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Effects of Simulated Rural Storage Conditions on the Quality of Plantain (*Musa paradisiaca*) Fruits

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Abstract: Mature, green, healthy, unbruised plantain fruits were completely separately covered with wood ash and sawdust in earthenware pots with cover. Some others were separately stored in wooden cabinets, desiccators or earthenware after inoculation with conidia of *Fusarium verticillioides*. All storage was at 25-26°C. The fruits were daily observed for rot development and peel colour change as indicator of ripening. Weight loss from fruits was determined at the end of storage. Fruits stored in wooden cabinets attained full yellow colour on 15 day, those in pots on 17 day and those in desiccators remained green throughout the storage period. Fruits covered with wood ash were still more green than yellow by 12 day while those under sawdust were at this same stage by 8 day. Disease development was slow throughout the storage period in wooden cabinets and for the first 19 days in earthenware pots, while there was no symptom of decay in desiccators. The green life of fruits was 13 days in pots and wooden cabinets while it was more than 24 days in desiccator. As fruits ripened, the carbohydrate content decreased while moisture content increased. Fruits covered with ash lost slightly more weight than those covered with sawdust. Weight loss was highest in wooden cabinets and lowest in desiccator.

Key words: Storage, plantain fruits, earthenware, ripening, *Fusarium verticillioides*, ash, sawdust

INTRODUCTION

Plantain is a staple food crop in the Southern parts of Nigeria and many countries in the tropic and subtropical regions of the world. In Nigeria, it ranks third after yams and cassava in order of importance in production. The crop however suffers serious storage problems after harvest when a large percentage may be lost due to mechanical injuries, over ripening and fungal wastage. Some of the fungi implicated in pathological disorders include *Thielaviopsis paradoxa*, *Colletotrichum musae*, *Fusarium roseum*, *Botryodiplodia theobromae*, *Fusarium verticillioides* (Alvindia *et al*., 2004; Nelson *et al*., 2006; Onyeke and Maduewesi, 2006). Usually, the fruits are harvested close to or at maturity but unripe in order to transport them to destination markets in firm, green conditions. They are sometimes degreened by local traditional methods which employ dark incubation in warm conditions, covering or submerging in wood ash or other plant residue materials, or exposure to heat of the sun for some hours prior to warm incubation. Plantain fruits sealed in polyethylene bags were also reported to have remained green for longer than those left on the open shelf (Ferris, 1997; Baiyeri, 2005).

Morrelli and Kader (2006) reported that at 7.2-10°C plantain fruits stored well without chilling injury for 7 days. Ferris (1998) noted that optimum storage temperature for plantain fruits is 13-14°C at which fully mature ripe or unripe fruits will store for 1 to 2 weeks. Plantains are however best

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stored at ambient temperatures because of the physiological problems reported for various fruits during low temperature storage (Dadzie and Orchard, 1997). Furthermore, low temperature storage is presently impracticable for commercial purposes in Nigeria because of the huge capital outlay required.

Wood ash has been reported to exhibit insecticidal and antifungal properties (Ofuya, 1986; Aborisade, 2003). Baiyeri (2001) also reported some success when plantain fruits were stored in sawdust with salt. Traditionally, earthenware pots have been used for storage of food items including oil, grains and vegetables. Unglazed earthenware is porous and is very suitable for products that need cooling (Lyimo *et al*., 1991; Shashidhar *et al*., 1992). This study seeks to determine the effect of some local storage containers and practices on storage life and quality of plantain fruits.

MATERIALS AND METHODS

Source and Preparation of Fruits

Bunches of mature green plantain fruits of the False Horn variety were harvested from a commercial farm in Ijare, Ondo State, Nigeria. The fruits were treated and stored within 24 h of harvest. Individual fruits were separated from the bunch while selection for maturity based on angular striations was done simultaneously.

Effect of Storage Containers on Green Life of Plantains

Mature green plantain fruits of were stored in pitchers (earthenware pots), wooden cabinets and desiccators all with covers. The desiccators provided airtight condition similar to polyethylene which has been reported to extend green life of fruits. All containers were sterilized prior to use. They were observed for changes in peel colour daily.

