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# Effects of Cultivar, Botanical and Gibberellic Acid Treatment on Physico-Chemical Changes of Yam (*Dioscorea rotundata* Poir) Tuber in Storage

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**Abstract**
**A storage experiment was conducted in an improved yam barn at the National Root Crops Research Institute, Umudike, Nigeria. Five cultivars of yam namely; Nwaopoko, Amula, Pepa, Danacha and Ezakwukpolo were obtained from four major yam producing states in Nigeria. The plant parts (botanicals) of *Azadiracdica indica* A. Juss (leaf), *Xylopia aethiopica* (Dun) A. Rich (fruit*), Occimum gratissimum* L. var (leaf) and *Zingiber officinale* Rosecoe (stem tuber) were obtained locally while the gibberellic acid ($GA_3$) was imported from Europe. The yam tubers were soaked in the chloroform extracts of the botanicals/$GA_3$ solution for 3 hours, air dried and stored in the barn for both physical and biochemical observations. The botanicals and $GA_3$ treatments significantly ($p \leq 0.05$) increased the moisture and dry mass contents of the stored tubers but had no effects on the crude protein, ash and fiber. Extension of dormancy period of the stored tubers by the storage treatments was in order of $GA_3$ > *A. indica* > *O. gratissimum* whereas X*. aethiopica* and *Z. officinale* reduced dormancy. Among the yam cultivar, $GA_3$ and *Azadiractha indica* always had the best effect of extending the dormancy, reduction in weight loss and rot incidence.**

**Keywords**: Yam; storage treatments; Physico-chemical changes
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## Introduction

Yam (*Dioscorea rotundata* Poir) is an important food crop in the humid and sub-humid tropics especially in Nigeria, where over 76% of the total global output is consumed year round (Orkwor et al., 2006). When yams are physiologically mature, they enter into dormancy and are usually harvested and stored for future use. Post-harvest losses of yam in storage have been attributed (Osagie, 1992) to such factors as sprouting, respiration, evaporation and micro-organisms. The dormant state is characterized by lack of visible growth of sprout or vine on the tuber. Okwuowulu et al (1995) noted that the readiness with which a yam tuber sprouted depended on the physiological age of the tuber. Although, the sprout is the only visible factor of loss in sound tubers, both respiration and evaporation are also important. Respiration as the oxidative breakdown of starch, sugar and organic acids with simple molecules as carbon dioxide and water lead to dry mass loss in stored yam while other source of loss is total damage through rot caused by micro-organisms. The principal micro-organisms associated with the rot of yam in Nigeria include *Botryodoplodia theobromae* Pat, *Fusarium moniliformae* var, *Penicillium oxalicum* Currie and Thorm, *Penicillium sclerotigenum* Yamtoma, *Aspergillus tarmarri* Kita, *Rhizoctonia* sp, and *Serratia* sp (Okigbo and Ikediugwu, 2000). Chemicals of various kinds including sodium ortho-phenyphenate, borax, captan, thiobendazole, benomyl, bleach (sodium hypochlorite) have been found to significantly reduce storage rot in yams (Ejechi and Ilondu, 1999). There is growing interest in the search and use of botanicals in preference to conventional chemicals especially for farmers who cannot afford to buy expensive synthetic pesticides.

Recently, some locally available botanicals have been found to prolong dormancy in yam thereby elongating the shelf life of yam tuber in storage (Eze et al, 2006). These earlier studies were mostly on the reduction of physical loses using one or two cultivars of yam as experimental units. This study was therefore, conducted to evaluate five cultivars of yam, four botanical extracts and gibberellic acid for their effects on the physico-chemical changes of yam tuber in storage and estimate the extent to which the botanical treatments interfere with the chemical composition of yam that warrants reduction in physical losses.

**Materials and Methods**

A storage experiment was conducted in an improved yam barn at the National Root Crops Research Institute, Umudike, Nigeria. Umudike is in the southeastern Nigeria, and is situated between latitude $05^0\ 29^1$ N and longitude $07^0\ 33^1$ E in the tropical rain forest zone and 122m above sea level and is characterized by low land tropical humid conditions. The roof of the improved yam barn was made of corrugated asbestos sheets with ceiling of bamboo and raffia mats (sheet made by interlocking the leaves of raffia palm) for heat insulation (Fig. 1). The sides of the barn consisted of a short wall (1m high) made of cement blocks and wire netting extended from the top of the short wall to the roof of the barn This feature enhanced air circulation and excluded some rodents. Inside the barn, wooden shelves were constructed on which the tubers were placed (Fig. 2).

