JASEM ISSN 1119-8362
All rights reserved

Full-text Available Online at
www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage. June, 2012
Vol. 16 (2) 189 - 193

Bio-deterioration of sweet potato (*ipomoea batatas* lam) in storage, inoculation-induced quality changes, and control by modified atmosphere

***OYEYIPO OLUTIMILEHIN OLAITAN**

Department of Microbiology, University of Port Harcourt, P. M. B. 5323, Port Harcourt, Nigeria

ABSTRACT: The biodeterioration of sweet potato (*Ipomoea batatas*) was investigated at Port Harcourt, south southern Nigeria. *Aspergillus niger*, *Fusarium oxysporum*, *Rhizopus stolonifer, Botryodiplodia theobroma* and *Penicillium* sp. were found to be associated with deteriorating sweet potato tubers and used for inoculation of fresh sweet potato samples. The four prevalent isolates (*Aspergillus niger, Fusarium oxysporum Botryodiplodia theobroma* and *Rhizopus stolonifer*) were each used to inoculate other sweet potato samples. Storage of samples in modified atmospheres and the effects of inoculation on quality changes were also evaluated. Modified atmospheres created by packing the samples inside a polythene bag of 18µm thickness significantly maintained the quality of the samples. Inoculation of samples with the four prevalent rot fungi significantly ($p = 0.05$) increased crude protein, lipid and ash content. In contrast, there was a significant decrease in carbohydrate and moisture content when compared with the controls. Modified atmosphere is therefore recommended for control of sweet potato rots and extension of storage life. @JASEM

Key words: sweet potato (*Ipomoea batatas*, post harvest rots; fungi; control; modified atmosphere

Sweet potato (*Ipomoea batatas* Lam) is the third most important root and tuber crop after cassava (*Manihot esculenta*) and yam (*Dioscorea rotundata*) within the sub-Saharan Africa (Ewell and Matuura, 1994). Sweet potato is a common root crop in Nigeria with enormous potential to be an efficient and economic source of food energy.

Compared with other roots and tubers, it contains the highest sugar and is near the top for other vitamins (Alvavez, 1996). The tubers and leaves can be consumed after boiling, mashing, roasting, baking or frying. The sweet potato tuber is rich in carbohydrate, lipid and low fibre content (Eka, 1979).

Post harvest rots of sweet potato have been substantially reported (Data *et al.,* 1987; Arinze, 1985; Onifade *et al.,* 2004). These rots are attributed to physical, physiological and microbiological factors. Mechanical damage during harvesting, storage or transportation has been implicated in tuber predisposition to storage rots or deterioration (Ogundana *et al.,* 1970; Snowdon, 1991). Pathogenic contamination through natural openings or wounds is considered the most critical factor in tuber decay (Degras, 1993; Udo *et al.,* 2000). The degree of pathogenicity varies and is largely dependent on storage conditions. Despite the present trend to discourage the use of chemical fungicides to control Post harvest diseases of produce, they are still extensively used in many developing countries (Ogundana, 1993; Champ *et al.,* 1994).

Until recently, only whole (i.e., uncut) sweet potato tubers without apparent wounds were retailed. May be, as a result of the difficult economic situation in developing nations, sweet potatoes are now halved (depending on the size of tubers), and packed in polyethylene bags for retail. However, the potential for storage rot associated with these practices has been given little attention and tubers showing various amounts of damage are now commonly retailed in the open market. Bruised or cut tubers readily become colonized by propagules of pathogens associated with the surface and those from adjacent infected tubers. A wide variety of microorganisms, particularly moulds, have been implicated in tuber spoilage, relatively few are implicated as primary pathogens (Data *et al.,* 1987; Onifade *et al.,* 2004; Arinze, 1985).

This study was therefore undertaken to investigate (i) the fungi associated with sweet potato rot, (ii) the pathogenicity of the fungal isolates, (iii) the influence of modified passive atmosphere storage on quality of inoculated sweet potato samples and (iv) biochemical changes induced by the prevalent rot fungi.

MATERIALS AND METHODS

*Sweet Potato Tubers***:** Sweet potato tubers (white variety) were obtained from the National Root Crops Research Institute, Umudike, Umuahia, Nigeria. Twenty tubers with lesions or rots and 66 healthy tubers were procured on two different occasions.

Fungal Evaluation of Rotting Potato Tubers: The method of Okafor (1966) was employed. The rot tissue was cut through with a sterile knife after surface-sterilization with 70% ethanol. Small portions of approximately 2mm diameter were cut from the rotting tissues using a flame-sterilized scalpel, and placed on potato dextrose agar (PDA, Difco). The plates (in duplicate) were then incubated at 27 ± 2^0C and examined for fungal growth every 2days for 6days.

