Middle-East Journal of Scientific Research 7 (5): 741-745, 2011
ISSN 1990-9233

Bioburden of Garri Stored in Different Packaging Materials under Tropical Market Conditions

Ogugbue, Chimezie Jason and Obi Gloria

Department of Microbiology, Faculty of Science,
University of Port Harcourt PMB 5323, Choba, 500004, Port Harcourt, Nigeria

Abstract: The bioburden of garri preserved for 60 days under market conditions in different retail packaging materials (gunny sack, HDPE bag, LDPE bag, plastic container) was investigated. The total culturable heterotrophic bacterial and total fungal counts of the stored garri samples were enumerated using appropriate media. The control consisted of garri openly displayed in basins. Results obtained showed that generally, there was a gradual increase in microbial counts of the stored product in all packages and in the exposed product albeit to varying degrees. Increase in mean bacterial counts in the exposed product was from 3.00±0.4 x 10^3 to 1.32±0.25 x 10^6 $CFUg^{-1}$ while mean bacterial counts in packaged product increased from 2.93±0.08 x 10^3 to 5.50±0.3 x $10^3 CFUg^{-1}$. Increase in mean fungal counts was from nil to 5.50±0.3 x $10^5 CFUg^{-1}$ in exposed samples and from nil to 9.50±0.2 x 10^2 $CFUg^{-1}$ in packaged samples. Increase in moisture content of product was higher in the exposed samples than in the packaged samples. Amongst the different packages used, HDPE bags was adjudged the best for garri retailing in markets since it showed the best microbial stability in stored product and minimal increase in moisture content of product. In conclusion, Rresults highlighted the need for proper packaging of garri for distribution in Nigerian markets in order to ensure food safety and consumer satisfaction.

Key words: Garri · Bacteria · Fungi · Safety · Packaging · Storage

INTRODUCTION

Garri is a gritty, starchy staple food with high energy content which is derived from cassava (*Manihot esculenta* Crantz) [1]. It constitutes a daily meal to some 150 million people world wide and is a popular West African food. It is a convenient product because it is stored and marketed in a ready-to-eat form; and can be processed minimally using hot water to make a dough-like meal called 'Eba' or 'Gari' and eaten with any of the African vegetable soups [2]. It can also be consumed directly (without cooking) with groundnut, smoked fish, coconut, cooked cowpeas, moimoi, or taken as a fast food when soaked in cold water.

Garri is rich in starch, has a high fibre content and contains some essential vitamins [3-5]. Its high fibre content makes it very filling and helps in the prevention or at least in reducing the likelihood of constipation and bowel diseases.

In Nigeria, the processing of cassava into garri is associated with practices such as drying on the floor mat or basins after frying, display in open buckets, bowls and mats at points of sale and the use of bare hands during handling and sales. These unhygienic practices may lead to microbial contamination due to deposition of bioaerosols on exposed products, transfer of microbes from dirty hands and utensils and frequent visits by animals and fomites which may carry infectious agents.

Previous reports have shown that moulds (such as *Aspergillus, Penicillium, Rhizopus, Cladosporium and Mucor*), insects and mites are usually associated with garri during storage [6-8] which enhances biodeterioration of the product. Previous studies investigated the effect of hygienic handling practices and the use of sodium benzoate treatment on the shelf stability of garri during storage [9] under tropical conditions. But, considering the open nature of markets in Nigeria, the mode of display of food items, the unwholesome environment in which some of the food products are sold and the need to maintain a constant supply of this product in the markets to cater for the demands of a teeming population, it has become pertinent to evaluate a suitable method for the distribution of garri to ultimate consumers.

Corresponding Author: Chimezie Jason, Department of Microbiology, Faculty of Science, University of Port Harcourt, P.M.B. 5323, Choba, 500004, Port Harcourt, Nigeria, Tel: +60194016194, +2348037704618, E-mail: ceejay55us@yahoo.com / cj.ogugbue@uniport.edu.ng.

