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MICROBIOLOGICAL SAFETY AND SENSORY ATTRIBUTES OF GARI IN SELECTED PACKAGING MATERIALS

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ABSTRACT

The effect of some selected plastic packaging materials on the microbial deterioration and sensory acceptability of packaged gari was investigated. Freshly prepared gari were packaged in polyester, polypropylene and hessian bags, with unpackaged samples in open container as a control. The gari samples were stored for six months at 16.0-34.5°C, 48.6-80.5% RH. The results showed that the total viable fungal count increased from about 1 to 56 x 10^4cfug-^{1}, 49 x 10^4, 95 x 10^4cfug-^{1} and 220 x 10^4cfug-^{1} while the total viable bacterial count also increased from about 1 to 10 x 10^4, 15 x 10^4, 30 x 10^4cfug-^{1} and 50 x 10^4cfug-^{1} in polyester, polypropylene, hessian bags and unpackaged samples respectively. The microbial loads at the end of storage periods were significantly different ($p<0.05$) from the initial values but within acceptable limits except, for the unpackaged gari which had become unacceptable. The overall sensory scores of gari in polyester and polypropylene bags indicated acceptability, while gari in hessian bag was not acceptable at the end of storage period. It is therefore recommended that gari should not be stored for more than three months when packaged in hessian bag since consumption of gari stored beyond this period may constitute health hazards. Gari packaged in polyester and polypropylene bags could still be microbiologically safe and sensorially acceptable for up to six months, while gari should not be stored unpackaged.

Keywords: Gari, packaging, hessian, polyester, polypropylene

INTRODUCTION

Nigeria is the current leading cassava (*Manihot esculenta Crantz*) producing country in the world, but almost all the cassava produced are used for human consumption with, less than 5% used in industries (FAO, 2002a; Bokanga & Otoo, 1991; Ajao & Adegun, 2009). Cassava is consumed in boiled, baked and fried forms, in addition to various other products that are obtained from fermenting the crop. Normally cassava is processed before consumption so as to detoxify, preserve and modify them (Oyewole & Sanni, 1995; Obadina *et al.*, 2009). The main cassava food products of considerable domestic importance in Nigeria are gari, lafun and fufu.

Gari is the most popular form in which cassava is consumed by several millions of people in the African continent, especially in the West Africa sub region (Ofuya & Akpoti, 1988; Ogiehor, 2002). Gari is processed by peeling the cassava root, washing, grating, followed by solid state fermentation, pulverizing and roasting (Oyewole & Sanni, 1995). Gari is a granulated, white or yellowish product, the colour depends on production methods. It is a dehydrated staple food with a high swelling capability and can absorb up to four times its volume in water. It is a shelf stable food consumed as processed or cooked.

Gari can be consumed directly without cooking by soaking in water without or with a variety of additives such as sugar, groundnut, fish, meat and stew.prior to consumption (Ajao & Adegun, 2009). It can also be made into a stiff gel by mixing with hot water (Oyewole, 2000). In Nigeria, the consumption pattern varies according to ecological zones and is widely accepted in both rural and urban areas. The various forms of consumptions as snack (refreshing light meal when soaked in cold water and eaten with coconut, banana, smoked fish or peanut) and as major meal (when made into thick paste called “eba” and eaten with various types of African soups) make it the most popular diet amongst the rich and the poor, with acceptability cutting across the various socio-economic and multi ethnic groups in Africa (Ogiehor, 2002; Ogiehor & Ikenebomeh, 2004). Gari production is laborious

and cumbersome. Production methods vary from one locality to another resulting in products of non-uniform quality.

Gari produced in Nigeria are usually packaged and stored in hessian bags. It is usually sold from open containers, polyethylene sheets or on a mat using small measures which makes it become subjected to post-process contamination. It has been recognized that certain bottleneck exists particularly in the packaging of products emanating from cassava roots. In line with this, the solution to the problem of packaging had been suggested to be polyethylene bag (Charles *et al.,* 2006). Polyethylene is widely used as a packaging material because of its good mechanical properties and low cost. However these qualities have been overshadowed by its high non-biodegradable nature, leading to waste disposal problems, particularly in short-term packaging applications (Sailaja & Chanda, 2001).

The producers of gari go about the storage and packaging of this product in a non-scientific way (Oyelade *et al.,* 2001) using hessian bags and transparent plastic polyethylene sheets. An advantage of the plastic film is that the product is visible and thus makes the checking of the content easier. The products may however look alright from outside, while its quality may be musty and completely bad when it is touched. This is an indication that faulty packaging can conveniently undo all that a food processor has attempted to accomplish by the most meticulous method of manufacturing practice (Fedrica, 2001).

