

Full Length Research Paper

Effect of moisture content and storage conditions on the storability of garri

J. E. Amadi* and M. O. Adebola

Department of Plant Biology, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria.

Accepted 24 October, 2008

Yellow and white garri samples obtained from different markets in Ilorin were stored under the same conditions using polyethylene bags, jute bags and plastic containers. The moisture contents of the yellow and white samples were 17.8 and 17.2%, respectively. Results showed that moisture content in storage increased with time in the two samples. Mouldiness was also observed in the stored samples. Six mould species isolated were *Aspergillus niger*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus glaucus*, *Penicillium* sp. and *Rhizopus* sp. *A. fumigatus*, *A. glaucus*, *Penicillium* sp. and *Rhizopus* sp. were more abundant with increasing moisture content. Air-tight polyethylene and plastic containers preserved garri better than jute bags. Nutrient components and physical properties of garri also depreciated in samples stored in jute bags. Biochemical analysis revealed that starch, sugar, proteins and lipids were greatly reduced with time and increasing moisture content. Market survey in this study showed that garri samples sold in Ilorin generally have high moisture contents.

Key words: Storage, fungi, moisture content.

INTRODUCTION

Garri is a staple food prepared from the roots of cassava (*Manihot esculenta* Crantz). The process of preparation involves grating and fermentation of the tubers. The fermented pulp is subsequently fried at high temperatures during which any associated microorganisms would have been killed (Akinrele et al., 1962; Halliday et al., 1967; Adeniji, 1976). However, during storage fungal moulds may infest garri and cause spoilage. The development of mould leads to great modification in the chemical composition of infected stored produce. One of the most significant changes is an increase in free fatty acids (FFA) and reducing sugars as well as a loss in protein content. Akano et al. (1986) had reported that all the food contents of garri diminished following infection.

Certain mould species have been isolated from garri samples under different storage and marketing conditions (Adeniji, 1976). The most important single factor encouraging mould contamination of garri is an initial high moisture content or increase in moisture content during storage. Halliday et al. (1967) had reported that garri on sale at certain times of the year had moisture contents

much higher than the 'safe' level of 12.7 - 13.6%. According to their report, mould deterioration of garri with high moisture content is much higher when stored under air-tight condition. The primary cause of fungal deterioration of stored products is moisture because of its importance for microbiological activity.

According to Mill (1992), the relative humidity (RH) of the air within and around any commodity is the controlling factor of its biological deterioration. Seventy percent (70%) RH is regarded as a 'safe' limit and commodities with moisture contents in equilibrium with relative humidity of 70% are relatively safe from microbial deterioration. Most products are hygroscopic and so will exchange moisture with the atmosphere of storage until equilibrium is reached (Anon, 1965). Consequently, dry produce will gain moisture if stored in an atmosphere of high humidity. Therefore, the relative humidity of storage is essential.

An occasional check is necessary on the moisture content of produce stored in atmospheres with fluctuating relative humidities. It is also possible for produce stored in bags to absorb moisture through the floor if placed directly on the floor (Best, 1978). A high moisture level in garri can be influenced by the cassava cultivar. This gives garri a dull appearance and poor keeping quality (Ekandem, 1965). Oyeniran (1980) and Akano et al. (1986)

*Corresponding author. E-mail: jamadi2007@yahoo.com.

Table 1. Mean weekly moisture contents of garri samples from six markets in Ilorin.

Gari	Location						Mean moisture content
	Okesuna	Oja Oba	Ipata	Baboko	Saw Mill	Offa Garage	
Yellow	14.6	16.2	16.3	15.9	17.8	16.4	16.0
White	16.1	19.2	17.0	17.6	18.1	16.7	17.3
Yellow	17.6	16.6	17.1	16.5	18.1	15.9	16.8
White	18.3	17.9	16.3	19.2	17.6	10.1	16.5
Yellow	18.2	18.9	17.2	16.8	16.7	15.9	17.2
White	17.5	18.0	18.1	17.0	17.0	18.2	17.5
Yellow	16.3	16.7	17.0	16.5	17.2	17.5	16.8
White	17.1	18.0	19.1	17.0	18.2	19.0	18.0
Yellow	18.1	17.5	17.5	17.2	19.6	18.0	18.0
White	18.2	17.0	14.6	19.5	18.7	17.2	17.5
Yellow	17.6	16.6	17.1	16.7	17.8	16.1	17.0
White	18.2	18.1	16.8	19.2	17.6	18.0	18.0
Yellow	18.4	17.2	17.2	16.5	17.2	18.0	17.4
White	18.6	18.1	17.8	19.0	18.2	17.8	17.8
Yellow	17.6	17.5	17.5	16.7	17.7	17.9	17.5
White	18.4	18.0	17.2	18.9	17.6	17.5	18.0

