EFFECT OF PACKAGING MATERIALS ON STORAGE PROPERTIES OF GARRI FROM TME 419-CASSAVA VARIETY IN SOUTHERN KADUNA, NIGERIA

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Abstract: This study is aimed at determining the best storage conditions and the suitable packaging materials for Garri from TME 419 in southern part of Kaduna State. The cassava variety TME 419 was processed mechanically, though it was manually fried into garri and stored with three different packaging materials such as low-density polyethylene (LDPE) bags, high density polyethylene (HDPE) bags and plastics buckets (PB) for four (4) months. The packaged garri were stored in three (3) different local government areas of the state: Sanga, Kagarko and Chikun for four (4) months. The experiment was designed as $3 \times 3 \times 4$ factorial arrangement in a Completely Randomized Design (CRD) and the experiment was examined at 2 levels. The data collected were analyzed using mean and analysis of variance (ANOVA). The results revealed the average moisture content in the packaging materials at 11.5%, 12.02% and 10.2% for LDPE bags, HDPE bags and PB respectively. The storage conditions i.e the temperature and relative humidity in all the three locations have the average values of (27.5 ^{o}C, 73.8% RH) which indicated the lowest moisture content in both packaging materials in the three location of the study area that gives a clear indication of longer shelf life and stability of garri. The findings revealed that plastic bucket was the best in keeping the quality attributes. It is recommended that cassava variety TME 419 should be properly processed into garri and stored with good packaging materials, either plastic bucket (PB) or high density polyethyethylene (HDPE) bags.

Keywords: Cassava (TME 419), Garri, Location, packaging materials, Storage Conditions

INTRODUCTION

Food is any substance consumed to provide nutritional support for an organism. Food is usually meant for human beings, animals and plants and should contain the essential nutrients such as carbohydrates, fats, proteins, vitamins or minerals. Food substances are digested by an organism and assimilated by the organism's cells to provide energy. However, preservation of food remains a big problem, affecting many crops including cassava (Siracusa, 2012).

Cassava (*Manihot esculenta crantz*) is a tuberous root crop grown in the tropics between latitudes 30°N and 30°S, with low cost of vegetative propagation. It belongs to the family of *Euphorbiaceae* and originated from South America (Nhassico *et al*, 2008). Cassava is a major staple crop in Nigeria, as cassava and its product are found in the daily meals of Nigerians. It has five primary industrial products which stand out to be very important for Nigerians, they are; native starch, garri, cassava flour, crude ethanol and animal feed (cassava chips pellets) (Onyenwoke and Simonya, 2014).

The pre-process storage is the main problem of cassava utilization on an industrial scale. Physiological deterioration occurs in cassava root 2-3 days after harvesting, followed by microbial deterioration 3-5 days thereafter. That result to root discoloration and reduces

the economic value of the root and most especially in the production of garri and *fufu*. Several modern storage methods have been developed to control the deterioration like refrigeration, freezing, waxing and chemical protection. While the traditional methods include, leaving roots, storing in trenches etc (Onyewoke & Simonya, 2014).

However, most of the modern methods may not be economically viable for storing of cassava roots prior to processing into major products like garri and fufu (Karim *et al*, 2009). Packaging materials used for the storage of garri products include plastic containers, polymeric paper bags, sack bags and polyethene bags. The packaging type and storage conditions applied will affect the quality, shelf life and safety of garri and other food products (Opara and Mditshwa, 2013). When packaging films are used, the permeability of the film to water vapour and gases is particularly important, especially with regard to the shelf life of dry products (Siracusa, 2012). The storage of agricultural raw materials is an essential aspect of food processing that ensures food remains available even in the time of scarcity (Osunde and Fadeyibi, 2011).

This research work is aimed at determining the best storage conditions and the suitable packaging materials for garri from TME 419 in three selected local government areas of Kauna State that least comprises its energy content and proximate compositions.

The loss of quality and quantity of garri during storage and packaging is a topic of concern because it affects the Farmers and the individuals that are involved in such enterprise. Garri is lost during storage due to the poor storage packaging materials used, storage conditions that have to do with location, time and moisture content. The ambient temperature of these locations can also affect the internal storage condition of any materials stored in various degrees depending on the location. Studies have also revealed that the reaction of garri to any chosen storage conditions would vary with location especially on the basis of moisture contents. Moisture content is a very important determinant of the microbial deterioration in stored garri. Microbial deterioration is still possible during storage and it affects the energy content in garri. The effects of location and time dependence on the packaging materials and storage properties of garri will lead to the loss of quality and quantity of garri, reduce its shelf life, affect the energy content and the economy of the farmers or the individuals that are involved in that value chain.