Effect of Surface Treatment on Fruits

Healthy, unbruised, mature fruits were completely covered with sawdust and wood ash separately up to 2 cm thick above the fruits inside pitchers. They were also daily observed for peel colour change and rated subjectively on a scale of 1 to 7 by a method adapted from banana ripening guide (Anonymous, 1972). By the scale, 1 = green; 2 = green with traces of yellow; 3 = more green than yellow; 4 = more yellow than green; 5 = full yellow; 6 = yellow lightly flecked with dark brown; 7 = yellow with more dark brown.

Inoculation, Storage and Assessment of Rot Severity

Individual plantain fingers were surface disinfected in 1.05% sodium hypochlorite solution. The cut stalk end was then dipped into the conidial suspension of *Fusarium verticillioides* for 5 sec with constant agitation of the suspension. Inoculated fruits were stored in earthenware pots and daily assessed for rot severity on a scale of 1 to 10. 1 = no evidence of infection; 2 = appearance of mycelia/discolouration at point of inoculation only; 3 = dark brown/black colouration on fruit stalk 4 = mould growth up to 2 cm on fruit with white mycelium; 5 = mould growth up to 2 cm with pinkish/peach mycelium; 6 = decay up to 2.5 cm but not > 5 cm; 7 = decay up to 5 cm but not > 7.0 cm; 8 = decay up to 7.0 cm but not $>^1/_3$ fruit length; 9 = decay more than $^1/_3$ length of fruit but not total; 10 = total decay. Fruits that showed decay beyond stage 6 were considered unfit for consumption.

Determination of Weight Changes During Storage

The fruits were weighed individually before and at the end of 30 days storage to determine weight changes in percentages.

Proximate Composition of Fruit Pulp at Different Stages of Ripening

Pulp samples were taken from the middle portion of fruits and analysed for moisture, ash, crude protein, crude fibre and fat content by standard analytical methods (AOAC, 1990). The carbohydrate content was obtained by difference.

Experimental Design

Completely randomized design was used for the experiments. Data obtained were subjected to analysis of variance and the means were compared by Fisher's Least Significant Difference (LSD) at p = 0.05.

RESULTS

The first indication of colour change was observed on the 5th day of storage both in wooden cabinets and earthenware pots. The fruits stored in wooden cabinets were the first to reach the full yellow stage of colour development. This occurred on the 15th day of storage. Those in earthenware pots ripened to the same stage on 17 day and those in desiccators remained green throughout the 24 day storage period. From 5 to 9 days, those in wooden cabinets remained at stage 2, but later developed yellow colour rapidly between the 10th and 15th days of storage. Fruits stored in pots showed a fairly constant rate of colour development over a thirteen day period from 5 day till 17 day but remained green or more green than yellow for the first ten days while those in wooden cabinets stayed at this same stage for the first 12 days (Table 1). Statistical analysis showed that there was significant difference in the observations made on fruits stored in pots and wooden cabinets and

Table 1: Disease severity of plantain fruit rot by *Fusarium verticillioides* and peel colour rating during storage in different containers