have reported *Aspergillus chevallieri*, *Aspergillus glaucus*, *Aspergillus flavus*, *Aspergillus niger*, *Mucor pusillus* and *Fusarium moniliforme* in garri stored for three months in jute bag.

The aim of this study is to evaluate the role of moisture and storage conditions in the storability of garri and determine the microorganisms involved in deterioration.

MATERIALS AND METHODS

Survey and sample collection

A survey was carried out in six major garri processing and selling centres in Ilorin, Kwara State, namely: Ipata, Oja-Oba, Baboko, Saw Mill, Okesuna and Ero-Omo. Samples of white and yellow garri were collected at weekly intervals for two months (May-June). The moisture contents were determined using the standard oven method of heating samples to dry up to a constant weight at 75°C for 24 h (A.O.A.C., 1980; Basunia and Abe, 2001).

Known weights (2.5 kg) of each of the two samples were stored in sterile polyethylene bags, jute bags and plastic containers. The duration of storage was three months. The initial moisture contents of the samples were 15.1 (yellow) and 15.2% (white). All the test samples were stored at room temperature of $26 \pm 2^\circ\text{C}$ and 76% RH (Oyeniran, 1980; Kuku et al., 1984).

The starch, sugar, protein and lipid contents of the samples were determined before storage and subsequently after one, two and three months in storage. Isolations were made from moulded samples using the pour plate method and the isolates identified.

Estimation of nutrient contents of stored samples

Samples were withdrawn from the stored produce after one, two and three month intervals for determination of the nutrient contents. The estimation of starch, total sugar, soluble protein and lipid contents of the test samples was carried out routinely (Lowry et al., 1951; Olaniyan, 1991). For the lipids, 5 ml of 0.01 M H_2SO_4 was

added to 10 ml of garri sample suspension in a flask. The mixture was incubated at 37°C for 1 h 30 min. 25 ml of 95% ethanol was added to release the free fatty acids (FFA) in solution. The mixture was titrated against 0.5 M NaOH using phenolphthalein as indicator. All the data obtained were analysed using ANOVA at 5%.

RESULTS

Moisture contents of samples

The moisture contents of white and yellow garri samples collected from six markets (Ipata, Oja Oba, Baboko, Saw Mill, Okesuna and Ero Omo) at weekly intervals for eight weeks were found to be in the range of 14.6 - 19.5% and 14.6 - 19.6% for white and yellow samples, respectively (Table 1). The mean moisture content was 17.2 and 17.8% for white and yellow garri, respectively. It was observed in this study that the moisture contents of the two samples stored separately in jute bags increased slightly over time. The increase was, however, not significantly different at 5%. There were also very negligible increases in moisture contents of the samples stored in air-tight polyethylene bags and plastic containers. There was no change in the physical qualities of the samples stored in these containers after three months. However, storage in plastic containers proved to be the best form for both white and yellow garri samples under the conditions of this study (Table 2).

Associated microorganisms

Different levels of mouldiness were observed in stored samples after three months. Deterioration in the form of discoloration, caking and foul odour occurred mainly in

Table 2. Moisture contents (%) of garri during and after storage under different conditions.

Time (months)	Yellow garri (%)					White garri (%)				
	Jute bag	Polythene	Plastic	Df	P. value	Jute bag	Polythene	Plastic	Df	P. value
0	15.1	15.1	15.1	2	1.0000	15.2	15.2	15.2	2	1.00000
1	15.3	15.3	15.2	2	1.0000	15.4	15.4	15.2	2	1.00000
2	16.5	15.9	15.2	2	0.9750	16.8	16.0	15.3	2	0.928296
3	17.2	16.2	15.2	2	0.9282	17.8	16.3	15.3	2	0.843036

Chi square sample test significance at 0.05 level.

