



EFFECT OF FUSARIUM NYGAMAI INFECTION ON THE CHEMICAL COMPOSITION OF FLOUR FROM TWO YAM VARIETIES

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ABSTRACT

Yams (*Dioscorea* spp) are among the oldest food crops. It is estimated that after six months of storage up to 56% of the crop is lost to rot. In Nigeria, fresh yam tubers are used for production of *Elubo* (yam flour) for preparation of *amala*, as it is called among the Yoruba in Western Nigeria, and *akwunaji* in the east of the River Niger. Many researchers have emphasized the importance of microbial rotting in causing storage losses. This study evaluated the effect of yam rot on the nutritional values of *Fusarium* infected yam tubers. Tubers from two yam (*Dioscorea rotundata* Poir.) varieties-Nwopoko and TDr95/19177-were infected with *Fusarium nygamai* pure culture and stored for 12 weeks, after which the tubers were used to produce yam flour and were analyzed for their nutrient composition comprising: dry matter/ moisture content, ash, total sugar, starch, amylose, vitamin C, protein and tannins. Wholesome yams of the same varieties were also used to produce yam flour and equally evaluated for the same nutrients. Infection with *Fusarium nygamai* led to a significant reduction ($p < 0.05$) in the nutrient composition of the infected yam flour compared with those of wholesome samples. Vitamin C content reduced from 41.10 to 27.26 (mg/100g) in variety Nwopoko and 36.30 to 30.53 (mg/100g); in variety TDr95/19177. Corresponding values for protein content was from 5.05 to 4.60% and 4.93 to 4.62%; Ash Content from 1.32 to 1.30% and 1.36 to 1.24%; Total Sugar Content from 5.34 to 5.20% and 5.21 to 5.02%; Starch 78.71 to 77.61 and 89.28 to 81.53%; Amylose from 29.95 to 28.87% and 30.01 to 27.95%. However, an increase in the tannin content – (1.84 and 1.94 mg/g) as against (0.31 and 0.26 mg/g) in Nwopoko and TDr 95/19177 varieties respectively was observed. The increase in the tannin content implies an increase in the antinutrient composition. The tendency to produce *Elubo* used for preparation of *amala* with rotten yam (possibly *Fusarium* infected) should be discouraged.

Key words: Yam ; elubo; *Fusarium nygamai*; nutrient composition and nwopoko.

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INTRODUCTION

Yam (*Dioscorea* spp) are important food crops in West Africa, the Caribbean, the Northern and Central parts of South- East Asia, including parts of China, Japan, Malaysia and Oceania Orkwor et al., 1998. West Africa produces the greatest percentage of yam mainly in Nigeria, Benin, Togo, Ghana and Ivory Coast- the five yam zone countries Orkwor et al., 1998. Yams are among the oldest recorded food crops. It is an important crop in Nigeria, where it is produced both as a food and cash crop. Fresh yam tubers are peeled, chipped, fermented, dried and milled into flour. This flour is cooked in boiling water, turned into a thick paste similar to fufu, and eaten with soup. Among the Yoruba in Western Nigeria this is called amala and east of the River Niger it is called akwunaji (Perfecto and Editha, 1995; Orkwor et al., 1998). Pounded yam, however, is by far the most popular food from yams in Nigeria (Hahn et al., 1987).

Nigeria remains the largest single producer of yam, accounting for over 70-76% of the world production. Nigeria produced 18.3 million tons of yams from 1.5 million hectares, representing 73.8% of total yam production in Africa. According to 2008 figures, yam production in Nigeria has nearly doubled since 1985, with Nigeria producing 35.017 million metric tons with equivalent of US\$ 5.654 billion. In Nigeria, postharvest losses due to microbial rot are high and it affects about 20-29.5 % of stored yam tubers (Okigbo and Ikediugwu, 2000). Food security is a critical issue in Nigeria. Three elements are keys to food security: production, availability and accessibility. A nation like Nigeria, drawing on its vast national resource endowment can be self-sufficient in food production and yet remains food insecure because the production cannot be stored for the appropriate period (Nwosu et al., 2004).