In this study, we presented a report on the effect of different ready-for-sale packaging materials on the microbiological quality of post-processed garri. Results of this study will help develop regulations for the distribution of garri in markets in order to ensure their microbial safety.

MATERIALS AND METHODS

Source of Garri: Processed garri was obtained from local producers in Port Harcourt, Nigeria. The samples were collected immediately after frying and cooling on well-cleaned surfaces. During collection and cooling, the samples were aseptically handled.

Packaging: Samples (5kg) of the processed garri were aseptically weighed into sterile gunny bags, high density polyethylene (HDPE) thermoplastic bags, low density polyethylene (LDPE) thermoplastic bags and thermoset plastic containers (TPC) and subsequently sealed. The thermoplastic bags were hermetically sealed with a mechanical sealing machine (Buyor, Japan). The various packs were kept under market sheds in Choba, Port Harcourt at ambient temperature (28±2°C) for 60 days. Control, consisting of freshly processed garri kept in sterile basins and exposed to air, was also set up. The control was set up to mimic the mode of display of this product during sale and distribution in Nigerian markets. Following incubation, representative sample packs and control samples (500g) were withdrawn intermittently from the market and transported to the laboratory for microbiological analysis.

Microbiological Analyses: Enumeration of microbial counts in garri samples was carried out using the surface-spread plate method. Ten grams of freshly processed or packed market samples were added to 90ml of 0.1% (w/v) sterile peptone water in a sterile 500ml beaker and allowed to stand with occasional stirring [9]. Subsequently, serial 10-fold dilutions of samples were prepared and 0.1ml aliquots were spread plated on plate count agar (Biotec) for total culturable heterotrophic bacterial (TCHB) count and on potato dextrose agar (Biotec) for total fungal (TF) counts. Plates were incubated for 24h at 35°C for bacteriological counts and for 3-5days at 25°C for fungal counts. Counts were expressed as colony-forming units per gram of sample.

Characterization and identification of the isolated bacteria were carried out based on their colonial, morphological and biochemical characteristics with reference to the Bergey's manual of systematic bacteriology [10]. The fungal isolates were identified according to the protocol of Samson and Reenen-Hoekstra [11] which was based on microscopic examination of their conidial heads, philiades, conidiophores and presence or absence of rhizoids.

Determination of Ph and Moisture Content: The pH of the garri samples was determined according to the method described by Ogiehor and Ikenebomeh [9]. Ten grams of each sample were homogenized in 10 ml of sterile distilled water and the pH of the suspension determined using a reference glass electrode pH meter (Mettler Delta 340, Mettler-Toledo Ltd. UK). The moisture content of the samples was determined by drying the samples in an oven at 105°C until a constant weight was obtained [12].

Statistical Analysis: Data obtained were subjected to statistical analysis to determine means and standard deviations of means. Significant differences between means of experiments were determined by analysis of variance (ANOVA). A significance level of 0.05 was chosen.

RESULTS

The changes in microbiological profile of the garri samples exposed to air and stored in different packaging materials under tropical market conditions are as presented in figs. 1 & 2. Generally, results obtained show that there was a steady increase in TCHB counts and TF counts in all samples throughout the keeping period albeit at different rates The most significant increase in microbial counts was obtained in garri samples (control) kept in basins exposed to air with counts increasing by more than a hundred fold within 60 days (Figs.1 & 2). TCHB counts of the control samples increased from $1.0x10^3$ CFU/g on the first day to $1.32x10^6$ CFU/g by the 60^{th} day of incubation, while increase in TF count was from nil to $5.5x10^5$ CFU/g by end of the experiment. Samples kept in the different packages showed a slow increase (<10 fold progression) in microbial counts with the least microbial proliferation rate (1.04 fold progression) recorded for garri samples in HDPE bags. The increase in microbial counts in the different packages was in the order: Gunny bag > TPC> LDPE >HDPE. The rate of increase in bacterial counts during the keeping period was higher than that obtained for fungal counts in exposed basins and packed samples.