Correspondence Email: mails4tim1@yahoo.com

Isolation and Identification of Fungi: Fungal colonies that developed on the plates were aseptically transferred onto PDA and incubated as above for 5-7 days. The colony morphology and pigmentation of the isolates were recorded before subculturing for purification and storage under refrigeration until required. Identification was by comparison with earlier descriptions (Barnett and Hunter, 1972; Samson *et al.,* 1984).

Pathogenicity Test: Healthy sweet potato tubers were surface-sterilized (70% ethanol, 2minutes) and cylindrical cores (5mm in length) removed with a sterile 5mm diameter cork borer. A 4mm disc cut from a 7-day-old culture of the test fungal isolate growing on PDA was introduced into the holes (4-5 holes per tuber depending on the size of the tuber) which were then sealed with sterile vaseline (Weerasinghe and Naqvi, 1985). Control samples were treated in the same manner except that uninoculated PDA was used. The treated samples and control were placed individually in sterile polyethylene bags and incubated at 27 ± 2^0C for 3weeks. At 1-week intervals, the samples were sectioned through the site of inoculation and examined for lesion development. Infected or decayed portions were aseptically transferred onto PDA to confirm that the infection was caused by the inoculants.

*Influence of Passive Modified Atmosphere Storage on Quality of Inoculated Sweet Potato Samples***:** Sweet potato samples (1.5cm height x 3cm diameters) were surface-sterilized (70% ethanol, 2minutes) and a 5mm deep wound made with a sterile 5mm diameter cork borer. Following inoculation with *Aspergillus niger, Fusarium oxysporum, Botryodiplodia theobroma* and *Rhizopus stolonifer* as described above, samples, except for controls, were packed aseptically in sterile polyethylene bags (9, 15 or 18 µm thick) and stored as indicated. Quality was evaluated by an 8-member panel familiar with quality of sweet potato using visual appearance and firmness; both quality attributes constituted overall quality. A 4-point scale (where 1 = extreme firmness, 2 = moderate firmness, 3 = typical (average) firmness and 4 = better than average firmness) was used to qualitatively assess (i.e., by application of pressure by finger) the firmness of the samples. Visual appearance of the samples was similarly evaluated: 1 = highly discoloured and unacceptable, 2 = moderately discoloured and marginally acceptable, 3 = typical (average colour) and acceptable and 4 = no discolouration and highly acceptable.

*Effects of Inoculation on Biochemical Changes of Sweet Potato Tubers***:** Various biochemical analyses (moisture content, lipid content, crude protein, ash content and carbohydrate content) in both fungal inoculated and uninoculated control experiments were determined following the procedures recommended by the Association of Official Analytical Chemists (A.O.A.C., 1980).

*Statistical Analysis***:** Data were subjected to analysis of variance and means separated using the least significant difference (LSD) method where significant difference between means of treatment at p= 0.05 were established (Steel and Torries, 1980).

RESULTS AND DISCUSSION

Fungi Associated with Sweet Potato Rots: Aspergillus niger, Fusarium oxysporum, Rhizopus stolonifer, Botryodiplodia theobroma and *Penicillium* sp. were isolated from sweet potato tubers showing rot. Colour, magnitude and texture of the symptoms varied with the organism. Comparable symptoms were observed following pathogenicity test but the symptoms became more pronounced with storage time.

Pathogenicity of the Isolates: Different sizes of rots were induced by the isolates (Table 1) with *Aspergillus niger* inducing the most extensive lesions followed by *Rhizopus stolonifer, Botryodiplodia theobroma, Fusarium oxysporum* and *Penicillum* sp. in that order (Table 1). On day 7, *Aspergillus niger,* and *Rhizopus stolonifer* significantly (p = 0.05) induced more extensive lesions (Table 1). On day 14, all the isolates significantly induced more extensive lesions but on day 21, no significant differences were observed in lesion/rot development. Generally, consistently greater lesions developed during the storage time.

Quality of Inoculated Sweet Potato Samples under Passive Modified Atmosphere Storage: Sweet potato samples inoculated and packed in polyethylene bags of different thickness showed lesions/rots of varying magnitudes (as reflected by sensory attributes; Table 2). All samples inoculated with the fungi and packed in polyethylene bags of 18µm thickness showed the highest scores (i.e., the best overall quality) control (unpacked) samples showed conspicuous discolouration and 'patchy' texture.