The crop is affected by numerous pests and pathogens, such as insects, nematodes, fungi, bacteria, and viruses which, either singly or in combination are responsible for the sub-optimal yields and deterioration in the quality of the tubers in storage. *Fusarium* rots of yam are among the most important post-harvest pathogens of yam worldwide (Rowe et al., 1995) causing much post-harvest losses in stored yam tubers. Yam rot caused by *Fusarium* spp is rated as one of the most important diseases of stored yam tubers worldwide. Rot caused by this pathogen is one of the critical constraints to yam production in the tropics because yams (more than any other tropical root crops) are stored for a long period by traditional methods (PAN, 1978). Bacteria, especially the soft rot group (*Erwinia* spp) play a role in yam rot. Under estimated, fungal rot alone is the greatest single cause of tuber loss in storage (Onwueme, 1978). Openings or cuts on the tuber surface serve as very suitable entry points and media for the growth of microorganisms.

Yams are good sources of vitamin B6 among other nutrients; which is needed by the body to break down homocysteine (which can directly damage blood vessels). Yams are good sources of potassium, a mineral that helps to control blood pressure (Lape and Treche, 1994). The Chemical composition of yam is characterized by moisture content and dry matter and the dry matter is composed mainly of starch, vitamins as well as sugar and minerals and (Degras, 1993; Okigbo and Ikediugwu, 2000). Yam has a high nutritional value compared to other root and tuber crops but there is variation based on species and processing method.

Cultivars of some yam species (e.g. *D. rotundata* and *D. dumetorum*) have been found to contain protein levels of 3.2 to 13.9% dry weight. A yam meal could supply 100% of the energy and protein, 13% of calcium and 80% of iron requirements of a male adult (Lape and Treche, 1994). Some food yams have been shown to contain phosphorus and vitamins such as thiamin, riboflavin, niacin and ascorbic acid (Eka, 1985; Bonire and Jalil, 1991). Species such as *D. dumetorum* (Knuth) Pax and some wild yams are rich in amino acids. Cooking yam with the peel intact helps retain vitamins. Yam may also contain small quantities of polyphenolic compounds (e.g. tannins), steroid derivatives (e.g. diosgenin), alkaloids (e.g. dioscorine) and calcium oxalate crystals, however these are reduced to safe level using appropriate methods of food processing.

Many workers such as Ikotun (1986), Nnodu and Nwankiti (1986) and Ogali et al. (1991), have emphasized the importance of microbial rotting in causing storage losses. However, there is dearth information on the nutritional losses in yam tubers infected by *Fusarium* spp. (rotten yam). Hence the aim of this work is to evaluate the effect of yam rot due to *Fusarium* infection on the nutritional value of yam tubers.

MATERIALS AND METHODS

Sources of Yam Tubers:

The yam (*Dioscorea rotundata* Poir.) tubers from Nwopoko and TDr 95/19177 were harvested at matured stage (8 months) from the field of the Yam Programme of the National Root Crops Research Institute (NRCRI), UmuDike. The tubers were carefully harvested to prevent bruises. They were of average sizes of 15-27 cm long and 5-7 cm mid region diameter.

Inoculation of the Yam with *Fusarium nygamai*:

The yams were washed under clean running tap water to clean them from soil and air dried before they were inoculated with *Fusarium nygamai* pure culture and stored in polyethylene bags for 12 weeks, while the inside was moist with distilled water damp cotton wool to maintain high relative humidity around the treated tubers. The rate of deterioration were measured weekly for 12 weeks.

The tubers were used to produce yam flour and were analyzed for nutrient compositions; wholesome yam flour of the same varieties was equally evaluated as control.



Chemical Evaluation of flour of the Yam Tubers:

Five yam tubers per each variety were used for the preparation of *elubo* (yam flour) from both *Fusarium* infected and wholesome yam tubers using the method described by Ukpabi and Omodamiro (2008). This flour was analyzed for the following proximate composition: Dry matter/ moisture content, ash, total sugar, starch, amylose, vitamin C, protein and tannins.