Eight bacterial genera (*Bacillus* spp. *Staphylococcus* spp. *Pseudomonas* spp. *Salmonella* spp. *Escherichia* spp. *Micrococcus* spp. *Acinetobacte*r spp. and *Achromobacter* spp.) were isolated from the garri samples while the fungal genera isolated were: *Aspergillus* spp.;

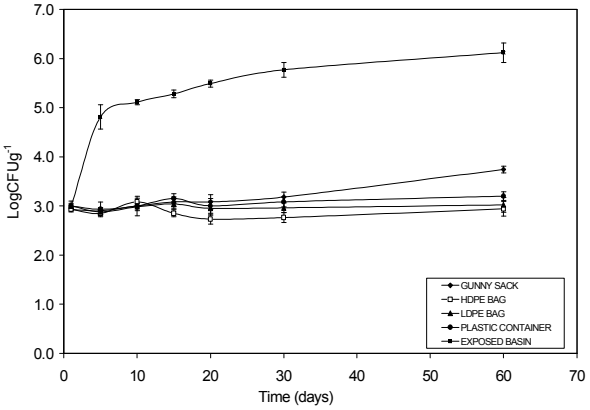

Fig. 1: Changes in total culturable heterotrophic bacterial counts of garri stored in different packaging materials during the study period. Values are means of duplicate determinations

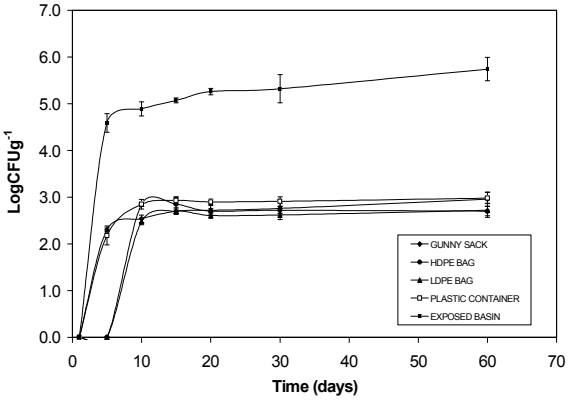

Fig. 2: Changes in total fungal counts of garri stored in different packaging materials during the study period. Values are means of duplicate determinations

Geotrichum spp. *Penicillium* spp. *Rhodotorula* spp. *Fusarium* spp. *Mucor* spp. and *Cephalosporium* spp. Only about 27% of the isolated genera (*Bacillus* spp. *Aspergillus* spp. *Geotrichum* spp. *Penicillium* spp.) were obtained from samples in all packages including the control samples. The rest of the bacterial and fungal genera were isolated from the control samples openly displayed in the market stalls during the period of study. The moisture content of samples also increased gradually in all packed samples albeit at varying rates (Fig. 3) with openly displayed samples showing the most increase from 10.52% after processing to 18.70% by the end of the study. Generally, a slight decrease in pH was obtained in all samples with the openly displayed samples showing the greatest variation followed by the samples in the gunny bags (data not shown).

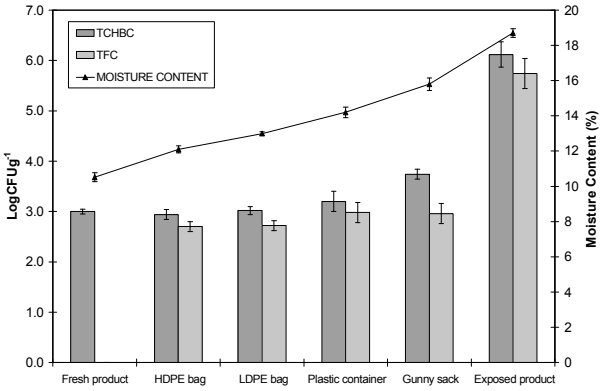

Fig. 3: Changes in moisture content and microbial counts of garri stored in different packaging materials at the end of the 60 day study period. Values are means of duplicate determinations

