International Journal of Women in Technical Education and Employment (IJOWITED)
The Federal Polytechnic, Ilaro Chapter
ISSN: 2811-1567. Volume 2 – Issue 2. December 2021
https://fpiwitedjournal.federalpolyilaro.edu.ng

Impact of Selected Packaging Materials on Microbial Assessment and Functional Properties of Cassava Flakes (Gari) During Storage

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ARTICLE HISTORY

Received: November 29, 2021
Revised: December 3, 2021
Accepted: December 15, 2021

Abstract

Gari was wrapped in a hessian jute bag, a woven polyethylene bag, a plastic container, and a high-density polyethylene bag after it was freshly produced. The gari samples were kept at 340°C and 48.6% relative humidity for 8 weeks. The differences in the gari's functional qualities could be due to differences in the quality and permeability of the various packaging materials, which demonstrate an increase in water absorption (240 to 322g/dm3). In h, the bulk density increased from (0.55-0.58(g/dm3) to (0.55-0.58(g/dm3). Swelling capacity rose from (187.33-228.31g/100g) to (187.33-228.31g/100g). During the 8-week storage period, solubility increased (6.55-7.75%) whereas foaming capacity decreased (8.44-4.38%). During an 8-week storage period, the fungus count in various packaging materials grew significantly (0.13103-3.01103logcfu/g), according to microbiological analysis. Total bacterial counts rise from (0.06103logcfu-0.93103logcfu/g) to (0.06103logcfu-0.93103logcfu/g). Gari packed in plastic containers and high-density polyethylene bags is microbiologically safe and acceptable after an 8-week period of storage.

Keywords: Cassava flakes (gari), Storage, functional properties, microbial assessment.

Citation
Adeosun, B.O and Adebisi, K.A. (2021). Impact of Selected Packaging Materials on Microbial Assessment and Functional Properties of Cassava Flakes (Gari) During Storage. *International Journal of Women in Technical Education and Employment (IJOWITED), The Federal Polytechnic, Ilaro Chapter*, 2(2), 86-92.

1. Introduction

Cassava flakes (gari) are fermented, dewatered, and roasted cassava granules that are commonly consumed in the West African sub-region, as well as in Brazil, where it is known as 'farinha de manioca' (Lanc et al., 2001). Many Nigerian households follow this diet, which provides approximately 11.835kJ per person per day (Osho, 2003). Gari is of poor quality and has a low protein content, so ongoing research on cheaper and better ways to enrich the product is needed to increase its appeal in terms of price and nutritional quality. The crude protein content of locally produced gari can be as low as 1.03 percent, while cyanide levels vary based on the processing method, variety, and location (0 – 32mg HCN equivalent Kg-1). Gari manufacturing is time-consuming and inconvenient (Ogiehor & Ikenebomeh, 2006). The techniques of production differ from one location to the next, resulting in products of varying quality. Given the time-consuming nature of the manufacturing process, the necessity to provide finished products to places with big buyers, the relevance of gari in dietary intake, and the need to meet rising international demand. (2006) (Ogiehor & Ikenebomeh). The purpose of packaging is to give food or any other product with a safe and convenient environment in which to safeguard it from physical, microbiological, and chemical deterioration (Komolafe, 2005). Advances in packaging materials and procedures have allowed the food industry to create items that can be stored, distributed, and promoted for several weeks to months without losing their freshness. As a result, consumers are the best tool for assessing the sensory shelf life of food products (Hough, et al., 2003). As a result, determining and identifying appropriate packaging materials that will improve the overall quality of gari during storage is crucial.

2. Materials and Methods

Local producers in Apata, Nigeria's Ibadan Oyo state, provided freshly processed gari samples. After frying, the samples were collected aseptically and cooled on well-clean surfaces. Packaging materials employed in the study were hessian jute bags, weave polypropylene, plastic container packaging materials, and high-density polypropylene. The market gari was aseptically weighed (5 kg/pack) and placed in Polythene bags, Hessian jute bags, low density polypropylene bags, and plastic buckets. All packaging materials were sterilized with 95 percent ethanol prior to packaging. Following that, paper tape was used to hermetically seal the individual packs. For two months, all packaged samples were maintained at room temperature (30± 2°C) in the laboratory.

Functional Properties

Absorption of Water and Oil Capacities were determined using Onwuka (2005) approach, bulk density using Nwanekezi *et al., (*2001) method, swelling volume, swelling power, and solubility using Onwuka (2005) method.