Determination of Ash Content

This was done using AOAC (2000) method, which involved weighing 2 g of the samples into a crucible, which had been previously weighed. The crucible containing the sample was then placed on a hot plate inside the fume cupboard to char the organic matter. The remaining residue (inorganic matter) was transferred into the muffle furnace (Fisher Scientific Co. USA, model 186A) maintained at 600 °C for 6 hours to ash the samples completely. The crucibles were transferred into desiccators to cool. They were weighed and the ash content was calculated as follows:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where:

W_1 = Weight of crucible.

W_2 = Weight of crucible + sample before ashing.

W_3 = Weight of crucible + sample after ashing.

Determination of Crude Protein Content

The Automated Kjeldahl Analyzer (Kjeltec 2300) was used to perform the distillation and titration of the digested sample. The power switch of the System was turned on and allowed to perform self-test. Function was selected after the self-test, then run was selected to run the blank.

For every batch of digestion/sample selection of blank was made by placing the blank tube in the distillation unit of the System. When the System displayed 'ready' after running of the blank, the door of distillation unit was opened and the tube removed.

The weight of the sample to be analyzed was entered, using the key board on the System. The tube containing the sample's digest was placed in the distilling unit of the System and the door gently released for the System to automatically perform the distillation and titration of the digest. Only about 5 minutes was required for each sample.

Calculation:

$$\% \text{ Total Nitrogen} = \frac{(\text{sample titre} - \text{blank titre}) \times N \times 14.007 \times 100}{\text{Sample weight (mg)}}$$

% protein (crude) = % Total Nitrogen x Conversion factor.

N = Normality of the acid.

Determination of Vitamin C (Ascorbic Acid)

Fifty grams (50 g) of the sample was immediately extracted with 200 ml meta-phosphoric-acetic acid solution by blending with Warring blender for 3 minutes.

The resulting slurry was then filtered and 50 ml of the juice extract was titrated with the dye solution. At the end point the color changed to rose pink that persisted for more than 5 seconds (AOAC, 2000 and AOAC1995).

Calculation

$$\text{Mg ascorbic acid/100g} = \frac{(X - B) \times F \times V}{E} \times 100$$

Where X = Average volume (ml) for test solution titration,

B = Average volume (ml) for test blank titration F = mg ascorbic acid equivalent to 1.0 mL indophenol standard solution, E = weight of sample, V = Volume of initial test solution and Y = Volume of test solution titrated.

Determination of Free Sugars and Starch Content

The method of AOAC, (2000) was used. This involved weighing 0.020 g finely ground sample into centrifuge tubes wetted with 1 ml of ethanol. Two ml of distilled water was added, followed by 10ml hot ethanol. The mixture was vortexed and centrifuged using Sorvall centrifuge (Newtown, Connecticut, USA, and model GLC-1) at 2000 rpm for ten minutes. The supernatant was collected and used for free sugar analysis, while the residue was used for starch analysis. To the residue was added 7.5 ml of perchloric acid and allowed to hydrolyze for 1 hour. It was diluted to 25 ml with distilled



water and filtered through Whatman no 2 filter paper. From the filtrate 0.05 ml was taken, made up to 1 ml with distilled water, vortexed and used for color development as was described for standard glucose preparation.

To the supernatant made up to 20 ml with distilled water, an aliquot of 0.2 ml was as taken. 0.5 ml of 5% phenol and 2.5 ml concentrated sulphuric acid were added. The sample was allowed to cool and the absorbance read on a spectrophotometer (Milton Roy Company, USA), Spectronic 60; at 490 nm wavelength. Free sugar was calculated as follows.

$$\% \text{ Free Sugar} = \frac{\text{Abs} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume}}{\text{Weight of sample} \times \text{Slope} \times 10,000}$$