DISCUSSION

The gradual increase in bacterial and fungal counts (Figs. 1 & 2) obtained during the period of study in the openly displayed garri and packaged samples may be attributed to the survival of spores and resuscitation of cells injured during processing (frying), contamination by bioaerosols from the ambient environment and the ability of these microbes to proliferate in the nutrient-rich microenvironment provided by the garri. Nonetheless, the packaging materials used in this study were able to reduce the magnitude of increase in microbial counts during the keeping period albeit at varying degrees. Comparing the bacteriological counts of garri samples in the exposed basins with the ones obtained for samples preserved in HDPE bags, LDPE bags, TPCs and the gunner bags, differences in log cycles of 3.18, 3.10, 2.92 and 2.38 respectively were observed after a 60 day keeping period, indicating a more rapid microbial proliferation in exposed samples. HDPE bagged samples gave the least microbial counts during the keeping period (Fig. 3). The magnitude of microbial proliferation in the exposed product when compared with samples stored in packaging materials suggests that higher counts obtained in the exposed samples may be due to the deposition of bioaerosols, dust and microbial spores on the samples from the ambient market environment. Visits by flies and insects during the period of study may also be responsible. This observation highlights the risk involved in the open display of garri during sale in markets as is widely practiced in Nigerian markets and demonstrates the need for proper packaging to be adopted as a retailing strategy for garri distribution. The packaging of this product will help safeguard

the health and wellbeing of its teeming consumers in sub-saharan Africa. Unhygienic handling as a reason for the increase obtained was ruled out in this instance since the samples were not tampered with during the period of study. The variation in the magnitude of proliferation in samples obtained from different packaging materials may be due to their relative permeability to oxygen, carbon dioxide and water vapour. Previous reports [7, 13, 14] have all suggested permeability characteristics and oxygen transfer rate (OTR) as factors responsible for differences obtained in microbial count progression in packaged materials. The relatively lower microbial counts obtained in samples kept in HDPE and LDPE bags and the TPCs may be attributed to the capability of these packaging materials to shield the microenvironment within them from the influence of the ambient environment. The presence of pores on gunner bags, however, may have been responsible for the relatively higher counts obtained in samples stored in them. Garri, being hygroscopic, may have absorbed gases and moisture from the surrounding environment through the pores in the gunner bags due to its high breathability which may have encouraged microbial proliferation. The foregoing is accentuated by the data obtained on moisture content of the garri samples in the different packs (Fig. 3). The product in the gunner bags showed the highest increase in moisture content amongst products stored in packaging materials which may have slightly increased rate of microbial proliferation. A moisture content of 18.70% was obtained for the exposed garri samples by the end of the study and this was considered much higher than the "safe" level of 12.7-13.6% [15]. These results show that the HDPE bags were suitable at ensuring the microbial safety of garri during storage and marketing, though the other packages also showed acceptable levels.

Eight different bacterial genera (*Bacillus* spp. *Staphylococcus* spp. *Pseudomonas* spp. *Salmonella* spp. *Escherichia* spp. *Micrococcus* spp. *Acinetobacte*r spp. and *Achromobacter* spp.) and seven fungal genera (*Aspergillus* spp.; *Geotrichum* spp.; *Penicillium* spp.; *Rhodotorula* spp.; *Fusarium* spp.; *Mucor* spp. and *Cephalosporium* spp.) were isolated from packaged and exposed garri samples in this study. Previous authors have reported the isolation of some of these bacterial and fungal genera from stored garri in their study [2, 7, 8]. The higher number of fungal species isolated from the packed samples compared to the isolated bacterial species may be due to the ability of the spores of these fungi to resist the frying stage during garri processing. Apart from the spore-forming *Bacillus* spp. which was predominant in the packed samples, the other isolated bacterial genera (which are Gram negative, non spore-formers) were only predominant in the exposed garri sample which suggests that they may have been introduced into the samples through aerial contamination. The low pH and low moisture content of the garri samples which are tolerable for fungal growth but unfavorable for bacterial growth may have contributed to the high rate of occurrence and distribution of fungi compared to bacterial species in the packed samples. Previous researchers [2, 16] collaborate this finding. The gradual decrease in pH obtained in all samples during the study might be attributed to the production of acidic metabolites by microorganisms during growth and proliferation.