The storability of a product in any packaging materials will depend on the location, time and the rate at which the packaging materials takes in moisture vapour into the product under the storage environment (Osunde and Fabiyi, 2011). Therefore, the knowledge of the location and time dependent effects of packaging materials and storage properties of garri from TME 419 cassava variety in three (3) three Local Government Areas (Sanga, Kagarko and Chikun) of Kaduna State is very important and cannot be overemphasized.

The processing of cassava to garri is one of the major cottage industries in Kaduna State. If this product (garri) is not properly processed, well packaged and preserved, it makes the products unsafe for consumption with minimal energy content. Hence it was reasonable to find storage conditions for garri that must be suitable on the basis of specific locations.

In terms of the shelf life of the products, good packaging materials and packaging procedure tends to extend the life span of garri when it is not consumed after processing, thereby preserving the market value of the product. This study intends to solve this problem for the selected local

government areas and the entire Kaduna State in general.

MATERIALS AND METHODS

The study areas were the three selected local government areas of Kaduna state, which are Sanga, Kagarko and Chikun. They are located in the southern part of Kaduna state in the north west region of Nigeria on latitude 10°31'20.06" N and longitude 7°26'17.81" E. The farming population around the study area is about 1,133,000. It is a tropical continental climate with two distinct seasonal climates, dry and rainy season. (Usman *et al*., 2017). The rainy season (April to October) and the dry season (November to March). The mean annual rainfall ranges from 1,016mm to 1,524mm. The climatic pattern of Kaduna State which is in Northern Guinea savanna vegetation zone of Nigeria is suitable for the cultivation of subsistent and cash crops (Usman *et al.*, 2017). The study area is shown in figure 1.

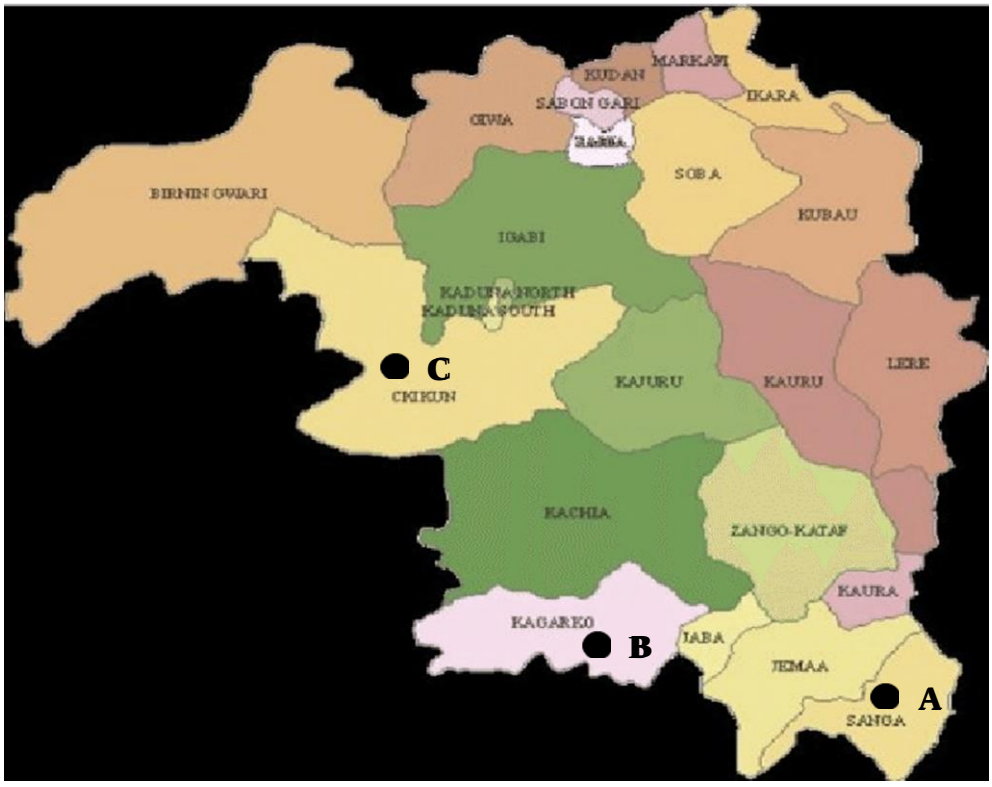

Figure 1: The locations of the study areas are marked A, B and C on the map.
Source: (Usman *et al.*, 2017)

The following materials were used for the processing of cassava TME 419 into garri: 100 kg of cassava variety (TME 419), cassava grating machine, hydraulic press, fermentation rack, fryers, jute bags, container and sieve.