The hygroscopic nature of gari is a major constraint to its keeping quality. The use of hessian bags by the local producers of gari for its packaging is due to the fact that the material is cheap, readily available and durable. The material also has ease of bulk packing and transportation of products with little or no attention paid to the quality of products stored. The hessian bag is not moisture proof or airtight and gari which is hygroscopic in nature makes the use of hessian bag grossly inadequate. Gari stored in hessian bag in a humid atmosphere can absorb sufficient moisture making them vulnerable to microbial growth. The absorption of moisture by dehydrated products generally leads to microbial growth, change in color, odour and taste, caking, etc, thereby reducing the quality and market value of products. The presence of fungal and other microbial growths in gari may lead to food poisoning when consumed.

The shelf-life of stored packaged gari will largely depend on the temperature, relative humidity, moisture content and thus the water activity (a_w) of the material when packed, for they determine the rate of microbial and physico-chemical deterioration (Igbeka, 1987, Ijabadeniyi 2007). There is therefore, the necessity to evolve packaging materials to effectively provide complete protection of the dehydrated products against moisture, light, air, dust, micro flora foreign odour and animal pests. The packaging materials also should provide strength and stability required to maintain the original properties of products through storage, handling and marketing. The objective of this work is to evaluate the microbial deterioration and sensory properties of gari packaged in hessian, polyester and polypropylene bags with a view to ascertain the microbial safety of packaged gari.

MATERIALS AND METHODS

Sample Preparation

Two hundred and thirty kilograms (230kg) of freshly harvested cassava roots of the common variety in Nigeria MS6 (*oko iyawo*) were selected. Gari were produced from the cassava cultivar using the procedure established and reported by 11TA (2003) as presented in Figure 1. The production was carried out in the Faculty of Agriculture, Research and Training Unit LAUTECH, Ogbomoso. 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 hessian bag and left for 3 days to ferment at room temperature. The fermented paste was then placed into a hydraulic jack press to dewater the mash. Using a woven polyester sieve, the dewatered mash was sieved (sifting process) to separate the fibrous material, oversized mash and also to ensure uniformity of particle size of the mash.

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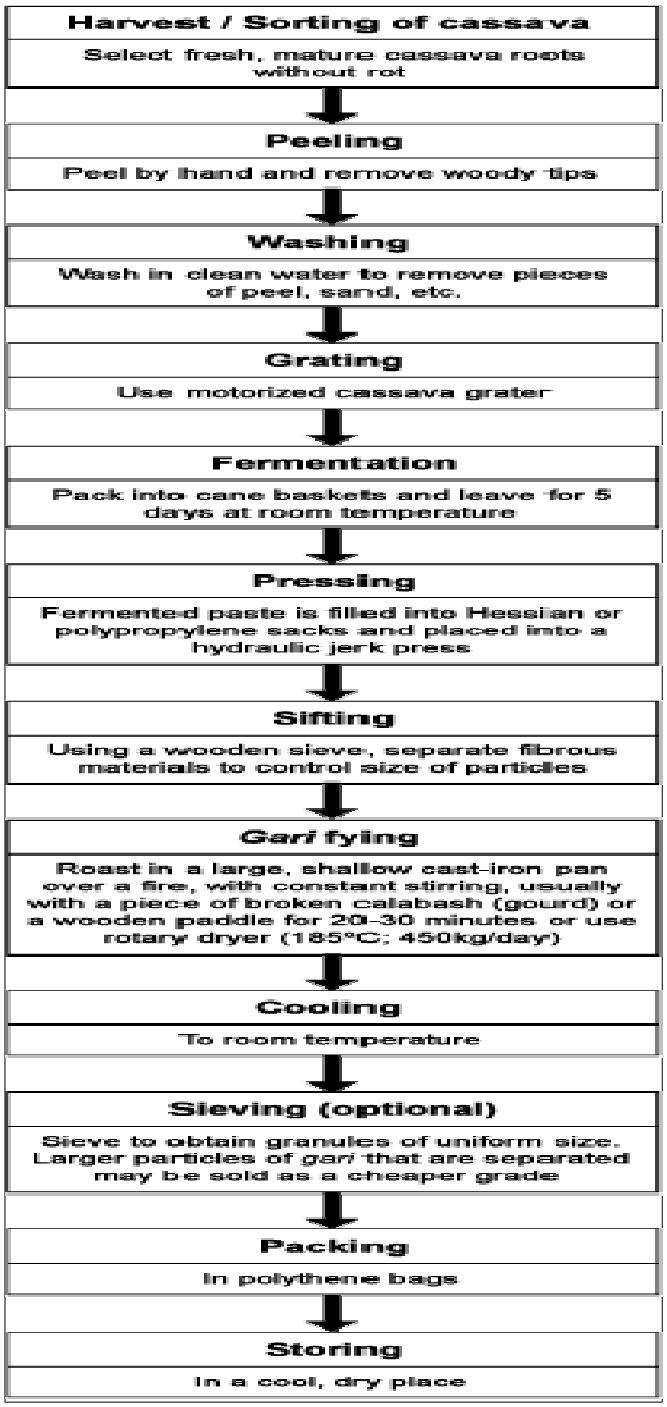