Where: Abs. = Absorbance; Dilution factor = 5; Volume = 20; Slope = 0.0055, and

Intercept = 0.0044

$$\% \text{ Starch} = \frac{\text{Abs} - \text{Intercept} \times \text{Dilution factor} \times \text{Volume} \times 0.9}{\text{Weight of sample} \times \text{Slope} \times 10,000}$$

Where: Abs. = Absorbance; Dilution factor = 20; Volume = 25; Slope = 0.0055, and

Intercept = 0.0044

Determination of Amylose Content

This was determined using the method of AOAC (1995) involving the preparation of stock iodine solution and iodine reagent. The amylose content was calculated as:

Amylose content (%) = $3.06 \times A \times 20$. Where: A = Absorbance value.

Determination of Tannins

One hundred milligrams (100 mg) of defatted sample was mixed with 20 ml of cold methanol, homogenized for 10 min and centrifuged at 3,000 rpm for 20 minutes. The supernatant was used for the assay. Percentage tannin was calculated as follows:

$$\% \text{ Tannin} = \frac{(A-I) \times V \times 100 \times D}{B \times W \times 10^6}$$

A= Absorbance of sample.

I= Intercept

V= Total volume of extract

B= Slope of standard curve

W= Weight of sample

Determination of Moisture Content/ Dry matter

Exactly 5 g of the sample was placed in a dried and weighed moisture can. The sample was dried to constant weight at 100-102 °C for 16 hours in a draft air oven. The loss in weight was reported as moisture.

Calculation:

$$\% \text{ Moisture Content} = \frac{W_2 - W_1}{W_3 - W_1} \times 100$$

Where: W_1 = Weight of moisture can; W_2 = Weight of moisture can + Sample before drying; W_3 = Weight of moisture can + Sample after drying

% Dry Matter Content = 100 - % Moisture Content.



RESULTS AND DISCUSSIONS

Table 1 shows the level of deterioration of the experimental yam tubers before use for the preparation of yam flour. Deterioration level ranged from 24-65% for Nwopoko and 24-68% for TDr 95/19177 within the period of 12 weeks.

Table 1: Levels of deterioration in yam varieties infected with *Fusarium nygamai*.

Duration (Weeks)	Percentage	
	Nwopoko	TDr95/19177
2 nd	24 ^h	24 ^k
3 rd	25 ^g	26 ^j
4 th	26 ^g	28 ⁱ
5 th	29 ^f	30 ^h
6 th	41 ^e	40 ^g
7 th	41 ^e	42 ^f
8 th	42 ^d	44 ^e
9 th	47 ^c	49 ^d
10 th	47 ^c	50 ^c
11 th	48 ^b	52 ^b
12 th	65 ^a	68 ^a
LSD _{0.05}	1.144	0.458

Means with the same superscript in each column are not significantly different ($p > 0.05$) from one another.

Table 2 shows the chemical composition of the yam tubers from the two varieties. Vitamin C content reduced from 41.10 to 27.26 mg/100 and 36.30 to 30.53 mg/100 in Nwopoko and TDr 95/19177 respectively after inoculation with *Fusarium*. The protein content reduced from 5.05 to 4.60% in Nwopoko and 4.93 to 4.62% in TDr 95/19177. There was significant reduction in the ash content of TDr95/19177 (1.36 to 1.24%) and (1.32 to 1.30) in Nwopoko. Ash content of the wholesome TDr 95/19177 tubers was significantly higher ($p < 0.05$) than that of Nwopoko tubers. This suggests that the mineral content of variety Nwopoko could be lower since ash content value is indicative of the mineral content.

Total Sugar Content of wholesome yam tubers was significantly ($p < 0.05$) reduced by *Fusarium* infection in variety Nwopoko. There was no significant difference ($p > 0.05$) in the total sugar contents of wholesome and infected tubers of TDr 95/19177. Infection with *Fusarium* led to a significant reduction in the starch content of in both varieties. The amylose content of wholesome TDr 95/19177 was significantly higher than that of wholesome Nwopoko variety. *Fusarium* infection significantly reduced the amylose content of both varieties.

