STUDIES ON THE MOISTURE AND MICROBIOLOGICAL (*Staphylococcus aurens*) CONTENTS OF GARI IN SELECTED PACKAGING MATERIALS

Adejumo B. A
Department of Agricultural Engineering
Ladoke Akintola University of Technology, Ogbomoso, Nigeria
e-mail: bolanleadejumo@yahoo.com

ABSTRACT

This work investigated the moisture and microbiological (*staphylococcus aurens*) contents of gari packaged in selected plastic packaging materials with a view to determine the suitability of the packaging materials for gari packaging. Gari with an initial moisture content of 4.5% was packaged and stored in polyester, polypropylene and hessian bags with unpacked samples as control in a storage environment condition range of 16.0-34.5°C, 48.6-80.5% RH. The moisture and microbiological (*staphylococcus aurens*) counts of packaged and unpackaged gari samples were determined on monthly basis for six months using standard methods. The results showed that the moisture and microbiological (*staphylococcus aurens*) contents of packaged gari in hessian bags at any point are always higher than gari in the polyester and polypropylene bags with the unpackaged having the highest value. The moisture absorbed and microbiological (*staphylococcus aurens*) contents of gari packaged in polyester and polypropylene bags were not significantly different ($p \leq 0.05$) all through storage. While the moisture absorbed by the gari packaged in hessian bag was not significantly different from the unpackaged gari. The microbiological (*staphylococcus aurens*) contents of gari at the end of storage period increased significantly ($p \leq 0.05$) from their initial values but are however within acceptable limits except for the unpackaged which had become unacceptable. It was concluded that gari should not be stored unpackaged or in open containers. The use of hessian bags for gari packaging should be discouraged due to the increases in the microbiological contents. It is suggested that gari should be packaged in less permeable materials.

Keywords: *Gari, moisture, hessian, polyester, polypropylene, staphylococcus aurens*

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is primarily grown for its starch containing tuberous roots, which are the major sources of dietary energy for more than 500 million people in the tropics (Lyman, 1993). Traditional cassava processing methods involve several steps including peeling, soaking, grinding, steeping in water or in the air to allow fermentation to occur, drying, milling, roasting, steaming, pounding, and mixing in cold or hot water. Specific combinations of these steps lead to a myriad of different cassava products with acceptable taste to a wide range of consumers (Bokanga and Otoo, 1991). In Nigeria, almost all the cassava produced is used for human consumption with less than 5% used in industries. The main food products of considerable domestic importance are gari, *fufu*, and *lafun.* Gari is a granulated, white or yellowish product depending on production methods. It is a dehydrated, staple food, consumed raw or cooked. The fresh cassava roots are peeled, washed, and grated; the mash is placed in bags and squeezed (either by tying it up with sticks and continuously tightening the ropes or by a variety of screw and hydraulic presses) for a minimum of 48 hours to allow detoxification by fermentation. The dough is fried dry (sometimes with palm oil) and stored in bags (Ene, 1992). Gari has a high swelling capability and can absorb up to 4 times its volume in water. It is a popular diet eaten in many flavors: in sugared water with groundnuts or transformed into pasta with hot water and eaten with a variety of sauces (vegetable, meats, and fish) or eaten as supplement to beans' preparations. The nutritional supplements provided by 100grams of gari as reported by Quemen (2004) consist of 87.30g of global glucocides, 1.82g indigestible glucocides, 1.03g ash and 1.12g protein.

In general the initial stages (grating, fermentation and dewatering) in the production of gari induce a starch damage of about 3 to 6% (Chuzel and Zakhia, 1991). During the process of garification complete gelatinization does not take place due to low initial moisture content of about 1g/g (Audu and Ikhu-Omoregbe, 1982). However there are losses in crystallinity and extensive swelling of the starch granules resulting in crisp grain-like product when dry. A complex metastable network is said to be formed that consist of amorphous regions (containing plasticizing water) and hydrated microcrystalline regions which did not dissolve during partial gelatinization and serve as junction zones (Levine and Slade, 1988). Chuzel and Zakhia (1991) suggested that increase in both temperature and water activity initiate a collapse process, which makes the soluble starch (amorphous fractions and branched segments) to leach out thereby increasing the number of available adsorption sites (glucose residues). This makes the moisture adsorption capacity of gari higher than ungarified products (Ikhu-Omoregbe, 2006, Chuzel and Zakhia, 1991).