Figure 1. Flow chart for production of *gari* (*source: IITA, 2003*)

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.

Experimental Set-Up

The microbial load of the gari samples was determined within 24h of its production. Five hundred (500g) each of 18 samples was then packaged in the selected packaging materials: polypropylene, polyester and hessian bag totaling 54 samples with unpackaged samples as control. The samples were

stored on a shelf at the normal atmospheric conditions which represent the common storage environment for the sale of gari.

The temperature and relative humidity of the storage environment were taken at 6 hours intervals using a HM 34C humidity meter with samples placed in open container to serve as a control. The experimental samples in the three packing types were analyzed monthly for microbial and sensory properties during the storage period at three replicates up to six months.

Microbial Analyses

Preparation of Sterile Water

Nine milliliters (9ml) of distilled water was pipetted into a clean dry test tube plugged with cotton-wool and wrapped with aluminum foil. The test tubes were placed inside an autoclave and sterilized by autoclaving at 121^{o}C for 15 minutes.

Preparation of Media

(a) Nutrient Agar (NA)

Twenty-eight grams (28g) of powdered commercially prepared nutrient agar was weighed on analytical metller balance into a clean dry one litre conical flask and 1000ml of distilled water placed inside a water bath set at about 90^{o}C, and allowed to dissolve. It was then distributed into McCartney bottles and sterilized in an autoclave set at 121^{o}C for 15 minutes.

(b) MacConkey Agar (MCCA)

Fifty-five grams (55g) of MacConkey Agar was weighed into one litre capacity of conical flask and brought to boil to dissolve the agar. It was then distributed into MacCartney bottles and autoclaved as for nutrient agar.

(c) Potato Dextrose Agar (PDA)

Thirty-nine grams (39g) of PDA was weighed into a one litre capacity of conical flask bring to boil and distribute them into MacCartney bottles and autoclaved as for nutrient agar.

Sample Preparation

The sample (10g) was suspended in a 90ml of sterile distilled water and was homogenized. The suspension was filtered through sterile wool. The samples were serially diluted under aseptic condition.

Viable Counting

The total fungal and bacterial plate counts were determined using the methods of Holding and Collee (1971). 0.2ml of each dilution of the sample was pipetted into the center of the appropriate dishes containing the MacConkey, potato dextrose, and nutrient agar in duplicate. The dishes in which the solutions were placed were allowed to set and then inverted and incubated at 37^{o}C for 72 h. The colonies that developed on the plates were counted and recorded after the incubation period.

Sensory Evaluation

The samples were assessed for changes in the sensory properties of the dried form at 30 days (one month) intervals by a taste panel procedure. A semi-trained panel of 10 students and staff of the Ladoke Akintola University of Technology evaluated the aroma, taste, colour, and overall acceptability of the gari samples. The panelists were selected on the basis of their familiarity with the product and ability to distinguish off flavour in the sample. The panelists were asked to sniff test and chew the samples for the degree of off flavour in comparison with the freshly made samples using a rank order test. The parameters were rated on a 5 point hedonic scale, where 1 = very poor, 2 = poor, 3 = average/fair, 4 = good and 5 = very good (Larmond, 1977). Gari samples were presented in cups as dry granules for evaluation. After each sample was evaluated, the panelist used water to rinse their mouths before another sample was evaluated.