Table 3. Frequency of mould species isolated from garri samples after three months of storage

Fungus	Jute bags		Polythene bags		Plastic containers	
	Yellow	White	Yellow	White	Yellow	White
<i>A. niger</i>	+	+	+	+	+	-
<i>A. flavus</i>	+	+	+	+	-	-
<i>A. fumigatus</i>	+	+	-	-	-	-
<i>Penicillium</i> sp.	+	-	+	-	-	-
<i>Rhizopus</i> sp.	+	-	-	-	-	-
<i>A. glaucus</i>	-	+	-	-	-	-

+ = Present; - = absent.

Table 4. Starch contents (mg/ml) of garri samples during and after storage for three months.

Time (months)	Yellow garri (mg/ml)					White garri (mg/ml)				
	Jute bag	Polythene	Plastic	Df	P. value	Jute bag	Polythene	Plastic	Df	P. value
0	48.3	48.3	48.3	2	1.0000	50.0	50.0	50.0	2	1.00000
1	31.0	35.6	42.8	2	0.2694	42.2	45.9	49.6	2	0.525123
2	21.4	29.3	40.6	2	0.0082	38.4	40.2	47.2	2	0.846482
3	15.7	25.5	39.5	2	0.0010	32.5	39.6	46.2	2	0.126511

Chi square sample test significance at 0.05 level.

the samples stored in jute bags and was more in the samples stored for three months. Six mould species were subsequently isolated from both the yellow and white samples. The isolates were *A. niger*, *A. flavus*, *A. fumigatus*, *A. glaucus*, *Penicillium* sp. and *Rhizopus* sp. The most frequently occurring organisms were *A. niger* and *A. flavus*. The samples stored in jute bags were more infested with moulds than any of the other samples. On the whole, more moulds were associated with yellow garri than with the white sample in this study. *Rhizopus* sp. and *A. glaucus* were the least isolated organisms from both white and yellow samples (Table 3). Garri samples in plastic containers were found to have the least incidence of mould infestation. The mould content of garri was found to depend on the initial moisture level and once microbial growth is stimulated, it goes on in storage.

The nutrient contents of the test samples before, during and after storage were evaluated. Results show that there was a decrease in all the contents over time and

with the level of mould infestation. The starch component was the most depleted of all the nutrients in all the samples. This decrease in starch was most pronounced in the yellow sample stored in jute bag (Table 4). The decrease in nutrient contents was significantly different at 5% for starch and sugar but not for the lipid and protein contents.

DISCUSSION

The results of this study show that the moisture content of garri samples on sale in Ilorin markets was generally higher than the reported safe levels (12.70% white; 13.60% yellow). Oyeniran (1980) has reported similar moisture contents at Ibadan but Halliday et al. (1967) and Opadokun (1977) had reported lower moisture contents in Kano, in Northern Nigeria. The moisture content of any produce will depend on factors such as location, the sea-

son, the produce itself and the methods of processing. Polyethylene bags and plastic containers preserved garri better than jute bags in the present study. This may probably be due to the ability of the containers to keep their microclimate shielded from the influence of the surrounding environment. Most materials are hygroscopic and would easily absorb water from the air around them. This would have been responsible for the spoilage of the garri samples in jute bags.

Six different fungi namely *A. niger*, *A. flavus*, *A. fumigatus*, *A. glaucus*, *Penicillium* sp. and *Rhizopus* sp. were isolated from stored garri samples in this study. Some of the mould species isolated had been reported in various stored foods (Adeniji, 1976; Oyeniran, 1980, Akano et al., 1984; Akano et al., 1986; Edward and Oyedeji, 1992). Ogiehor and Ikenebomeh (2005) isolated six bacteria and nine fungi from stored garri and suggested that handling was a major factor in garri storage. The high level of mould infestation recorded in this study may be due to contamination as a result of local method of processing. It is also known that garri is offered for sale in the markets in large open bowls. Oyeniran (1980) had also reported discoloration in garri stored in jute bags.