However, due to the large numbers of small scale gari processors, there is often little or no quality control on the finished product. This usually results in the product having higher moisture content than recommended, thereby making it unsuitable for long-term storage. Gari which is a low moisture dried foods must be protected from water vapor due to its hygroscopic nature and should be packed in containers having low permeability to water vapor (Connor and Schiek, 1997). The agents that contaminate and spoil stored gari are mould, fungi, insects and mite (Igbeka, 1987). The storage quality of gari therefore depends on the rate of reproduction and growth of these organisms which in turn depends on some biological and non-biological variables. The most important of these variables are temperature and moisture. The survival of any of these organisms in any stored products depends on whether the intensity or levels of these two variables are conducive. Microbiological growth is a major factor in deciding the most suitable material for packaging a food product. Not only does the packaging material affect the microbial patterns in foods resulting from the absorbed moisture but there is also the effect of microorganisms on the packaging material itself. Some of the factors to be taken into consideration are the protection of foods from external microbial contamination by the correct use of packaging (Schmidheiny *et al.,* 1997). The objectives of this work are to evaluate the moisture and microbiological (*staphylococcus aurens*) contents of gari packaged in selected plastic packaging materials with a view to select an appropriate one to enhance its shelf stability.

MATERIALS AND METHODS

Gari samples were produced from fresh cassava cultivar using the procedure established and reported by 11TA (2005). Fresh matured cassava roots without rots were selected. Peeling was done using knife and the roots were washed in clean water to remove pieces of peels, sand and other dirt. The roots were grated, packed into a bag and left for 3 days to ferment at room temperature. The fermented paste was then dewatered using a hydraulic jack press. Using a woven polyester sieve, the dewatered mesh was sieved (sifting process) to separate the fibrous material, oversized mesh and also to ensure uniformity of particle size of the mesh. Roasting/frying was done in large shallow iron pan over a fire with constant stirring, with a wooden paddle for 20-30 minutes. The samples were then allowed to cool at room temperature before packaging.

Five hundred grams (500g) each of 18 samples with an initial moisture content of 4.5% was aseptically packaged in the selected packaging bags: polyester, polypropylene and hessian bags, totaling 54 samples with unpackaged **s**amples as a control. The samples were stored on a shelf at the normal atmospheric conditions having a temperature and relative humidity range of 20.0-34.5^{o}C and 48.6-80.5% respectively. The experimental samples in the three packing types at these storage conditions were analyzed monthly for moisture content variations during the storage period at three replicates up to six months. The moisture content of the samples was determined using methods prescribed by AOAC (1990).

Ten grams (10g) of each sample was homogenized with 90mL of sterile Maximum Recovery Diluents (MRD oxoid CM 733) by stomaching for two (2) minutes (Colworth Stomacher 400). Subsequent decimal dilutions were prepared in sterile MRD and appropriately diluted suspension of sample (1.0ML) was mixed with molten (45^{o}C) media and poured into plates. *Staphylococcus aurens* were enumerated in poured plates of Mannitol salt agar (Himedia MM 118 India) incubated at 35^{o}C for 24 - 48h. Colonies appearing at the end of the incubation period were counted (Collins *et al.*, 2004, Holding and Collee, 1971). The data obtained were subjected to statistical analysis using SPSS 15.0 statistical packages. A one-way analysis of variance (ANOVA) was carried out to determine differences and Duncan's multiple range tests to separate means.

RESULTS AND DISCUSSIONS

The result showed that there were increases in the moisture and microbiological (*staphylococcus aurens*) contents of the packaged and unpackaged gari. The analysis of variance of the results showed that the packaging materials and storage duration had significant effects ($p \leq 0.05$) on the moisture and *staphylococcus aurens* contents of packaged and unpackaged gari (Table 1). The moisture content of gari in the different packaging materials during six month of storage are as shown in Figure 1. The permeabilities of the packaging materials are 18.0 x 10^{-6}, 2.28 x 10^{-6} and 1.5 x 10^{-6} Kg H_2Om^{-2} Pa^{-1} day^{-1} for the hessian, polyester and polypropylene bags respectively as reported by Nwachukwu and Igbeka (1983), Chuzel and Zakhia (1991) and Anon (2006). The water vapour transmission of the packaging material plays a very important role in the moisture sorption of stored gari. Materials with high permeability will allow more sorption than those with low permeability under the same environmental conditions. This was observed in the higher moisture content of the packaged stored gari with the highest absorbed moisture by the gari packaged in hessian bags.

