INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 6, No. 4, p. 40-47, 2015

RESEARCH PAPER OPEN ACCESS

The potentials of pre-storage curing and nanobiotectnology in the control of postharvest losses of yam (*Dioscorea rotundata* Poir.) tuber

S.C. Eze[1*], S.I. Umeh[1], K.I. Ugwuoke[2], G.I. Ameh[3], C.C. Onyeke

[1]*Department of Crop Science, University of Nigeria, Nsukka, Nigeria*

[2]*Department of Applied Biology and Biotechnology, Enugu State University of Science and Technology, Enugu, Nigeria*

[3]*Department of Plant Science and Biotechnology, University of Nigeria, Nsukka, Nigeria*

Key words: Yam tuber, Curing, Storage, Nanobiotechnology, Storage barn.

http://dx.doi.org/10.12692/ijb/6.4.40-47 Article published on February 28, 2015

Abstract

Postharvest losses of fresh yam tuber constitute a problem of food shortage in Africa. A 4 x 7 factorial experiment was therefore conducted at the University of Nigeria, Nsukka to investigate the potentials of curing and silverneem on the control of postharvest losses of yam tuber in storage. The treatments comprised of 3 levels of silverneem solution and no-treatment control thus: 0, 85.5, 175, 250 mg/ml and curing that ranged from S_0 –S_6 where the subscripts 0, 1, 2, 3, 4, 5, 6 represent the seven groups of the tubers that were being exposed to the sun daily until the last group which was removed on the 6th day. After curing, the tubers were treated by dipping in the prepared solutions and then air dried and then stacked in an improved yam storage barn. The dormancy period of yam was significantly ($P \leq 0.05$) extended by the silverneem at the three levels of concentration. Rot incidence was also significantly reduced but weight loss was not affected. A combination of 4 days curing with dipping the tubers in 250 mg/ml of silverneem solution significantly ($P \leq 0.05$) increased the dormancy period of yams. Curing beyond 4 days induced multiple sprouts on the tuber and significantly ($P \leq 0.05$) increased sprout growth rate which resulted in greater weight loss. However, further research is recommended to explore other applications of silverneem in agriculture and at least to attain the optimum level for fresh yam tuber storage.

* **Corresponding Author:** S.C. Eze ✉ simon.eze@unn.edu.ng

Introduction

Yam (*Dioscorea rotundata* Poir) is an important food crop especially in West Africa. In Nigeria, especially in southeast, yam is regarded as men's crop and has ritual and socio-cultural significance (Orkwor, *et al*., 1998). Demand for yam from other countries of the world has made yam an export commodity to United Kingdom and United States of America. One of the major problems facing the full utilization of yam is its post harvest spoilage or yam rot which sets in at 3-6 months after harvest (Eze and Ugwoke, 2010).

Conventional cold room methods or storage below 10° C causes dehydration, loss of taste and quality and when the product is brought back to ambient temperature, microbial spoilage increases (Osagie, 1992). Trials by the method of irradiation (Osagie, 1992) had controlled sprouting and prolonged dormancy period of yam. None of the methods has direct effect on microbial or pathological causes of yam spoilage. Okigbo and Ikediugwu (2002) associated different forms of yam tuber rotting to microbial attacks that probably took place in the field and developed in storage. The use of chemicals has been found to be effective in reducing fungal rots of yams but there is a growing awareness on the dangers associated with the use of some chemicals for storage and preservation of farm produce. Some of these chemicals have high mammalian toxicity and are considered not safe on the environment. Consequently, emphasis is now being placed on the use of non-toxic and environmentally friendly chemicals particularly those of plant origin. Plant extracts have found greater acceptance in modern storage methods of agricultural produce. There are several local plant species whose extracts have proved effective in protecting yam produce before and after harvest. Some of the plant extracts include ashes from oil palm (*Elaesis guineensis*) inflorescence, kola nut (*Cola nitida*) leaf, mango (*Mangifera indica*) leaf (Ogbeni, 1995).