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Statistical Analysis

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 DISCUSSION

The average temperature and relative humidity of the storage environment obtained during the storage period ranged between 16.0-34.5°C and 48.6-80.5% respectively. This spanned through the dry and wet seasons. These temperature and relative humidity ranges for the storage environment are within those ranges reported for Oyo state, Nigeria (FAO, 2002b) being the location of this experiment. These environmental conditions also exist in different parts of Nigeria at different times of the year. The temperature and relative humidity of the environment play an important role in the stability of stored dehydrated food products.

Microbiological Deterioration

The results of the variations in the bacterial and fungal counts of the packaged gari in the various packaging materials as presented in Figures 2 and 3. The analysis of variance of the microbiological properties of packaged gari showed that the packaging materials had significant effects of the microbial load of the packaged and unpackaged gari (Table 1). The comparison of means (Table 2) showed that there are no significant differences in the microbial load of the gari packaged in polyester and polypropylene bags, the highest load was observed in the unpackaged gari.

The total viable bacterial count increased from about 1 to 10 x 10^4, 15 x 10^4, 30 x 10^4cfg^{-1} and 45 x 10^4cfug^{-1} and the total viable fungal count increased from about 1 to 56 x 10^4cfug^{-1}, 49 x 10^4, 95 x 10^4cfug^{-1} and 220 x 10^4cfug^{-1} in gari packaged in polyester, polypropylene, hessian bags and unpackaged gari respectively. The steady and gradual increase recorded in the total viable bacterial and fungal counts in all the samples in the various packaging materials suggest a favorable micro environmental conditions and nutrient availability. This is attributed to the permeability of the packaging materials to atmospheric gases such as oxygen, carbon dioxide and water vapour.

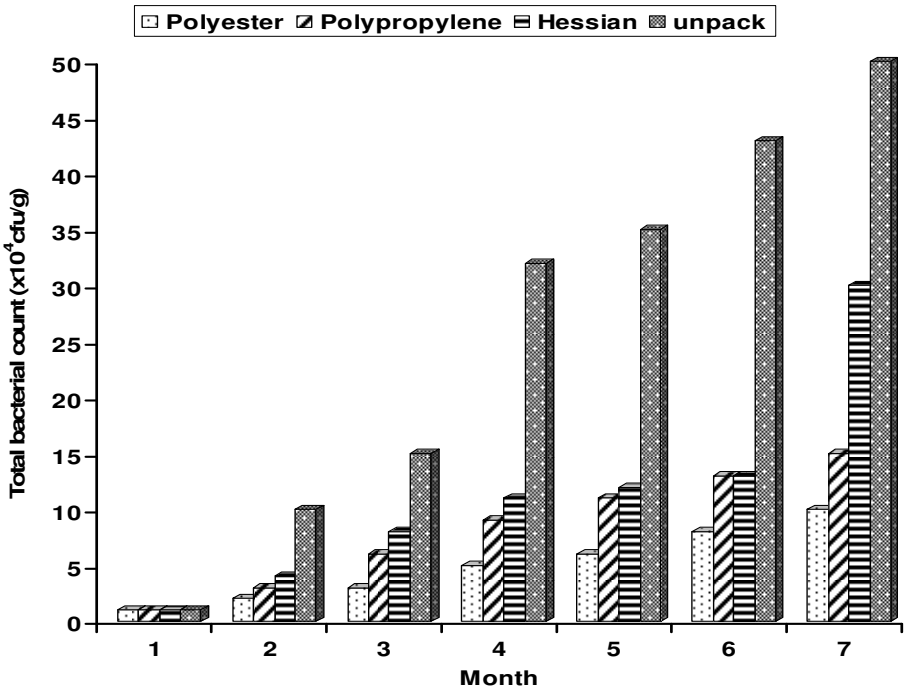

Figure 2. The effect of packaging materials on the total viable bacterial count of packaged gari