Table 2: Chemical Composition of yam flour made from wholesome and *Fusariumnygamai* infected Yam Tubers.

Sample	Dry MC (%)	Ash (%)	Vit.C (mg/100)	Protein (%)	Total Sugar (%)	Starch (%)	Amylose (%)
Nwopoko(U)	11.30 ^a	1.32 ^b	41.10 ^a	5.05 ^a	5.34 ^a	78.71 ^c	29.95 ^b
Nwopoko(I)	10.60 ^b	1.30 ^b	27.26 ^d	4.60 ^b	5.20 ^b	77.61 ^d	28.87 ^c
TDr95/19177(U)	11.01 ^a	1.36 ^a	36.30 ^b	4.93 ^a	5.21 ^b	89.28 ^a	30.01 ^a
TDr95/19177(I)	10.61 ^b	1.24 ^c	30.53 ^c	4.62 ^b	5.02 ^b	81.53 ^b	27.95 ^d
LSD _{0.05}	0.368	0.028	0.690	0.028	0.193	0.009	0.009

Where U = Wholesome Yam Samples. I = *Fusarium* infected Yam Samples. Means with the same letter in each column are not significantly different ($p > 0.05$) from one another.

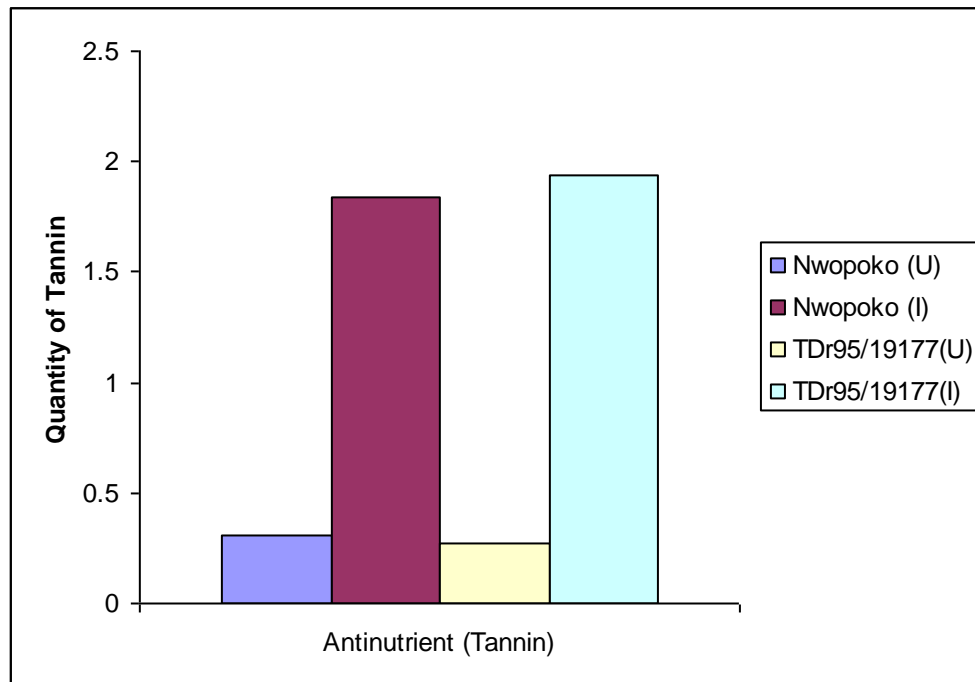


Figure 1: Tannin (mg/g) composition of wholesome and *Fusarium nygamai* infected Yam Tubers Where U= wholesome yam flour and I= *Fusarium* infected yam flour.

RECOMMENDATION AND CONCLUSION

Tannin composition increased significantly due to *Fusarium* infection.(Figure 1). This implies an increase in the antinutrient content. The tendency to produce *Elubo* (yam flour) used for preparation of *amala*-an ethnic food among the Yorubas (Western Nigeria) with rotten yam (possibly *Fusarium* infected) should be discouraged.

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