Fig. 1. Side view of improved yam barn

Fig. 2. Yams inside the barn

Yam tubers of Nwaopoko, Pepa, Ezakwukpolo and Danacha cultivars were obtained from four major yam producing states in Nigeria because of their popularity and general acceptance among the consumers throughout the country.

Four medicinal plants namely; *Azadiracdica indica* A. Juss (leaf), *Occimum gratissimum* L. var (leaf. *Xylopia aethiopica* (Dun) A. Rich (fruit*),* and *Zingiber officinale* Rosecoe (stem tuber) were the botanicals, obtained locally while gibberellic acid ($GA_3$) tablets were imported from Europe. *A. indica* and *X. aethiopica* trees were climbed and with the aids of big knife and hook the plant parts were cut and plucked respectively. Freshly harvested *Z. officinale* stem tuber and *O. gratissimum* leaves were purchased from the local market. The selected plant parts were air dried under shade to make them less brittle during crushing in a harmer mill into powder. Four kilogrammes of each plant part were weighed out using mettler sensitive balance and poured into 2 L conical flasks and kept overnight. The supernatants were stirred with magnetic stirrer before they were filtered with clean muslin cloth. Each solution was heated in an oven at $60^0$C. About 25.5 g of each dark solid material (plant extracts) obtained after evaporation was dissolved in 4 ml of Diomethylsulphoxide (DMSO). The substances were subjected to further dilutions to obtain a concentration of 1.06 g $L^{-1}$. A solution of $GA_3$ was prepared by dissolving four tablets of $GA_3$ each weighing about 6.25 mg in 24 L of water to get a concentration of 1.04 mg $L^{-1.}$

*Experimental design and treatment application:* The storage experiment was a factorial laid out in randomized complete block design (RCBD) with four replications. The wooden shelves arranged in stacks in the yam barn served as blocks. Each replicate contained 25 treatments combinations. Each treatment contained 10 tubers which weighed 0.9 – 1.2kg and were labeled individually for a particular treatment before treatment application. A total of 1200 tubers were used. Before soaking the tubers in each of the

prepared solutions, the primary nodal complex (head of the tubers) were removed or fresh cuts made where the complexes were detached during harvest or handling. This was to ensure that the extracts/chemicals permeated the tubers. The tubers were soaked 30 cm deep in the appropriate solutions with the apical sections touching the floor of the bowls and allowed to stay for 3 hours. After soaking, tubers were air dried and placed on the appropriate racks in the yam storage barn according to design (RCBD).

Yam tubers were sampled one tuber per replicate at intervals of 0, 4, 12, and 24 weeks in storage. At each sampling, tubers were cleaned, peeled, cut into slices, washed and oven dried at $50^0$C for 72 hours. The dried materials were pulverized with a electric blender and wrapped in cellophane bags and stored in desiccators for proximate analysis. The processed samples were analyzed for moisture content, dry matter, crude protein, starch, total sugar, ash and fibre using AOAC (1990) methods. Total sugar and starch were analyzed by the method of Dubois et al (1956). Nitrogen was determined by Kjeldhal digestion and colorimetric determination on Technicon Auto-analyzer, ERMA INC model AE-11m & AE-11D while crude protein was determined by multiplying the N value with a factor of 6.25.

Sprouting was evaluated visually for presence or absence of sprouts and recorded daily from the start of storage to the $87^{th}$ day of storage. The duration of dormancy was determined by calculating the number of days from the start of the storage to the first visible sign of sprout. 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. Percentage weight loss was determined by the difference between the initial weight and successive weight loss divided by the initial weight, and multiplied by 100. These physical measurements were calculated thus:

Dormancy (days) = Number of days from start of storage to the first visible sign of sprout.

$$\text{Rotting (\%)} = \frac{\text{Number of tubers with symptoms of rot not earlier scored} \times 100}{\text{Original number of tubers stored}}$$

$$\text{Weight loss (\%)} = \frac{\text{Difference between initial and successive weights} \times 100}{\text{Initial weight of tubers at the start of storage}}$$

*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 statistical analysis system (SAS) software (SAS 1999). Statistical differences were denoted by Duncan's Multiple Range Test.

