brown layer extending 1-2 cm into the tuber. This was described as the typical dry rot disease associated with nematodes. This differs from the views of Smit[25] that the nematodes only acted as incitants of the disease and the 'dry rot' was caused primarily by fungi such as *Fusarium* spp.

Ogundana[21] reported that pre-harvest rot was greatly reduced in yam tubers produced from setts (or seed pieces) which had been treated with Benlate or Thiabendazole before planting. Both fungicides were more effective in controlling soft rot of stored yams than Captan when applied as a dip at either 500 ppm or 1000 ppm before storage, although all three could be recommended for tuber treatment prior to storage.

In studies on curing technique, Adesuyi[2] found temperatures of 25°C and R.H. of 55–62 for five days to be the most suitable for curing fresh yam tubers to control rot during storage. High humidities and higher temperatures were not suitable, because the microorganisms responsible for decay require high humidities for optimum growth[19], while temperatures of 37°C and above cause damage to yam tissues[15]. Some pathogens can also survive temperatures up to 45°C, e.g. *Botryodiplodia theobromae*[7] which is one of the major microorganisms associated with rot in yams.

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TABLE 1

Cumulative percentage of sprouting of yam tubers stored at 15°C and irradiated tubers stored in the yam barn for six months and their control

Period of storage in months	15.0 krad	12.5 krad	10.0 krad	control	15°C	control
0	0	0	0	0	0	0
1	0	0	0	24	0	0
2	0	0	0	68	0	30
3	0	0	0	92	0	88
4	0	0	0	92	0	100
5	0	0	0	96	0	100
6	-	-	-	-	2	100

Irradiated tubers were treated one month after harvest and stored for another five months after treatment.

TABLE 2

Cumulative percentage loss in weight of yam tubers stored at 15°C and irradiated tubers stored in the yam barn for six months and their control

Period of storage in months	15.0 krad	12.5 krad	10.0 krad	control	15°C	control
0	0.0	0.0	0.0	0.0	0.0	0.0
1	7.3	6.4	8.1	9.3	2.5	6.2
2	8.1	8.6	9.3	14.5	5.3	9.0
3	9.2	10.4	12.8	15.3	8.2	13.9
4	15.3	15.9	16.7	20.1	11.6	23.4
5	17.7	19.8	20.0	39.7	15.1	37.5
6	-	-	-	-	18.6	43.0

TABLE 3

Cumulative percentage of rotting of irradiated tubers stored in the yam barn for six months

Period of storage in months	15.0 krad	12.5 krad	10.0 krad	control
0	0	0	0	0
1	8	0	8	0
2	12	0	8	12
3	12	4	16	32
4	16	16	36	48
5	20	28	40	56

At 15°C, 22 percent of the yam tubers were rotten by the sixth month of storage and 48 percent rotten in the control i.e. in the yam barn. The difference between the treated and the controls can be attributed to physiological rot.

TABLE 4

Palatability test results expressed as a percentage of assessments at the end of storage at 15°C and of irradiated yams stored in the barn and their unirradiated controls

Grading	15.0 krad	12.5 krad	10.0 krad	con-trol	15°C	control
A	85	95	45	-	75	20
B	15	5	55	-	25	20
C	-	-	-	15	-	40
D	-	-	-	85	-	20

A = very good
B = good
C = fair
D = poor