Microbial Assessment

The microbial loads of newly made and stored Gari were tested in various packaging materials. Microbiological analyses were carried out according to Oluwole *et al.,* (2013). With a sterile mortar and pestle, 1 g of sample was weighed and crushed to powder. To prepare the stock, it was placed in a sterile test tube and homogenized with 10 ml of sterile distilled water. In sterile distilled water, homogenate was serially diluted to 10^2. Using the pour plate method, 0.1ml aliquots of appropriate dilutions were inoculated onto Nutrient agar, MacConkey agar, and Potato Dextrose agar plates, respectively, for total aerobic plate count, coliform count, and fungal counts. After allowing the plates to set, they were incubated at 37°C for 48 hours. Potato Dextrose Agar (PDA) plates, on the other hand, were incubated for 72 hours at 25°C. The culture plates were checked for enumeration and identification of colonies enumerated at the conclusion of each incubation period.

Enumeration and Identification of microbial Isolates

A digital colony counter was used to count colonies at the end of each incubation period, and total microbial load was expressed as colony forming units per gram of sample. Until described, pure cultures of isolates acquired by repeated subculturing were stored on slants at 4ºC. Bacterial isolates were identified using Bergey's Manual of Determinative Bacteriology and their Gram-stain response and biochemical test. Based on morphological traits and microscope testing, fungal isolates were identified (Tsuneo,2010).

Statistical Analysis

For each sample, all analyses were performed in duplicate. The study's data was subjected to an analysis of variance (ANOVA). Duncan Multiple Range Test (DMRT) at 5% level ($P \leq 0.5$) will be used to differentiate differences between means.

3. Results and Discussion

Table 1 shows the functional qualities of newly made and stored Gari in various packing materials. The bulk density of fresh Gari decreased from 0.55 g/dm3 to 0.54 g/dm3 in samples A and C, 0.52 g/dm3 in sample B, and 0.57 g/dm3 in sample D, respectively. Sample D had the greatest growth, while sample B had the smallest. After two weeks of storage, there was no significant ($p \leq 0.5$) increase in bulk density. The bulk density of samples A, D, and B, C increased after 4 weeks of storage, with values of 0.56 g/dm3 and 0.57 g/dm3 correspondingly. There was no statistically significant ($p \leq 0.5$) increase in the number of samples. The bulk

density of all the samples increased after 6 and 8 weeks of storage, with values ranging from 0.56 g/dm3 to 0.58 g/dm3 respectively. Gari samples in various packaging with a range of bulk densities. Water absorption results in a 220%, 267% rise in fresh Gari in sample A, 312% in sample B, 291% in sample C, and 320% in sample D, respectively. Sample D had the highest increase, while sample A had the lowest. After two weeks of storage, all of the samples had significant ($p \leq 0.5$) improvements in water absorption capacity. Water absorption capacity increased from sample A to D after 4 weeks, with values ranging from 268% to 322%, with sample D having the highest increase and sample A having the lowest. All of the samples showed a significant ($p \leq 0.5$) increase. At 6 weeks, all of the samples increased from 263% to 306%, with sample D having the biggest rise and sample A having the lowest. In samples A, B, and C, there was no significant ($p \leq 0.5$) increase. There was also an increase in all of the variables at 8 weeks. The water absorption capacity of all samples was not significantly different ($p \leq 0.5$). The water absorption capacity values obtained in this investigation were higher than those reported by Adebowale et al. for all treatments (2008). Swelling capacity increased from 187.33 g/100g in fresh Gari sample to 200.3 g/100g in sample A, 213.33 g/100g in B, 218.35 g/100g in C, and 196 g/100g in sample D. Sample C showed the greatest rise, whereas sample D showed the smallest. At 4 weeks, there was a substantial ($p \leq 0.5$) rise in the swelling capacity of samples, as well as an increase in all sample values, which ranged from 201 percent g/100g to 228 g/100g. There was also an increase in all the samples at 6 and 8 weeks, ranging from 196 g/100g to 214.66 g/100g and 195.66 g/100g to 212.33%, respectively. When compared to fresh Gari, the solubility of the Gari samples held in various packaging materials increased slightly. Falade and Okafor (Falade & Okafor, 2013). The Gari samples' foaming capacity in various packing materials is lower than Awolu's claimed values (2017). Foaming capacity can be impacted by a number of elements, according to Onimawo and Egbekun (1998), including temperature, pH, salt content, protein type, and preparation process.