Synthetic chemicals (Gibberellic acid, Thiabendazole) and some botanicals such as *Azadirachta indica, Xylopia aethiopica* and *Occimum graticimum* have been employed in the control of postharvest losses of yam (Girardin *et al.,* 1998, Eze, *et al*., 2010). Application of no chemical treatment of curing of yams in the sun immediately after harvest has been reported (Okigbo and Ikediugwu 2002) to be the simplest and most effective ways to extend storage life of yam. According to the researchers, curing is the process in which the skin thickens and new tissues form beneath the surface of injured areas in the tuber and that the best conditions for curing yams are 29°C to 32°C (85°F to 90°F) and high relative humidity (90% to 96%). Eze, *et al*. (2005), reported that results obtained with synthetic chemical and plant extracts storage treatments showed no wholesome response regarding yam rot and sprouting which are major sources of yam loss in storage.

Advances in research show that nano-science which combines biological principle with physical and chemical procedures to generate nano-sized particles with specific function has great potentials in various contexts. A combination of silver nitrate and plant extracts to generate nano particles is a nano-biotechnology. Antibacterial properties of silver nanoparticles have been investigated and found useful in the control of *Staphylococus aureus* (Kong and Jang, 2008). According to Furno *et al.* (2004), silver nanoparticles had no toxic chemicals and no adverse effects on food. Works previously done on yam storage studies that used curing (Okigbo and Ikediugwu), or plant extracts (Eze *et al*,2005), or synthetic chemicals (Girrardin *et al,* 1998) as yam storage treatments investigated separately either the effects of these treatments on the physical or biochemical characteristics of yam tuber in storage. As the nanorevolution in the realms of medical and technological applications unfold (Han *et al,* 2007), the development and application of green metallic nanaoparticles in Agriculture is likely to turn a new era in the nation's efforts in solving food security problems. Against this background, we hypothesized that combined application of curing, botanical extracts and metallic nano particles will give outstanding result. Motivation and aims of the study are the potentials of pre-storage curing and

nanobiotectnology in the control of postharvest losses of yam tuber in storage.

Materials and methods

Location of the Experiment

The experiment was conducted at the improved yam barn of the Department of Crop Science, University of Nigeria, Nsukka. The area is located by latitude 6º 52' N and longitude 7º 23' E and altitude 400 m above sea level and has a humid tropical climate. Rainfall is bi-modal with an annual total of about 1500 mm and relative humidity ranges from 70% to 80% while ambient temperature ranges from 25ºC to 30ºC during rainy season (Asadu, 1990).

Source of Yam

The tubers were harvested from the research farm of the Department of Crop Science, University of Nigeria, Nsukka. The tubers were carefully dug out of the soil with hoe and digger on the 27th of December, 2011. This period was the peak of hamartan in the study area purposely chosen to ensure that any tuber wounded during harvest or handling quickly dried up by harmatan before storage. The tubers were sorted and those without much blemish were selected for storage.

The storage structure

The experiment was conducted in an improved yam barn at the location. The roof of the improved barn was made of corrugated aluminum sheets with ceiling of bamboo and raffia mats for heat insulation. The sides of the barn consisted of a dwarf wall (1m high) made of cement blocks and wire netting extended from the top of the dwarf wall to the roof of the building. This feature enhanced air circulation and excluded rodents. Inside the barn, wooden shelves were constructed on which the tubers were placed. Also installed inside the barn, were the gadgets for measurement of temperature and relative humidity of the storage environment.

Experimental design

The curing treatment that preceded storage experiment had its layout in the open place near the storage barn. A layout of 3 x 7 treatments giving a total of 21 experimental units was marked out on the ground using a white marker (paint). The yam tubers were divided into 7 portions and each portion was further divided into 3 portions of 5 tubers each for curing treatment. A total of 105 tubers were used for the study. It was a completely randomized design (CRD) experiment. The tubers were labeled thus: S_0 (not cured control) S_1 (cured for one day)' S_2 (cured for two days), S_3 (cured for three days), S_4 (cured for four days), S_5 (cured for five days) and S_6 (cured for six days). The tubers were then randomly allocated to the experimental units. The tubers are left in the sun between 10 am and 4.00 pm every day. That is, the S_1 group was displayed once and removed, S_2 group displayed twice and removed until the last group which was the end of the curing treatment. The tubers were shuffled every two hours to ensure that no particular portion/s of the tubers enjoyed shadow cast as the sun was moving to the west. Storage experiment was the same with the curing treatment except that the tubers were raised in wooden trays stacked in an improved yam barn.