Table 1: The ANOVA of the moisture and microbiological (*staphylococcus aurens*) contents of packaged gari in storage

		Sum of Squares	df	Mean Square	F	Sig.
EMC	Between Groups	12.799	6	2.133	2.864	0.049
	Within Groups	10.427	14	0.745		
	Total	23.226	20			
PMC	Between Groups	3.844	6	0.641	0.400	0.867
	Within Groups	22.433	14	1.602		
	Total	26.277	20			
HMC	Between Groups	196.496	6	32.749	17.219	0.000
	Within Groups	26.627	14	1.902		
	Total	223.123	20			
UMC	Between Groups	167.670	6	27.945	143.269	0.000
	Within Groups	2.731	14	0.195		
	Total	170.401	20			
ESAC	Between Groups	128.459	6	21.410	1357.098	0.000
	Within Groups	0.221	14	0.016		
	Total	128.680	20			
PSAC	Between Groups	319.251	6	53.208	77595.646	0.000
	Within Groups	0.010	14	0.001		
	Total	319.260	20			
HSAC	Between Groups	340.852	6	56.809	51421.586	0.000
	Within Groups	0.015	14	0.001		
	Total	340.867	20			
USAC	Between Groups	398.571	6	66.429	4608.523	0.000
	Within Groups	0.202	14	0.014		
	Total	398.773	20			

Where: EMC = moisture content of gari in polyester bags, PMC = moisture content of gari in polypropylene bags, HMC = moisture content of gari in hessian bags, UMC = moisture content of unpackaged gari, ESAC = staphylococcus count of gari in polyester bags, PSAC = staphylococcus count of gari in polypropylene bags, HSAC = staphylococcus count of gari in hessian bags, USAC = staphylococcus count of unpackaged gari

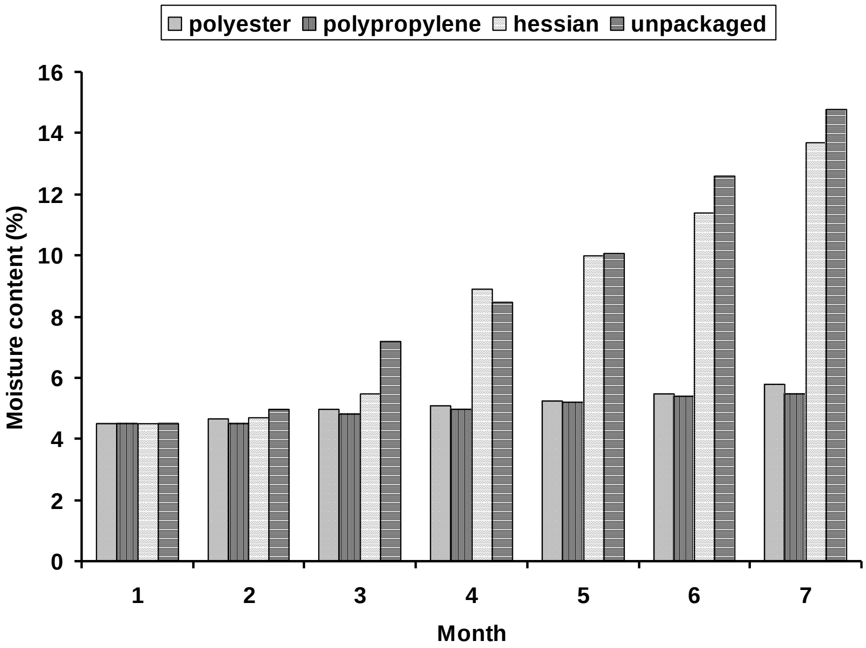

Figure 1: The moisture content of gari in different packaging materials

The effect of the packaging materials on the moisture content during the six month of storage showed that the moisture content in the hessian bag at any point is always higher than in the polyester and polypropylene bags. The higher permeability of the hessian bag made it more permeable to moisture than the other two packaging materials. The moisture adsorbed by the gari packaged in polyester and polypropylene bags were quite similar all through the storage period, (5.8%) and (5.5%) respectively and 13.7% in hessian bag at the end six month of storage. The separated means (Table 2) showed that there were no significant differences in the moisture content of gari packaged in polyester and polypropylene bags. The lower moisture absorbed by gari packaged in polyester and polypropylene bags suggests their suitability for gari packaging. There are no significant differences ($p \leq 0.05$) in the moisture absorbed by the gari packaged in hessian bags and the unpackaged gari; this indicates that the hessian bags may not be suitable for gari packaging.