	Container type					
Storage time	D		W		E	
(days)	Disease severity	Colour rating	Disease severity	Colour rating	Disease severity	Colour rating
1	1.00±0.00^{a}	1.00±0.00*	1.00±0.00^{a}	1.00±0.00*	1.00±0.00^{a}	1.00±0.00*
2	1.00±0.00^{a}	1.00±0.00*	1.00±0.00^{a}	1.00±0.00*	1.00±0.00^{a}	1.00±0.00*
3	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	1.00±0.00*	1.00±0.00^{a}	1.00±0.00*
4	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	1.00±0.00*	1.75±0.25^{b}	1.00±0.00*
5	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	2.00±0.00**	1.75±0.25^{b}	1.50±0.50*
6	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	2.00±0.00**	1.75±0.25^{b}	1.75±0.75*
7	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	2.00±0.00*	1.75±0.25^{b}	2.75±0.75*
8	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	2.00±0.00*	1.75±0.25^{b}	2.75±0.75**
9	1.00±0.00^{a}	1.00±1.00*	2.00±0.00^{b}	2.00±0.00*	2.00±0.00^{b}	3.00±1.00**
10	1.00±0.00^{a}	1.00±0.00*	2.00±0.00^{b}	2.75±0.25*	3.00±0.00^{b}	3.00±0.00**
11	2.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	3.00±0.00*	3.00±0.00^{a}	3.25±1.25*
12	2.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	3.00±0.00*	3.00±0.00^{a}	3.50±1.19**
13	2.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	3.25±0.25**	3.75±0.25^{b}	3.75±1.18**
14	2.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	4.00±0.00**	3.75±0.25^{b}	4.00±1.22*
15	2.00±0.00^{a}	1.00±0.00*	2.00±0.00^{a}	5.00±0.00**	4.25±0.75^{b}	4.25±1.31*
16	2.00±0.00^{a}	1.00±0.00*	2.25±0.25^{a}	5.00±0.00**	4.50±0.50^{b}	4.75±1.03*
17	2.00±0.00^{a}	1.00±0.00*	2.50±0.50^{a}	5.00±0.00**	5.00±0.00^{b}	5.25±0.75*
18	2.25±0.25^{a}	1.00±0.00*	2.75±0.75^{a}	5.50±0.28**	5.00±0.00^{b}	6.00±0.57*
19	2.75±0.25^{b}	1.00±0.00*	3.25±0.94^{a}	6.00±0.00**	5.75±0.25^{b}	6.50±0.28*
20	2.75±0.25^{a}	1.00±0.00*	3.25±0.94^{a}	6.00±0.00**	6.00±0.00^{b}	7.00±0.00*
21	3.00±0.40^{a}	1.00±0.00*	3.50±1.19^{a}	6.50±0.28**	6.75±0.25^{b}	7.00±0.00*
22	3.25±0.47^{a}	1.00±0.00*	4.00±1.08^{a}	7.00±0.00**	6.75±0.25^{b}	7.00±0.00*
23	3.50±0.50^{a}	1.00±0.00*	5.50±1.19^{b}	7.00±0.00**	8.00±0.00^{c}	7.00±0.00*
24	3.75±0.62^{a}	1.00±0.00*	6.25±1.03^{b}	7.00±0.00**	8.00+0.00^{bc}	7.00±0.00*

Values are means of four replicates±standard error of the mean. D = Desiccator (25±2°C, 95-98% r.h). E = Earthenware pot (25±2°C, 85-98% r.h); W = Wooden cabinet (26±2°C, 75-90% r.h); D = Desiccator (25±2°C, 95-98% r.h). Values followed by different letter(s) or number of in alternate columns across rows are significantly different, *: p<0.05, **: p<0.01 by Least Significant Difference (LSD) for disease severity and colour rating, respectively

Table 2: Peel colour ratings of plantain fruits stored in earthenware pots at 26°C

Storage time (days)	Treatments		
	Open fruits	Sawdust cover	Wood ash cover
1	1.00±0.00[a]	1.00±0.00[a]	1.00±0.00[a]
5	1.25±0.25[a]	1.75±0.25[a]	2.00±0.00[b]
8	2.75±0.75[a]	3.25±0.75[a]	2.00±0.00[a]
12	3.50±1.19[a]	4.75±0.94[a]	3.25±0.25[a]
17	5.25±0.75[a]	6.00±1.00[a]	6.25±0.47[a]

Values are means of four replicates±Standard error of the mean. Values followed by different letter(s) across rows are significantly different at significance level by Least Significant Difference (LSD). Temperature range 25-26°C; Relative humidity 85-98%

Table 3: Weight loss from plantain fruits stored at ambient conditions for thirty days

Container/treatment	Weight loss (%)
Desiccator	0.33
Wooden cabinets	26.76
Earthenware pots	19.04
Fruits under sawdust	16.41
Fruits under wood ash	18.53

Table 4: Proximate composition of stored plantain fruits at different stages of ripening

Ripening stage	Ash	Moisture	Protein	Crude fibre (g/100 g fresh weight)	Total carbohydrate	Fat
1 Green	1.0	55.82	1.51	0.34	41.33	0.80
2 Trace yellow	1.0	58.20	1.50	0.34	41.06	0.80
3 More green	1.05	59.60	1.50	0.34	37.46	0.77
4 More yellow	1.08	60.31	1.70	0.38	36.53	0.76
5 Full yellow	1.12	66.71	1.80	0.70	29.67	0.78
6 Yellow brown	1.13	68.14	1.60	0.80	29.33	0.73
7 More brown	1.13	71.14	1.60	0.80	26.14	0.71

between those in cabinets and those in desiccators on 5 day of storage. There was still a difference between fruits in cabinets and those in desiccators on 6 day. From 13 day, there was significant difference between the fruits in desiccators and those in the other two containers (Table 1).