In conclusion, the present study has revealed the effect of different packaging materials on the bioburden of garri stored under ambient conditions in the market. These results highlight the need to deviate from the normal mode of retailing of garri in markets and adopt the use of packages for distribution of garri to consumers. Packaging is needed, especially in the tropics where humidity is high, in order to retain the low moisture content of the product, prolong its shelf life, increase product popularity and acceptability and ensure food safety for millions of garri consumers.

ACKNOWLEDGEMENT

The authors wish to thank Prof. N. A. Oranusi for technical assistance and the laboratory crew of Department of Microbiology, University of Port Harcourt for their support.

REFERENCES

1. Ernesto, M., A.P. Cardoso, J. Cliff and J.H. Bradbury, 2000. Cyanogens in cassava flour and roots and urinary thiocyanate concentration in Mozambique. J. Food Composition and Analysis, 13: 1-12 .
2. Ogiehor, I.S., M.J. Ikenebomeh and A.O. Ekundayo, 2007. The bioload and aflatoxin content of market garri from some selected states in southern Nigeria: public health significance. African Health Sci., 7(4): 223-227.
3. Adepoju, O.T., Y.G. Adekola, S.O. Mustapha and S.I. Ogunola, 2010. Effect of processing methods on nutrient retention and contribution of cassava *(Manihot* spp.) to nutrient intake of Nigerian consumers. African J. Food Agriculture and Nutritional Develop., 10(2): 2099-2111.

4. Oboh, G., A.A. Akindahunsi and A.A. Oshodi, 2002. Nutrient and anti-nutrient contents of *Aspergillus niger*-fermented cassava products (Flour and Gari). J. Food Composition and Analysis, 15: 617-622.
5. Okwu, D.E. and A.N. Awurum, 2001. Effects of fertilizer application on the chemical composition of cassava tubers and their garri product. J. Applied Chemistry and Agricultural Res., 7:112-119.
6. Adeniyi, O. 1976. Fungi associated with deterioration of garri. Nigerian J. Plant Protection, 2: 74-77.
7. Amadi, J.E. and M.O. Adebola, 2008. Effect of moisture content and storage conditions on the storability of garri. African J. Biotechnol., 7(24): 4591-4594.
8. Osho, A., O.O. Mabekoje and O.O. Bello, 2010. Comparative study on the microbial load of Gari, Eluboisu and Iru in Nigeria. African J. Food Sci., 4(10): 646-649.
9. Ogiehor, I.S. and M.J. Ikenebomeh, 2005. Extension of shelf life of garri by hygienic handling and sodium benzoate treatment. African J. Biotechnol., 4(7): 744-748.
10. Holt, J.G., N.R. Krieg, P.H.A. Sneath, J.T. Staley and S.T. Williams, 1994. Bergey's Manual of Determinative Bacteriology, 9th edn. Lippincott Williams and Wilkins, Baltimore, M.D.,
11. Samson, R.A. and E.S. van Reenen-Hoekstra, 1988. Introduction to foodborne fungi, 2nd Edn. Central bureau voor schimmel cultures, Baarn.
12. AOAC, 1990. Official methods of analyses of association of analytical chemist (15th ed.). Washington DC: AOAC.,
13. Efiuvwevwere, B.J.O. and G.U. Uwanogho, 1990. Effects of packaging materials following ethanol and benonyl treatments on chemical and microbiological changes in tomatoes (*Lycophersicon esculentum)* fruits. J. Science Food and Agric., 52: 393-402.
14. Paine, F.A., 1992. Studies on the safety of water stored in high density polyethylene water bottles. J. Food Technol., 30(4): 256-263.
15. Halliday, D.J., A.H. Quareshi and J.A. Broadbent, 1967. Investigations on the storage of garri. Rep. Niger. Stored Prod. Res. Inst. Tech. Rep., 16: 131-141.
16. Ibeh, I.N., N. Uriah and J.I. Ogonor, 1991. Dietary exposure to aflatoxin in Benin city, Nigeria: a possible public health concern. International J. Food Microbiol., 14: 171-174.