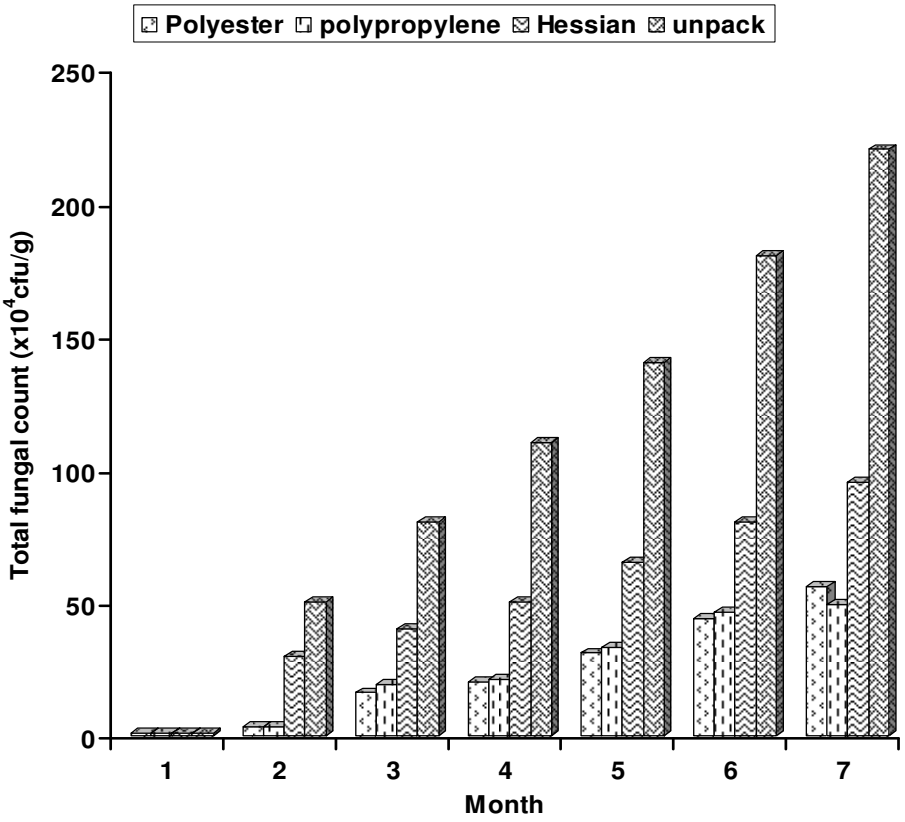

Figure 3. The effect of packaging materials total viable fungal count of packaged gari

Table 1. The ANOVA for total viable fungal and bacterial counts of gari in the selected packaging materials

Property		Sum of Squares	df	Mean Square	F	Sig.
TVFC	Between Groups	105554.036	3	35184.679	21.004	0.000
	Within Groups	134010.112	80	1675.126		
	Total	239564.148	83			
TVBC	Between Groups	5736.429	3	1912.143	17.172	0.000
	Within Groups	8908.217	80	111.353		
	Total	14644.646	83			

Where;

TVFC = Total viable fungi counts

TVBC = Total viable bacteria counts

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Table 2. The mean[1,2] effect of packaging materials on total viable fungal and bacterial counts (x10^{4}cfu/g) of packaged gari

Packaging material	Total viable bacterial count	Total viable fungal count
Polyester	4.88[a]	24.16[a]
Polypropylene	8.16[a]	24.44[a]
Hessian	15.16[b]	51.44[b]
Unpacked	26.44[c]	111.12[c]

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

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 evaluated to be in the order of polypropylene < polyester < hessian bags which in turn enhances the increase in microbial growth of the packaged gari. The agents that contaminate and spoil stored gari are fungi, bacteria, 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 content. The survival of any of these organisms in any stored products depends on whether the intensity or levels of these two variables are conducive.

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 & Ikenebomeh, 2004). In addition the high fungal count compared to the bacterial count was due to the ability of fungi to tolerate and survive in slightly harsh environmental conditions such as low pH and moisture content (Adeyemi, 1976; Ekundayo, 1984; Ogeihor, 2002). However the microbial load at the end of the six month storage period is still within the limits and in agreement with the reports of Ijabadeniyi (2007) while the unpackaged gari was no more microbiologically safe in the third month of storage. 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 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.

Sensory Quality of Gari

The analysis of variance showed that the packaging materials had significant effects on the qualitative attributes of packaged gari (Table 3). The comparison of means is as shown in Table 4. The gari packaged in polyester and polypropylene bags are not significantly different ($p< 0.05$) in terms of the sensory score and general acceptability but are however significantly different from the gari packaged in hessian. The summary of the results of the ten panelists are as shown in Figure 4.