Preparation of the solution (silverneem)

Fresh neem (*Azadiractha indica*) leaf was collected from the botanical garden of the Plant Science and Bio-Technology Department of the University of Nigeria, Nsukka. The leaves were air dried in the laboratory for 7 days and milled in a harmer mill into powder. One and a half kilograms of the powder were extracted using Peak and Tracy (1956) method. The extraction was repeated two more times using 1200 ml in each case. The solution was heated under reduced pressure and solid materials of different weights were obtained. One gram of the dark solid material obtained after evaporation was dissolved in 4 ml of Diomethylsulphoxide (DMSO). Thereafter, it was filtered and 20 ml of the filtrate was dissolved in 2 ml of silver nitrate to obtain a solution termed silverneem. The substance was then subjected to serial dilutions to obtain three levels of concentrations thus: 250, 175, 87.5 mg/ml.

Application of silverneem

The primary nodal complexes at the heads of the tubers were removed to create freshness in that part of the tuber. Fresh cut was made on the tuber if the primary nodal complex disappeared during harvest or handling. This was to ensure effective movement or exchange of materials between the tuber and the prepared silverneem solution. The apical sections of the tubers were soaked to 6 cm depth for 30 minutes. After soaking, tubers were air dried and then placed on the appropriate racks in the yam storage barn according to design for subsequent observation and records.

Measurements

Temperature (T°C) and relative humidity (RH) of the storage environments were monitored at 10.0 am and 4.0 pm sessions daily using a thermocouple. The daily temperature and RH was obtained by average of the two sessions. Consequently, monthly temperature and RH were also obtained by average of the daily readings in each environment. The fresh weights of the tubers were taken with a top loading scale before storage and subsequently at intervals of 4 weeks during the storage. The duration of complete dormancy was determined as defined by Ireland and Passam (1985) which was given as the number of days from the start of storage to the first visible sign of sprouting.

$$\text{Rotting (\%)} = \frac{R_o - R_1}{R_o} \times 100$$

Yam rot incidence was determined thus:

$$\text{Rot incidence (\%)} = \frac{R_o - R_1}{R_o} \times 100$$

Where R_o is the number of tubers with no symptom of rots before storage and R_1 is number of tubers with symptoms of rots after storage.

Weight loss was determined thus:

$$\text{Weight loss (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where W_1 is the weight of tubers before storage and W_2 is the weight after storage.

Sprout length (m) = Length of the sprout at 16 weeks of storage.

Temperature use efficiency of the storage barn (TUE) was calculated thus: T_o - T_i where T_o is the temperature reading value outside the barn and T_i is the temperature inside barn.

Relative humidity use efficiency (RHUE) of the storage barn was also calculated thus:

$RH_i - RH_o$ where RH_i is relative humidity inside barn and RH_o is the relative humidity outside barn.

Data analysis

All the data collected were subjected to analysis of variance (ANOVA) according to the procedure for a randomized complete block design using the SAS statistical software (SAS, 1999). Treatment means were tested using least significant difference (LSD) of the means at 5% probability level. The graphical presentation was prepared with Excel chart wizard.

Result and discussion

The temperature and relative humidity of the study area both outside and inside the storage barn are shown in Table 1. The improved yam barn reduced the temperature with (1.5 – 4.5 ± 1°C) and provided cooler environment for the yams compared to the outside barn temperature. The reduction was high in the months of January to April, as shown in the temperature use efficiency (TUE). Conversely, the relative humidity inside the storage barn was high with relative humidity use efficiency (RHUE) of (12.5-25.5 ±1%). The improved yam barn used in this study had roof and insulated material as ceiling which probably helped to reduce the barn temperature while higher RH probably resulted from moisture conservation due to less air movement inside the barn. This is similar to a report by Girardin *et al.* (1998) who compared storage in pits and shades, and found that the pits had lower temperature and higher RH than the shades.