**Results**

Moisture content of the tubers significantly ($p \leq 0.05$) decreased with increase in time of storage while dry mass significantly increased with increase in time of storage (Table1). Similarly, starch significantly ($p \leq 0.05$) decreased with increase in time of storage whereas sugar levels increased as the time of storage was increasing. Crude protein was not affected by increase in time of storage while starch, ash and fibre varied with increase in time of storage. The botanicals and $GA_3$ treatments significantly ($p \leq 0.05$) increased the moisture and dry mass contents of the stored tubers but had no effects on the crude protein, ash and fiber (Table 2).

Danacha and Nwaopoko cultivars had lower moisture and higher dry mass contents than the other cultivars but crude protein, starch, sugar, ash and fibre levels were statistically the same in all the cultivars (Table 3). Extension of dormancy period of the stored tubers by the storage treatments was in order of $GA_3$ > *A. indica* > *O. gratissimum* whereas X*. aethiopica* and *Z. officinale* reduced dormancy compared with the no treatment control. Cultivar effects on dormancy varied with cultivar type. Danacha and Nwaopoko significantly ($p \leq 0.05$) had longer dormancy period. Tuber weight loss was reduced by $GA_3$ and *A. indica* while *Z. officinale* increased weight loss. Rotting incidence was reduced by $GA_3$ and *A. indica* treatment while *Z. officinale* induced rotting in stored tubers. Cultivar effects on rotting showed that Amula and Ezakwukpolo significantly had higher rotting incidence while Pepa had the least.

Table 1. Effects of time on proximate composition of yam

| Storage time (weeks) | Moisture content | Proximate composition of stored tubers: Dry matter | Crude protein | Starch | Sugar | Ash | Fibre |
|---|---|---|---|---|---|---|---|
| 0 | 73.0[a] | 27.0[b] | 2.5[a] | 21.0[a] | 0.9[b] | 0.7[c] | 1.5[c] |
| 4 | 72.3[b] | 26.9[b] | 2.1[a] | 19.6[b] | 1.0[ab] | 0.7[c] | 1.6[b] |
| 12 | 69.2[c] | 28.8[a] | 2.0[a] | 18.4[c] | 1.2[a] | 0.8[b] | 1.6[b] |
| 24 | 67.2[d] | 28.9[a] | 2.0[a] | 18.0[d] | 1.3[a] | 0.9[a] | 1.7[a] |

Means followed by the same letter or letters in each column do not differ significantly at $p \leq 0.05$ by Duncan's Multiple Range Test

Table 2 Effects of storage treatments on the proximate composition of stored yam tubers after 24 weeks in storage

| Storage treatment | | Proximate composition of stored tubers: Moisture contents | Dry matter | Crude protein | Starch | Sugar | Ash | Fibre |
|---|---|---|---|---|---|---|---|---|
| | Control | 68.9[b] | 27.0[c] | 1.9[a] | 18.7[a] | 1.4[a] | 0.8[a] | 1.7[a] |
| | $GA_3$ | 69.2[a] | 29.0[a] | 1.9[a] | 18.4[bc] | 1.2[b] | 0.8[a] | 1.6[a] |
| Botanicals | *O. gratissimum* | 69.1[a] | 28.2[a] | 1.9[a] | 18.3[c] | 1.2[b] | 0.8[a] | 1.7[a] |
| | *X. aethiopica* | 68.7[b] | 28.6[b] | 1.9[a] | 18.6[a] | 1.4[a] | 0.8[a] | 1.7[a] |
| | *Z. officinale* | 69.1[a] | 28.2[b] | 1.9[a] | 18.0[d] | 1.3[ab] | 0.8[a] | 1.7[a] |
| | *A. indica* | 69.2[a] | 29.0[a] | 2.0[a] | 18.5[b] | 1.2[b] | 0.8[a] | 1.7[a] |
| | Amula | 68.9[a] | 27.5[a] | 1.9[a] | 18.7[a] | 1.5[a] | 0.8[a] | 1.6[a] |
| | Pepa | 68.6[a] | 28.3[a] | 1.8[a] | 18.6[a] | 1.4[a] | 0.8[a] | 1.7[a] |
| Cultivars | Danacha | 67.9[b] | 29.0[b] | 1.8[a] | 19.3[a] | 1.3[a] | 0.8[a] | 1.7[a] |
| | Nwaopoko | 68.3[b] | 29.2[b] | 1.9[a] | 19.5[a] | 1.2[a] | 0.8[a] | 1.6[a] |
| | Ezakwukpolo | 68.6[a] | 28.2[a] | 1.9[a] | 18.8[a] | 1.3[a] | 0.8[a] | 1.7[a] |