Table 3. The ANOVA for the qualitative attributes of gari in the selected packaging materials

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	819.800	2	409.900	75.907	0.000
Within Groups	469.800	87	5.400		
Total	1289.600	89			

Table 4. The mean[1,2] qualitative attributes of gari in selected packaging materials

Packaging type	Qualitative attributes
Polyester	12.30[a]
Polypropylene	12.50[a]
Hessian	6.00[b]

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

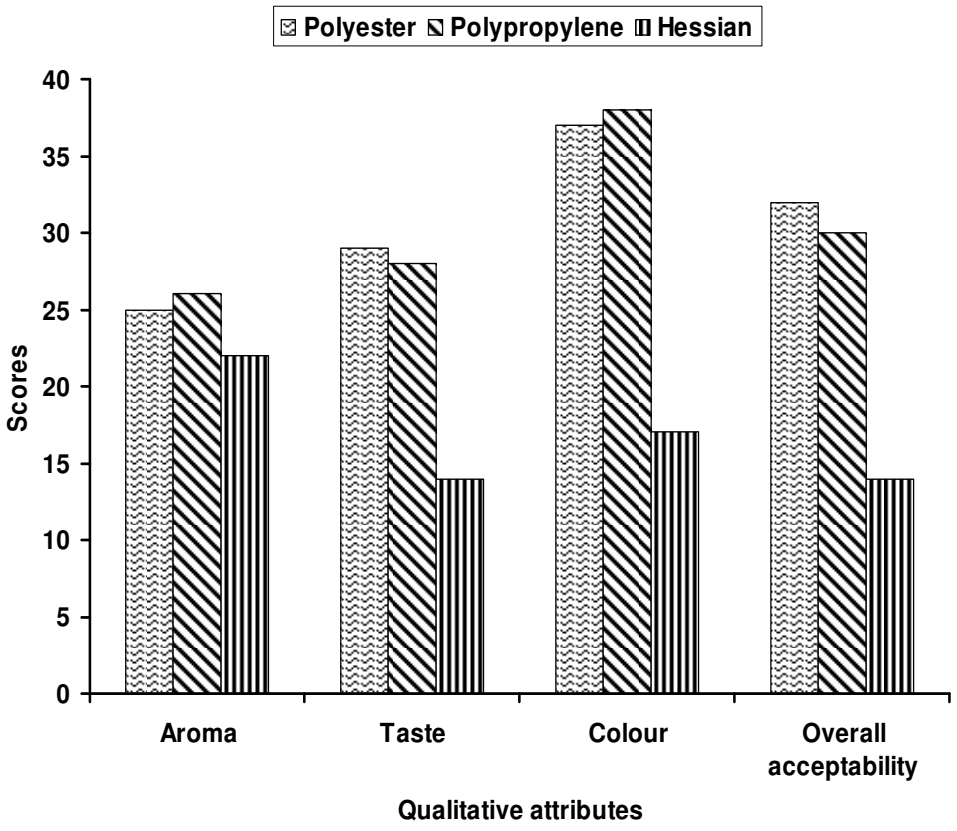

Figure 4. The effect of packaging materials on the sensory score of packaged gari

The sensory score of unpackaged gari was not evaluated due to the presence of visible contaminants seen in the samples to avoid the likelihood of food poisoning of the panelists. Data from the taste panel evaluation indicated that the gari samples are acceptable for one month in gari packaged in polyester and polypropylene while off flavor was noted in hessian bag. Off flavor marked by the low scores was noted from the fifth month in the polyester and polypropylene, while it had become unacceptable in hessian bag by the second month. Similar changes in flavor quality of gari, *lafun* instant pounded yam flour and *elubo*, which had similar processing history, had been reported (Onayemi & Oluwamukomi, 1987).

The results showed that the overall acceptability of the gari packaged in polyester and polypropylene bags had similarly high sensory scores while it was least in gari packaged in hessian bag. This is due to the fact that these packaging materials have lower permeabilities, hence are more moisture proof and airtight. This property will enhance their ability to retain the sensory qualities, while the hessian bag which does not possess these qualities will result in the low acceptability of the packaged gari. The

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various degrees of changes observed in the quality attributes of colour, aroma/flavour, moldiness amongst the different samples maybe partly associated with the migration, permeation, adsorption properties of the packaging materials evaluated and the associated microbes which is similar with previous reports (Linssen & Roozen, 1994).

The overall acceptability scores showed that the polyester and polypropylene bags do not significantly affect the sensory score and general acceptability of gari at this storage conditions. The hessian bag however has significant effect on the sensory scores and overall acceptability of gari at $p < 0.05$ level of significance.

CONCLUSION

It can therefore be concluded that gari may be microbiologically safe and sensorially acceptable for consumption up to six months when packaged in polyester and polypropylene bags but likely unsafe when packaged in hessian bag. It is recommended that gari should not be stored for more than three months when packaged in hessian bag since consumption of gari stored beyond this period may constitute health hazard to it consumers. The use of hessian bag for gari packaging and storage should therefore be discouraged and gari should not be stored in open containers.

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