A decrease in most of the nutrient contents was observed in garri after three months of storage. The decrease was most pronounced in the starch contents. This decrease is likely to be due to the activities of microbes invading the stored produce. Microorganisms are known to use starch and proteins as sources of carbon and nitrogen, respectively and would expectedly lead to nutrient depletion. Marin et al. (1999) have reported such a decrease in maize following *Fusarium* infection. The decrease in protein contents might be as a result of the breaking down of protein by the fungi in the food. The palm oil added to yellow garri during processing was hydrolyzed to free fatty acid by lipase enzymes produced by the moulds leading to decrease in lipid contents. The characteristic odour and flavour of fatty acids may probably be responsible for the rancid taste of garri samples stored in jute bags. Ogiehor and Ikenebomeh (2005) have reported that a combination of hygienic handling and sodium benzoate (SB) treatment has maximum positive impact on the microbial quality, shelf stability and acceptance of garri during storage.

REFERENCES

- Adeniji MO (1976). Fungi associated with the deterioration of garri. *Niger. J. Plant Prot.* 2:74-77.
- Akano DA, Afolabi JF, Kuka FO (1984). Moisture and Micro-flora content of cassava flour stored in plastic containers. *Rep. Niger. Stored Prod. Res. Inst. Tech. Report. No. 7:* 68-73.
- Akano DA, Afolabi JF, Opadokun JS (1986). Longterm storage of garri. *Rep. Niger. Stored Prod. Res. Inst. Tech. Report. No.2:* 40-43.
- Akinrele TA, Cook AS, Holgate RA (1962). The manufacture of garri from cassava. *Fed. Int. Ind. Res. Lagos Nig., Res. Rep. No 13:* 1-88.
- Anon (1965). The relationship between atmospheric humidity, temperature and equilibrium water content of cassava chips. *Rep. Trop. Prod. Inst. L1:* 1-4.
- Association of Official Agricultural Chemists (A.O.A.C.) (1980). *Official Method of Analysis.* 13th Edition Washington, D.C. USA.
- Basunia MA, Abe T (2001). Moisture desorption isotherms of medium-grain rough rice. *Stored Product Research* 37(3); 205-209.
- Best R (1978). Cassava processing for animal feed. In *Cassava Harvesting and Processings, Proceedings of a Workshop held at Ciat, Cali, Columbia.*
- Edward AWA, Oyedeji NO (1992). Variations in population dynamic of microflora of garri in storage. *Niger. J. Pure Appl. Sci* 7:199-209.
- Ekanem MJ (1965). Cassava in Nigeria Part 2. Northern Nigeria Fed. Dept. Agric. Memo No. 87, Ibadan, Nigeria. Federal Department of Agricultural Research.
- Halliday DJ, Quareshi AH, Broadbent JA (1967). Investigations on the storage of garri. *Rep. Niger. Stored Prod. Res. Inst. Tech. Rep. No. 16:* 131-141.
- Kuku FO, Afolabi JF, Akano Da (1984). Moisture and Mycoflora contents of cassava flour stored in plastic containers. *Rep. Nig. Stored Prod. Res. Inst. Tech. Report No. 7:* 68-73.
- Lowry OH, Rose Brough NJ, Farr AL, Randall RJ (1951). Protein measurement with flowing – phenol reagent. *J. Biol. Chem.* 193: 265-275.
- Marin S, Homedes V, Sanchis V, Ramos AJ, Magan N (1999). Impact of *Fusarium moniliforme* and *F. proliferatum* colonization of maize on calorific losses and fumonisin production under different environmental conditions. *J. Stored Prod. Res.* 35: 15-26.
- Mill JT (1992). Safe storage guidelines and their products. *Post-Harvest News and Information.* 3: 111N-115N.
- Ogiehor IS Ikenebomeh MJ (2005). Extension of shelf life of garri by hygienic handling and sodium benzoate treatment. *Afr. J. Biotechnol.* 4(7): 744-748.
- Olaniyan J (1991). Microbial and food analysis of locally produced milk products. M.Sc. Dissertation University of Ilorin, Nigeria.
- Opadokun JS (1977). The aflatoxin contents of locally consumed food stuffs Part 1. Garri. *Rep. Niger. Stored Prod. Res. Inst. Tech. Report No. 7.*
- Oyeniran JO (1980). Mould development in garri during storage in polythene. *J. Agric. Sci.* 2(2): 151-165.