The dormancy period of yam was significantly ($P \leq 0.05$) extended by the silverneem at the three levels of concentration compared to the control (Table 2.).

Weight loss was not affected at any level of silverneem concentration but rot incidence and sprout lengths were significantly ($P \leq 0.05$) reduced. The extension of yam tuber dormancy by the silverneem suggests that this compound has hormonal effects on physiology of yam. Tschannen (2003) made similar observation in his trials with different concentrations of gibberellic acid for controlling postharvest losses of yam. Although, dormancy is considered to be controlled by endogenous factors (Craufurd *et al.*, 2001), storage losses might also be influenced by environmental conditions. Subjecting the tubers in this study to 6 days curing before storage is exogenous treatment which probably spurred action in the endogenous processes of the fresh yam tubers in storage.

Table 1. Temperature and relative humidity variations in the storage environments (inside and outside the storage barn).

Temperature °C					Relative humidity (%)		
Location	Months	Outside barn	Inside barn	TUE	Inside barn	Outside barn	RHUE
	Jan.	32.0	28.4	3.6	90.1	65.4	24.7
	Feb.	33.5	29.0	4.5	92.5	68.2	24.3
	March	34.0	29.4	4.6	89.6	72.1	17.5
Nsukka	April	33.0	28.9	4.1	85.7	74.4	11.3
	May	31.0	28.8	2.2	84.3	75.4	8.9
	June	29.2	27.9	1.3	81.9	70.0	11.9
	July	28.5	28.3	0.9	77.8	65.9	11.9

TUE = Temperature use efficiency of the storage barn

RHUE = Relative humidity use efficiency of the storage barn.

Table 2. Main effects of varying concentration of silver-neem on dormancy, weight loss, rot incidence and sprout length of yam in storage.

Conc. Mg/ml	Dormancy Period (Days)	Weight loss (%)	Rot incidence (%)	Sprout length (m)
250	92.0	33.0	44.6	104.2
175	93.0	33.2	47.6	110.4
85.5	93.4	34.2	47.8	134.2
0	84.8	32.5	51.6	130.4
LSD $_{0.05}$	1.57	ns	1.50	2.23

Ns = Not significant.

Curing as a single treatment decreased the dormancy period of yam in storage though the differences were not significant (Table 3). In contrast, the weight loss was increasing as the dormancy period was decreasing. Long period of curing resulted in high rot incidence with the highest rot occurring at day 6. Similarly, sprout length varied with the varying period of curing and was significant at day 6. In terms of curing duration and amount of sun light required, it appeared that curing for 4 days between 10.0 am and 4.0 pm morning and evening respectively is the optimum period because tubers cured beyond 4 days had higher rot incidence, higher weight loss and early sprouting than those tubers cured for less than 4 days suggesting that curing beyond 4 days probably predisposed the tuber to physiological breakdown and senescence. It has been reported that exposure to high temperature, (35°C) has led to early sprouting (Passam, 1977). According to his finding, under natural conditions, the temperature fluctuated and sprouting also occurred progressively in warmer conditions until the optimum was attained. This report also strongly support our justification for storing the tubers in an improved yam barn which temperature environment was in the range of 27.9 – 29.4 °C throughout the storage period.

Table 3. Main effects of curing treatment on dormancy, weight loss, rot incidence and sprout length on yam tuber in storage.

Curing period (Days)	Dormancy period (Days)	Weight loss (%)	Rot incidence (%)	Sprout length (m)
0	91.0	31.4	45.7	123.2
1	90.6	32.6	46.8	124.3
2	89.0	32.8	48.7	120.6
3	89.1	33.1	48.9	125.9
4	89.0	33.8	48.6	126.8
5	88.5	34.2	50.1	130.6
6	88.0	34.3	50.5	134.2
$LSD_{0.05}$	ns	ns	3.25	2.55

Ns = Not significant.