Table 1: Functional properties of stored *Gari* in different packaging materials

Samples	Bulk Density (g/dm^3)	Water Adsorption Capacity (%)	Foaming Capacity (%)	Swelling Capacity (g/100 g)	Solubility (%)
Fresh	0.55±0.03	240±0.08	8.44±0.05	187.33±0.03	6.55±0.07
2 Weeks of storage					
A	0.53 ± 0.01^{a}	267 ± 0.05^{a}	6.69 ± 0.63^{b}	200.31 ± 3.21^{a}	7.15 ± 0.05^{b}
B	0.52 ± 0.08^{a}	312 ± 0.03^{c}	7.56 ± 0.34^{c}	213.33 ± 2.08^{b}	6.83 ± 0.07^{a}
C	0.53 ± 0.02^{a}	291 ± 0.03^{b}	5.99 ± 0.63^{a}	218.35 ± 1.53^{b}	7.75 ± 0.05^{c}
D	0.54 ± 0.01^{a}	320 ± 0.04^{d}	6.03 ± 0.12^{b}	196 ± 3.45^{a}	7 ± 0.05^{a}
4 Weeks of storage					
A	0.57 ± 0.07^{a}	268 ± 0.03^{a}	5.11 ± 0.85^{b}	205.3 ± 3.05^{a}	7.25 ± 0.05^{b}
B	0.56 ± 0.02^{a}	312 ± 0.06^{c}	5.77 ± 0.69^{d}	222.7 ± 3.06^{b}	6.9 ± 0.05^{a}
C	0.56 ± 0.04^{a}	299 ± 0.03^{b}	4.48 ± 0.28^{a}	228.31 ± 1.53^{c}	7.65 ± 0.05^{c}
D	0.57 ± 0.04^{a}	322 ± 0.03^{d}	5.45 ± 0.28^{c}	201 ± 2.46^{a}	6.9 ± 0.05^{a}
6 Weeks of storage					

A	0.58±0.05[a]	263±0.02[a]	5.39±0.09[d]	198±2.00[a]	7.16±0.07[b]
B	0.56±0.01[a]	299±0.02[c]	5.15±0.30[c]	205.33±4.04[b]	6.85±0.05[a]
C	0.57±0.03[a]	283±0.05[b]	4.48±0.39[a]	214.66±1.52[c]	7.55±0.05[c]
D	0.57±0.05[a]	306±0.07[d]	4.83±0.39[b]	196±2.64[a]	6.87±0.05[a]
8 Weeks of storage					
A	0.58±0.02[a]	256±0.02[a]	4.67±0.23[b]	195.66±1.53[b]	7.11±0.07[b]
B	0.56±0.03[a]	295±0.01[c]	4.59±0.15[b]	204±1[c]	6.8±0.05[a]
C	0.57±0.04[a]	283±0.01[b]	4.38±0.24[a]	212.33±1.52[d]	7.53±0.02[c]
D	0.57±0.01[a]	299±0.01[c]	4.34±0.23[a]	193.67±2.08[a]	6.83±0.02[a]

Values represent mean and standard deviation, means with different superscript within a column are significantly different ($p \leq 0.05$)

A- *Gari* stored in hessian jute bag

B- *Gari* stored in woven polyethylene

C- *Gari* stored in High density polyethylene

D- *Gari* stored in plastic container

Microbial Assessment

Table 2 shows the findings of the microbiological characteristics of preserved Gari in various packing materials. The freshly made Gari has a total live, fungus, and lactic acid bacteria (LAB) count of 0.060.17log cfu/g. In the freshly produced Gari, no coliform, salmonella, or staphylococcus bacteria were found. At 2 weeks of storage, the total viable count increased significantly ($p \leq 0.5$) with values ranging from 0.48 to 0.58 log cfu/g, with the biggest rise in sample A and the lowest in sample C. Sample A had the highest total viable count at 4 weeks, while sample D had the lowest. After 6 weeks of storage, all samples increased from 0.64 0.79 log cfu/g to 0.73 0.93 log cfu/g after 8 weeks of storage. The fungus count revealed an increase in the fresh sample, with a value of 0.13 log cfu/g× 0.20 log cfu/g in sample A, 0.31 log cfu/g in B, 0.37 log cfu/g in C and 0.22 log cfu/g in D respectively. Sample C had the fastest growth, whereas sample D had the slowest. From 4 to 8 weeks of storage, there was a significant (p0.5) rise in fungus count, with values ranging from 0.270.34 log cfu/g, 1.321.41 log cfu/g, and 2.53.01 log cfu/g, respectively. The lactic acid bacterial result likewise shows a rise in fresh Gari with values of 0.17 log cfu/g 0.24 log cfu/g for sample A, 0.24 log cfu/g for sample B, 0.20 log cfu/g for sample C, and 0.18 log cfu/g for sample D. At 2 to 4 weeks of storage, there was no significant (p0.5) rise in (LAC). At 6 to 8 weeks of storage, LAC increased from 0.50 to 0.57 log cfu/g and 1.11 to 1.20 log cfu/g, respectively. The increase in total viable bacterial, staphylococcus, lactic acid bacterial, and fungal counts in all of the samples in the various packaging materials implies that environmental conditions are favorable. Ogiehor and Ikenebomeh (2006).