*Changes in Proximate Composition of Sweet Potato Inoculated with the Four Prevalent Rot Fungi***:** Inoculation of sweet potato tubers with pure cultures of *Aspergillus niger, Fusarium oxysporum,*

Botroydiplodia theobroma and *Rhizopus stolonifer* significantly (p = 0.05) increased crude protein, lipid and ash content of the tubers (Table 3). However, there was significant decrease in carbohydrate and moisture content (Table 3).

Table 1: Pathogenicity of Fungal Isolates Inoculated into Sweet Potato Samples

Inoculum	Storage Time (days)		
	7	14	21
Aspergillus niger	3.4a	4.0b	7.6a
Fusarium oxysporum	2.4a	2.1a	5.8b
Rhizopus stolonifer	3.0b	3.6b	7.4a
Botryodiplodia theobroma	2.8b	3.1a	5.6b
Penicillium sp.	2.1c	3.0d	5.1b
Overall	2.74a	3.16b	6.3a

Each value represents the mean from two independent experiments. Lesions (values) induced by each isolate in the same row (for each time interval) having different letters are significantly different at p= 0.05. Each value represents the overall means of lesions/rots induced by all the five isolated with storage time.

Table2: Influence of Passive Modified Atmosphere Storage on Quality of Inoculated Sweet Potato Samples

Inoculum	Thickness (µm) of packaging bag	Visual appearance	Firmness	Overall acceptability
Aspergillus niger	Control (unpacked)	1.2d	1.4a	1.3a
	9	2.3c	2.3b	2.3b
	15	2.0b	2.4b	2.2b
	18	3.0a	3.2c	3.1c
Fusarium oxysporum	Control (unpacked)	1.0b	1.0a	1.0a
	9	1.6b	1.3a	1.4a
	15	1.1b	2.0b	1.5a
	18	2.0a	2.6a	2.3b
Botryodiplodia theobroma	Control (unpacked)	10.b	1.0a	1.0a
	9	1.0b	1.6a	1.3a
	15	1.1b	2.1b	1.6a
	18	2.1c	2.4b	2.2c
Rhizopus stolonifer	Control (unpacked)	1.1a	1.1a	1.1a
	9	2.1c	1.9a	2.0b
	15	2.2c	2.4b	2.3b
	18	2.8c	3.0c	2.9b

The higher quality indices of firmness and visual appearance indicate better quality. Values in columns for each inoculum having different letters are significantly different at p = 0.05.

Table 3: Changes in Nutrient Composition of Sweet Potato Inoculated with the Four Prevalent Rot Fungi after 21days Incubation at 27 ± 2^0C

Fungi	Nutritional Composition				
	Moisture	Carbohydrate	Protein	Fat	Ash
Aspergillus niger	43.7a	39.0b	5.8c	5.9b	5.6b
Fusarium oxysporum	46.9b	37.5a	5.2c	5.3b	5.1b
Botryodiplodia theobroma	47.6b	36.6a	5.4c	5.1b	5.3b
Rhizopus stolonifer	45.1b	38.0c	5.7c	5.9b	5.3b
Control (uninoculated)	49.6c	41.2d	4.6a	2.2c	2.4c

Values in columns for each Nutrient for the respective moulds having different letters are significantly different at p = 0.05

The result of this study showed that *Aspergillus niger, Fusarium oxysporum, Botryodiplodia theobroma, Rhizopus stolonifer* and *Penicillium* sp. were found associated with sweet potato rots/lesions (Table 1). The high rainfall pattern, high humidity and the temperature of between 19 and 31^0C prevailing in the agroecology of southern Nigeria, favours the development of fungal diseases in field, market and in storage. The isolation of these pathogens confirms the studies of Data *et al.,* (1987) and Onifade *et al.,* (2004). Pathogenicity test revealed that four of the isolated fungi were highly pathogenic. *Aspergillus niger* and *Rhizopus stolonifer* induced the most extensive rots, *Botryodiplodia theobroma* and *Fusarium oxysporum* were moderately pathogenic while *Penicillium* sp was the least pathogenic. This suggests that, *Penicillium* sp. is not likely to be a pathogen of sweet potato but rather a contaminant.

Sweet potato tubers have very low respiratory rates, consequently, the benefits of the 18µm thick polyethylene bags may be attributed to low water vapour build-up with moderate oxygen and carbon dioxide permeability, since gas barrier properties increase with increase in density of packaging material (Hui, 1992), thereby creating a suitable equilibrium modified atmosphere within the packs. The conspicuous and exacerbated discoloration observed in control (unpacked) samples could be attributed to the effects of enhanced oxidative browning. The possible effect of high carbon dioxide and low oxygen levels in the packs is suppression of fungal growth, and this may have in part been responsible for the variations in the quality of the samples (Table 2).