Means followed by the same letter or letters in each column do not differ significantly at $p \leq 0.05$

Table 3. Effects of storage treatments on the physical storage characteristics of yam

| Storage treatments | | Physical storage characteristics: Dormancy (Days) | Weight Loss (%) | Rotting incidence (%) |
|---|---|---|---|---|
| | Control | 61.4d | 33.5c | 36.4bc |
| | $GA_3$ | 72.6a | 33.4c | 34.0d |
| Botanicals | *A. indica* | 68.0b | 33.0c | 35.5c |
| | *O. gratissimum* | 64.0c | 36.0bc | 37.0b |
| | *X. aethiopica* | 59.8c | 37.0b | 37.9b |
| | *Z. officinale* | 53.0f | 39.4a | 40.2a |
| | Amula | 58.0d | 39.3a | 39.7ab |
| | Pepa | 68.6[a] | 39.3[a] | 31.8[d] |
| Cultivars | Danacha | 67.9[b] | 29.0[b] | 37.8[b] |
| | Nwaopoko | 68.3[b] | 29.2[b] | 32.7[c] |
| | Ezakwukpolo | 68.6[a] | 35.4[a] | 40.2[a] |

Means followed by the same letter or letters in each column do not differ significantly at $p \leq 0.05$

## Discussion

The decrease in moisture contents of the stored tubers caused an increase in dry mass of the stored tubers. This essentially resulted from moisture loss through evaporation. The starch contents of the stored tubers reduced with increase in time of storage while sugar levels increased. Passam et al (1978) obtained similar result and attributed it to the metabolic processes in yam which convert starch to sugar. Storage treatments especially with $GA_3$ and *A. indica* extended dormancy period of yams in storage. In the present study, extended dormancy period by $GA_3$ was less than that obtained in other similar studies (Girardin et al, 1998 and Wickham et al 1984). Among the possible explanations for the difference may include cultivar differences, age at harvest and other environmental variables. Okwuowulu et al (1995) reported that yam cultivar and age at harvest significantly affected weight loss and sprouting of yam tubers during storage. The tubers used in this study were purchased from the yam growers so the exact date of harvest was not guaranteed.

Tuber weight loss varied significantly among the cultivars with or without botanical or $GA_3$ treatment. However, weight loss was less where the treatments were applied than the no treatment storage. This lower weight loss exhibited by the $GA_3$ and botanical treatments could be related to the delay in sprouting caused by these treatments. Jerkins (1981) noted that the physiological losses through respiration and evaporation of moisture were increased by sprouting.

Rotting incidence also varied significantly among the cultivars. The lower incidence of rotting in $GA_3$ and *A. indica* treated tubers compared with the other botanicals could be due to the efficacy of these chemicals in extending dormancy in yam. This can be explained in the light of a report by Girardin et al (1998) that yam is less susceptible to fungal attack during dormancy than during germination. The reduction of rot by *A. indica* was an indicator of its anti-microbial activities. This result suggests that *A. indica* is a fungicide since it reduced rots and majority of rots in yams are caused by fungi (Okigbo and Ikediugwu, 2000).

The use of chemicals in reducing post-harvest losses of fresh yam tubers in storage by peasant farmers is limited by availability and cost. However, given that the use of herbs in traditional medicine is still wide spread among peasant farmers, use of botanical extracts may be attractive enough for adoption. We however recommend that further research be conducted on the extraction methods and concentrations of the botanicals for the control of post-harvest loss of yam and other agricultural products.

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