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Table 2: Microbial load of stored *Gari* in different packaging materials

Samples	Total Viable Count (log cfu/g)	Coliform Count (log cfu/g)	*Salmonella* (log cfu/g)	*Staphylococcus* (log cfu/g)	Fungi Count (log cfu/g)	LAB Count (log cfu/g)
Fresh	0.06±0.40	ND	ND	ND	0.13±0.01	0.17±0.20
2 Weeks of storage						
A	0.54±0.04^{b}	0.06±0.02^{a}	ND	0.04±0.02^{a}	0.2±0.02^{a}	0.24±0.02^{b}
B	0.49±0.05^{a}	0.04±0.02^{a}	ND	ND	0.31±0.02^{b}	0.20±0.02^{a}
C	0.42±0.03^{c}	ND	ND	0.06±0.02^{b}	0.37±0.03^{c}	0.34±0.03^{c}
D	0.48±0.03^{c}	ND	ND	0.03±0.01^{a}	0.22±0.03^{b}	0.18±0.04^{a}
4 Weeks of storage						
A	0.68±0.03^{ab}	0.07±0.01^{b}	ND	0.05±0.01^{b}	0.29±0.04^{a}	0.25±0.03^{a}
B	0.54±0.04^{a}	0.04±0.01^{a}	ND	0.01±0.03^{a}	0.27±0.03^{a}	0.21±0.02^{a}
C	0.63±0.02^{b}	0.02±0.01^{a}	ND	0.03±0.01^{a}	0.34±0.01^{b}	0.35±0.02^{b}
D	0.53±0.03^{a}	0.03±0.01^{a}	ND	0.02±0.01^{a}	0.28±0.02^{a}	0.21±0.04^{a}
6 Weeks of storage						
A	0.79±0.04^{b}	0.04±0.01^{a}	ND	0.04±0.01^{b}	1.35±0.03^{a}	0.50±0.14^{a}
B	0.69±0.02^{a}	0.03±0.01^{a}	ND	0.02±0.01^{a}	1.32±0.02^{a}	0.56±0.03^{b}
C	0.74±0.02^{b}	0.01±0.00^{a}	ND	0.03±0.01^{a}	1.41±0.03^{b}	0.57±0.02^{b}
D	0.64±0.04^{a}	0.03±0.01^{a}	ND	0.02±0.01^{a}	1.35±0.03^{a}	0.50±0.02^{a}
8 Weeks of storage						
A	0.93±0.03^{b}	0.06±0.01^{b}	ND	0.07±0.01^{b}	3.01±0.15^{a}	1.20±0.01^{b}
B	0.73±0.04^{a}	0.05±0.01^{b}	ND	0.04±0.01^{a}	2.5±0.1^{a}	1.14±0.01^{a}
C	0.86±0.02^{b}	0.04±0.01^{a}	ND	0.05±0.01^{ab}	2.77±0.15^{b}	1.13±0.01^{a}
D	0.77±0.01^{a}	0.03±0.01^{a}	ND	0.03±0.01^{a}	2.63±0.25^{a}	1.11±0.02^{a}

Values represent mean and standard deviation, means with different superscript within a column are significantly different ($p \leq 0.05$)

A- *Gari* stored in hessian jute bag:
B- *Gari* stored in weavon polyethylene bag
C - *Gari* stored in High density polyethylene bag.
D- *Gari* stored in plastic container

4. Conclusion

Different packaging materials have an effect on the microbiological quality and functional qualities of Gari stored under tropical environmental settings, according to this study. The information gathered could be helpful in the handling and storage of Gari. As a result, Gari, when stored in a plastic container and a polyethylene bag, may be microbiologically safe for eating for up to two months.

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