Fungal infection has been reported to increase the protein content of sweet potato (Onifade *et al.,* 2004). The significant decrease in carbohydrate could result from the hydrolysis of complex carbohydrate to glucose which is then used as a source of carbon and energy for microbial growth. Extracted lipid from the inoculated tubers increased over the uninoculated tubers. Similar increases in lipid content of the pulp of sweet potato during the fermentation by *Aspergillus niger* and *Rhizopus stolonifer* was reported (Onifade *et al.,* 2004), and the increase may be partly attributed to biotransformation. Moisture reduction observed in this study must have been enhanced by the respiratory activities of both the sweet potato and the mould. Loss of moisture content in produce has previously been attributed to the difference in water vapour pressure within the commodity and the surrounding air (Kader 1992).

The incidence of post harvest sweet potato rots has been demonstrated to be influenced by a number of factors, therefore; modified atmosphere storage will go a long way to minimize storage rots, thereby enhancing storage life.

REFERENCES

A.O.A.C. 1980. Official Methods of Analysis, 13th ed. Association of Official Analytical Chemists, Washington, DC.

Alvarez, M.N. 1996. Sweet potato and the African Food Crisis, Tropical Root Crops. Proceedings of the 3rd Triennial Symposium of the International Society for Tropical Root Crops, Owerri. Pp. 66-69.

Arinze, A.E. 1985. The Action of Polygalacturonase and Cellulose Enzymes of *B. theobromae* on Yams and Sweet potatoes. Phytopathol. Zeit 144:234-242.

Barnett, H.L., B.B. Hunter 1972. Illustrated Genera of Imperfect Fungi, 3rd ed. Burgess, Minnesota.

Champ, B.R., E. Highley, G.I. Johnson 1994. Postharvest Handling of Tropical Fruits. Proceedings of the International Conference. Chiang, Mai, Thailand, 19-23 July 1994.

Data, E.S., J.C. Diamente, P.S. Eronico 1987. Postharvest Handling and Storability of Sweet potato Roots. International Sweet Potato Workshop. Visayas State College of Agriculture, Philippines. pp.19.

Degras, L. 1993. The Yam: A Tropical Root Crop, 1st ed. MacMillan, London.

Eka, O.O. 1979. Effect of Yeast Fermentation of Rice and Sweet potatos on their Nutritive Status. Nig. J. Sci.. 51:243-250.

Ewell, P.T., U. Matuura. 1994. Sweet Potato in the Food Systems of Eastern and Southern Africa. In: Tropical Root crops in a Developing Economy, Proceedings of the 19th Symposium of International Society for Tropical Root Crops. Accra pp. 531.

Hui, Y.H. 1992. Encyclopaedia of Food Science and Technology, Vol. 3. Wiley, New York.

Jay, J.M. 1992. Modern Food Microbiology, 4th ed. Van Nostrand, New York.

Kader, A.A. 1992. Post harvest Technology of Horticultural Crops, 2nd ed. Publication 3311. University of California, Division of Agricultural and Natural Resources, Oakland, CA.

Ogundana, S.K. 1993. Storage Rot of Yam Tubers in Nigeria. Adv. Yam Res. 2:124-134.

Ogundana, S.K., S.H.Z. Naqvi, J.A. Ekundayo. 1970. Fungi Associated with Soft Rot of Yams (*Discorea* sp.) in Storage in Nigeria. Braz. Mycol. Soc. 54: 445-451.

Onifade, A., H.N. Atum, T.T. Adebolu. 2004. Nutrition Enrichment of Sweet Potato (*Ipomoea batatas L*) by Solid Substrate fermentation using Four Fungal species. Global J. of Pure Appl. Sci. 10(60):31-36.

Samson, R.A., E.S. Hoekstra, C.A.N. Van Oorschot, 1984. Introduction to Food-borne Fungi. 2nd ed. Centraadlbureau voor Schimmelcultures, Baarn.

Snowdon, A.L. 1994. A Color Atlas of Post harvest Diseases and Disorders of Fruits and Vegetables, Vol. 2: Vegetables. Wolfe Scientific, Aylesbury, UK.

Steel, R.G.D., J.H. Torries. 1980. Principles and Procedures of Statistics. McGraw-Hill Book Company Inc. New York, USA.

Udo, S.E., B.E. Madunagu, C.D. Isemin. 2000. Inhibition of Growth and Sporulation of Fungal Pathogens on Sweet potato and Yam by Garlic Extract. Nig. J. Bot. 14:35-39.