Table 4. Interaction effects of silverneem x curing on the dormancy period of fresh yam tuber in storage.

Curing (Days)	Silverneem concentrations (mg/ml)				
	0	85.5	175	250	Mean
0	92.4	87.6	89.5	87.6	89.3
1	89.5	89.4	88.6	89.7	89.3
2	88.7	90.5	90.1	92.2	90.4
3	89.6	90.2	91.3	91.8	91.2
4	89.4	87.9	93.3	93.9	93.4
5	90.2	89.7	92.6	92.6	91.3
6	89.4	89.5	93.5	92.5	91.4
Mean	89.9	89.3	91.1	92.5	90.5

$LSD_{0.05}$ for comparing any two curing periods = 0.98

$LSD_{0.05}$ for comparing any two silverneem concentrations = 1.08

$LSD_{0.05}$ for comparing any two silvrneem conc. x curing period =2.25.

The interaction effects of silverneem and curing on dormancy period of yam differed significantly ($P \leq 0.05$). On the average, silverneem significantly ($P \leq 0.05$) increased dormancy period of yam at 250 mg/ml (Table 4). Curing as a single treatment or in combination with silverneem for 4 days appeared to be the optimum period for effective storage of yam. However, curing up to the 6th day in combination with silverneem at 175 or 250 mg/ml resulted in extension of dormancy period of yams.

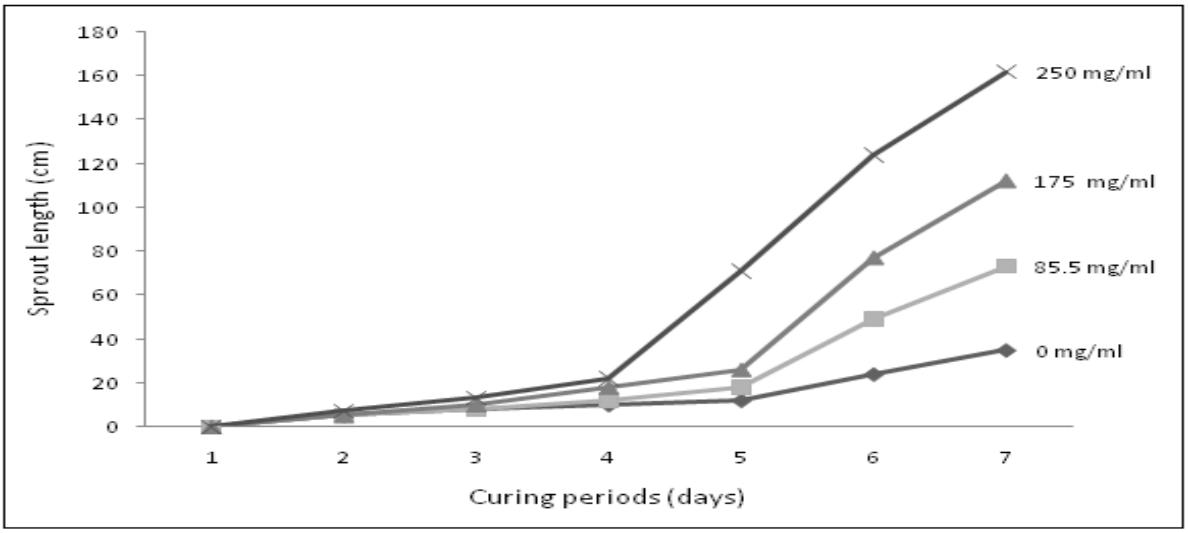

Fig. 1. Yam tuber sprouting pattern as affected by cuing period and silverneem concentrations.

The yam tuber sprouting pattern varied with different levels of silverneem concentrations (Fig. 1). The sprout growth rate of tubers treated with 250 mg/ml of silverneem and cured for 4 days was higher than those treated with lower concentrations and cured for longer than four days. The yam tuber sprouting pattern in this study showed that higher concentration of silverneem led to early and longer sprouting compared to no-treatment control suggesting that the silverneem could be a plant growth regulator.