Inoculated fruits stored in the three types of containers had those in pot decaying fastest while those in desiccators were the slowest. Decay of between 5.0 and 7.0 cm fruit length was observed on fruits in earthenware while those in wooden cabinets and desiccators had means of 6.25 and 3.75, respectively on day 24 of storage. There was however very little rot (almost insignificant) by day 12 among fruits in pots with mean rot severity of 3.0. For those in cabinet and desiccator, rot did not progress beyond stage 2.0 till days 15 and 17, respectively (Table 1). Statistical analysis showed significant difference between fruits in desiccator and those in the pot throughout the storage period and between pot and cabinet from day 13 to 23. Results for days 9 to 12 were not statistically significant for all containers. There was significant difference in results for cabinet and desiccator only on 4, 5 and 24 days.

Fruits covered with sawdust were close to the full yellow colour by day 11 with mean colour rating of 4.75 while those covered with wood ash reached the same stage on day 14 and those without any of these two materials did so on day 16. By the 16th day, fruits with sawdust and wood ash were already overripe. Fruits covered with sawdust ripened fastest (Table 2). Statistically however, there was significant difference only on day 5 between wood ash and sawdust treatments.

All the fruits lost weight during storage. Fruits stored in cabinets lost 26.76% of their initial weight while those in desiccator lost only 0.33%. Weight loss in fruits kept in earthenware pots was 19.045%. Covering fruits with ash resulted into a slightly higher weight loss of 18.53% than with sawdust which lost 16.41% at the same relative humidity of 85-100% (Table 3).

The ash, protein and fat contents varied little with progression of ripening. Moisture and crude fibre contents increased while total carbohydrate content decreased (Table 4).

DISCUSSION

The prolonged green life and insignificant weight loss observed in fruits in desiccator show that airtight storage kept plantain fruits longest under ambient conditions. This confirms earlier reports that plantain and bananas sealed in polyethylene bags remained green for longer period than fruits that received some ventilation (Ferris, 1997; Narayana *et al*., 2004). The present observation in which fruits in pots and wooden cabinets did not ripen beyond the more-green-than yellow (stage 3) by day 13 show that the containers may potentially be useful especially where airtight packaging and refrigerated storage are impracticable. Covering fruits with ash also seemed to slow down ripening by about four days compared with sawdust. Sawdust covered fruits reached stage 3 on day 8 of storage while ash covered fruits did the same on day 12. The wood ash being of smaller particle size probably efficiently covered the stomata thereby preventing the release of endogenous ethylene to the atmosphere around the fruits creating a stable microenvironment which was deficient in ethylene. This slowed down ripening more than sawdust in which there was quicker diffusion of ethylene to the surrounding environment around the fruits surface. This observation compares favourably with another reported by Dadzie (1998). He reported that plantain harvested 100 days after floral emergence (shooting) had a green life of 7 to 11 days at 27±1°C while those harvested 114 to 117 days after shooting had green life of 17 to 25 days at 14±1°C. Covering fruits with ash also resulted into more weight loss when compared with sawdust.

The observation of an initially slow rot development process for the first two weeks and longer for earthenware and wooden cabinet stored fruits respectively, support the earlier stated fact that they might still serve as useful containers for storage of even already infected fruits. Disease progression in the same containers was kept below the critical stage of 6 for 19 and 23 days, respectively. Using these containers may in addition provide an economic advantage with no need to cool and or maintain low temperature for storage although unacceptable high weight loss occurred in fruits stored in wooden cabinets. The weight loss was likely to be from the peel.

Both *in vitro* and *in vivo* studies have revealed that wood ash and ash from other plant materials have antifungal action on moulds including species of *Fusarium* (Asare-Bediako *et al*., 2007; Amusa *et al*., 2003), although there is as yet no report of their effects on *Fusarium verticillioides* used in this study. This implies that ash may be useful for disease control especially when infected fruits with little or no symptom to show at the time of harvest are stored.

The increase in moisture, crude fibre and sugar contents observed as ripening progressed in this study is consistent with earlier reports on proximate composition of ripening fruits including plantain (Onwuka and Onwuka, 2005).

The rural storage conditions presently reported show that plantain fruits can have green life up to thirteen days at ambient temperature. The presently observed length of preservation is close to the 14 days reported for plantain even at 13-14°C (Ferris, 1998). Future studies should attempt to optimize the reported advantages of these local materials in solving some of the storage problems of plantain, a climacteric fruit.