The moisture content of gari packaged in hessian bag is significantly higher than the 12% recommended by FAO/WHO, 1991. Gari stored in hessian bag in a humid atmosphere had absorbed sufficient moisture making them vulnerable to bacterial and fungal growths. The results also showed that the *staphylococcus aurens* counts in packaged and unpackaged gari decreased initially in the first month of storage then increased from the second month of storage, the increments continued all through to the end of storage (Figure 2). The separated means (Table 2) showed that the *staphylococcus counts* of the gari packaged in polyester bags were significantly lower while there are no differences in the gari packaged in polypropylene and hessian bags. The unpackaged gari had the highest *staphylococcus counts* at the end of storage.

Table 2: The mean[1, 2] moisture and *Staphylococcus aurens* contents of packaged gari

Packaging type	Moisture content (%)	Staphylococcus count ($x10^4 cfug^{-1}$)
Polyester	3.90^a	5.50^a
Polypropylene	4.30^a	8.95^b
Hessian	7.46^b	9.76^b
Unpackaged	7.89^b	12.86^c

[1] Means of three replicate [2]Means with the same letters for a particular measurement are not significantly different ($p \leq 0.05$)

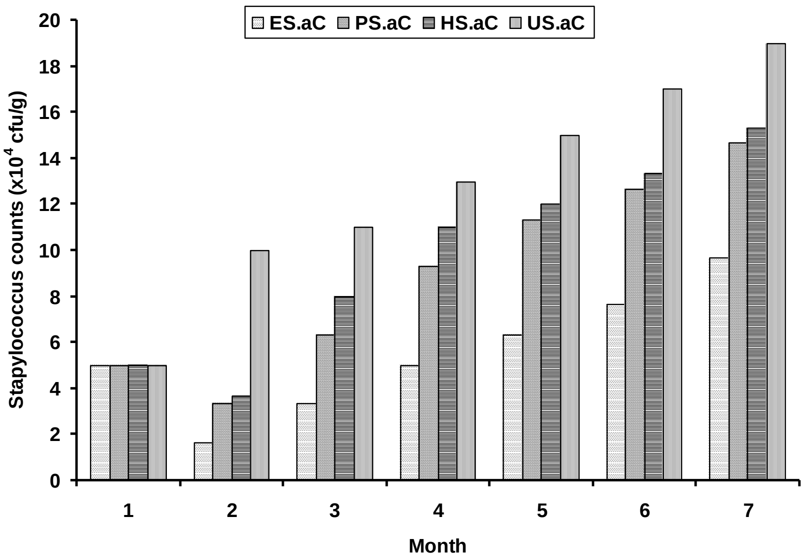

Figure 2: Staphylococcus count of gari in selected packaging materials

The increase in the *staphylococcus counts* of gari indicates a favourable environment and nutrient availability which can be attributed to the increase in moisture absorbed by gari especially in the unpackaged gari. These results are in agreement with the previous reports of Efiuvwevwere and Uwanogho, (1990); Turtle, (1991) and Paine, (1992) which showed that oxygen transfer rate and the permeability characteristics of the packaging materials will enhance the increases in microbial growth of the packaged gari. Gari, being hygroscopic, absorbs the gases with resultant increase in moisture content which subsequently exacerbates microbial proliferation. Similar reports for other food items have been documented (Steinkraus, 1993; Ogiehor and Ikenebomeh, 2004). However the *staphylococcus counts* of packaged gari are still within the limits and in agreement with the reports of Garbutt, 1997 and Omafuvbe, *et al.*, 2007 who reported a maximum level of 5.0 log_{10} $cfug,^{-1}$ thus ruling out the possibility of food poisoning resulting from its consumption. The unpackaged gari was no more microbiologically safe from the third month of storage.

CONCLUSIONS

It was concluded that gari, due to its hygroscopic nature, should not be packaged in hessian bag since this material is not moisture proof or airtight. Gari should not be stored unpackaged or in open containers but packaged in moisture proof materials such as polyester and polypropylene bags so as to extend its shelf life and ensure microbiological safety.

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