Conclusion

Evidence in this study showed that combining silver nitrate and neem leaf extract that resulted in a new product termed silverneem has potentials in controlling postharvest losses of fresh yam tuber. The dormancy period of yam was significantly ($P \leq 0.05$) extended by the silverneem at the three levels of concentration, therefore the optimum level was not attained. Rot incidence was also significantly reduced. Silverneem has acted as both fungicide and hormone in this study. This metallic-nano-biological compound is likely to be the best alternative to synthetic chemicals that are toxic to human and environment or plant extracts which are easily degradable. Curing of yam in the sun before storage was effective as a storage technique but curing should not exceed four days in order to avoid physiological break down of the yam tuber cells. However, further research is recommended to explore other applications of silverneem in agriculture and at least to attain the optimum level for fresh yam tuber storage.

References

Asadu CLA. 1990. A comparative characteristics of two slopes in Nsukka Area of Eastern Nigeria. Soil Science **150,** 527 – 534.

Attama AA, Nnamani PO, Nwafor CN. 2005. In vitro study of the interaction between amoxicillin and norfloxacin with lansoprazole; Biological Research, **3(2),** 52 – 55.

Craufurd PO, Summerfield RJ, Asiedu R, Vera Prasad P. V.2001. Dormancy in Yams. Experimental Agriculture **37**, 147 – 181.

Eze SC, Eze EI. 2010. In vitro study of Biofungicidal Effects of *Cassia alata* Leave Extracts on Some Pathogenic organisms of White Yam (*Dioscora rotundata*) Tuber in Storage. Biological Research, **8(2),** 703-706.

Furno F, Morley KS, Wong G, Sharp BI, Howedle SM. 2004. Silver nanoparticles and Polymertric medical devices: a new approach to prevention of infection. Journal Antimicrobes **54,** http://dx.doi.org/1019-10. 24.

Han G, Ghosh P, Rotello VM. 2007. Nanamedicine (London, U. K.), **2,** 681-693.

Girardin OC, Nindjin Z, Farah F, Escher PS, Otokore D. 1998. Use of Gibberellic acid to prolong Traditional storage of yams. Journal Science. Food Agriculture **77,** 172-178.

Ireland CR, Passam HC. 1985. Effects of exogenous batatasin analogues and gibberellins on the dormancy of stored yam tubers. Tropical Agriculture **62,** 41 -45.

Kong H, Jang J. 2008. Anti-bacterial properties of novel of poly (methyl) methacrylate) nanofiber containing silver nanoparticles, Langmuir **24,** 2051-2056.

Morris VJ. 2005. Is Nanotechnology going to change the future of food Technology? International Review of food science and Technology **3,** 16-18.

Okigbo RN. 2004. A review of biological control methods for postharvest yams (*Dioscorea spp*) in storage in South Eastthern Nigeria. KMTL. Science Journal **4,** 207-215. http://dx.doi.org/10.1126/scisignal.2005906

Okigbo RN, Ikediugwu EO. 2002. Evaluation of water loss in different regions of yam (*Dioscorea*

rotundata) tuber storage in Nigeria. Journal of Experimental and Applied Biology **3,** 317-321.

Orkwor GC, Ugwu BO, Surma D, Eze SC. 2006. Studies on identification of (*Dioscorea rotundata*) foods and factors that determine choice criteria for consumption in Nigeria. Niger Agriculture Journal ; **36,** 145-153.

Passam HC. 1977. Sprouting and apical dominance of yam tuber. Tropical Science **19,** 29–39.

Peak K, Tracy MV. 1956. Modern methods of plant analysis. Springer Verlag, Berlin.

Tschannen A. 2003. Controlling Post-harvest Losses of Yam (*Dioscorea spp*.) by Application of Gibberellic Acid. A dissertation submitted to the Swiss Federal Institute of Technology Zurich for the degree of Doctor of Technical Sciences, 122.

SAS Institute. 1999. SAS STAT user's Guide, release 6.12. SAS Institute, Inc., Cary, Nc, USA.