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REFERENCES

Aborisade, A.T., 2003. Preliminary studies on the effect of sodium hypochlorite and wood ash on *Rhizopus stolonifer* and *Aspergillus niger*. Nig. J. Exp. Applied Biol., 4: 197-201.

Alvindia, D.G., T. Kobayashi, K.T. Natsuaki and S. Tanda, 2004. Inhibitory influence of inorganic salts on banana postharvest pathogens and preliminary application to control crown rot. J. General Plant Pathol., 70: 61-65.

Amusa, N.A., A.A. Adegbite, S. Muhammed and R.A. Baiyewu, 2003. Yam diseases and its management in Nigeria. Mini review. Afr. J. Biotechnol., 2: 497-502.

Anonymous, 1972. Banana Ripening Guide. Division of Food Research Circular 8 1972. Melbourne, Australia.

AOAC, 1990. Official Methods of Analysis. 15th Edn., The Association of Official Analytical Chemists Washington DC., USA., pp: 272-280.

Asare-Bediako, E., F.A. Showemimo, Y. Opoku-Asiama and D.H.A.K. Amewowor, 2007. *In vitro* analysis of growth media and the control of yam minisett-rot. Biotechnology, 6: 40-44.

Baiyeri, K.P., 2001. Effects of Storage Media on the green life span and culinary quality of plantain *Musa* sp. AAB fruits. Agro-Science, 2: 19-25.

Baiyeri, K.P., 2005. Variable light transmission through four polyethylene colours used for plantain *Musa* sp. AAB fruits storage as influencing its postharvest and culinary qualities. Int. Agrophy., 19: 19-25.

Dadzie, B.K. and J.E. Orchard, 1997. Physiological Disorders. In: Routine Post-Harvest Screening of Banana/Plantain Hybrids: Criteria and Methods. INIBAP Technical Guidelines 2: Biodiversity Int., pp: 75.

Dadzie, B.K., 1998. Post-harvest characteristics of black Sigatoka resistant banana, cooking banana and plantain hybrids. INIBAP Technical Guidelines, 4, pp: 74.

Ferris, R.S.B., 1997. Improving Storage life of plantain and banana. IITA Research Guide 62. Training Materials Unit. IITA.

Ferris, R.S.B., 1998. Factors affecting ripening. In: Postharvest physiology of plantain and banana. IITA Research Guide 64. Training Materials Unit. IITA.

Lyimo, M.H., S. Nyagwegwe and A.P. Makeni, 1991. Investigations on the effect of traditional food processing, preservation and storage methods on vegetable nutrients: A case study in Tanzania. Plant Foods for Hum. Nutr. (Formerly Qualitas Plantarum), 41: 53-57.

Morrelli, K.L. and A.A. Kader, 2006. Plantain Banana. Recommendations for Maintaining Postharvest Quality. Postharvest Technology Research and Information Center. University of California, Davis. http//postharvest.ucdavis.edu/produce /producefacts/fruit/plantain.shtml.

Narayana, C.K., P. Krishnan and S. Sathiamoorthy, 2004. Effect of bunch covering and postharvest treatment on quality of banana during storage at low temperature. In: Postharvest processing for the diversification of income. International Congress on *Musa*: Harnessing Research to Improve Livelihood. Session, 4: pp: 246.

Nelson, S.C., R.C. Ploetz and A.K. Kepler, 2006. *Musa* species (Banana and Plantain). Musaceae (banana family). In: Species Profiles for Pacific Island Agroforestry, pp: 15. Pacific: http//www.traditionaltree.org/extension.html.

Ofuya, T.I., 1986. Use of wood ash, dry chilli pepper fruits and onion scale leaves for reducing *Callosobruchus maculatus* (Fabricus) damage in cowpea seeds during storage. J. Agric. Sci. (Cambridge), 107: 467-468.

Onwuka, G.I. and N.D. Onwuka, 2005. The effects of ripening on the functional properties of plantain and plantain based cake. Int. J. Food Properties, 8: 347-353.

Onyeke, C.C. and J.N.C. Maduewesi, 2006. Evaluation of some plant extracts for the control of post-harvest fungal diseases of banana (*Musa sapientum* Linn.) fruit in South-Eastern Nigeria. Nig. J. Bot., 19: 129-137.

Shashidhar, R.B., Y. Ramakrishnay and R.V. Bhat, 1992. Moulds and mycotoxins in sorghum stored in traditional containers in India. J. Stored Prod. Res., 28: 257-260.