The following materials were used for packaging of produced garri:

I. LDPE – Nylon bag.
II. HDPE – Woven plastic sack.
III. PB.

The following materials were used for determination of storage properties, Thermometer, hygrometer, White and yellow garri, weighing balance, moisture meter, conical flask, oven, desiccators, other laboratory apparatus and some laboratory reagents.

100kg of the cassava variety TME 419 was used to prepare garri according to the procedure recommended by Oyeyinka *et al*, (2019). The roots were peeled and grated to pulp using diesel powered grating machine. The pulp was packed into a jute bag and dewatered. The pulp was fermented for 5 days, sieved to remove coarse fibre and roasted/fried to obtain garri.

Furthermore, half of the quantity of garri produced from TME 419 cassava variety was set aside in a container and two litres of palm oil was sprinkled on it and then properly mixed to produce the yellow sample of the garri.

Three (3) sets of the two samples of garri (i.e., white and yellow) was prepared and labeled with different packaging materials (Aw_1, Ay_1), (Bw_1, By_1) and (Cw_1, Cy_1) in the three locations of the selected local government areas which are as follows:

A----------Sanga.

B----------Kagarko.

C----------Chikun.

Where:

white sample of the garri was represented by W_1

yellow sample of the garri was represented by Y_1

The same is applicable for the other two locations, that is, B and C.

The fresh processed garri, both white and yellow was weighed (4.0kg) and packaged in the packaging materials, which includes:

I. Low density polyethylene bags (LDPE) – Nylon bag.
II. High density polyethylene bags (HDPE) – Woven plastic sack.
III. Plastic buckets.

The samples (packaged garri) in the selected locations (the LGAs) were stored for sixteen weeks (16) weeks i.e 4 months in each location.

Replicate measurement of the samples was taken on weekly basis and recorded in the different locations. These measurements are: moisture content, temperature and relative humidity.

While the proximate analysis was carried out on the samples on monthly basis and recorded for the different locations and the microbial analysis were also carried out on monthly basis on the samples in the three (3) different locations. The temperature was measured using a digital thermometer. Humidity refers to the amount of water vapour in the air. Relative humidity (RH) compares the current amount of water in the air (in g/m^3) at a given temperature to the maximum possible water content at that temperature. The relative humidity was

measured using a digital hygrometer, (Usman *et al.*, 2017).

Four grams (4 g) of each sample was weighed in a crucible. The crucible and its content were dried in the oven at 105°C for 3 hours. It was cooled in a desiccator and re-weighed. The weight was recorded while the sample was returned to the oven for further drying.

The drying, cooling and weighing was repeatedly done until a constant weight is obtained. Percentage (%) moisture content was calculated (Olaleye *et al*., 2013) as;

$$\%\text{moisture} = \left(\frac{W_2 - W_3}{W_3 - W_1}\right) \times 100\% \quad \text{(i)}$$

Where:

W_1 is Weight of dried crucible.

W_2 is Weight of crucible + sample before drying.

W_3 is Weight of crucible + sample after drying to constant weight.

Experimental design

The experiment was designed as $3 \times 3 \times 4$ factorial arrangement in a 3 CRD. The experiment was exermined at 2 levels i.e., white and yellow garri.

The first factor is "Location" which was examined at 3 levels, which Sanga, Kagarko and Chikun Local Government Areas.

The second factor is storage packaging materials i.e., LDPE, HDPE and PB, while

The third factors is time which is 4 months:

Statistical Analysis

The data collected was analyzed using SPSS version 21 software to examine the various effects of time and storage material on garri quality**.**

RESULTS AND DISCUSSION

Table 1. Effect of Variation of Moisture Content with Location and packaging Materials for Location A (Sanga) (White Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	20.5 ± 0.15^{ab}	24.6± 0.22^{ac}	26.5±0.14^{cd}	23.3±0.16^{de}
	HDPE	20.5 ± 0.15^{ab}	24.6± 0.22^{ac}	26.5±0.14^{cd}	23.3±0.16^{de}
	PB	20.5 ± 0.15^{ab}	24.6± 0.22^{ac}	26.5±0.14^{cd}	23.3±0.16^{de}
Relative Humidity (%)	LDPE	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	70 ±0.45^{ab}	69.0 ±0.40^{b}
	HDPE	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	70 ±0.45^{ab}	69.0 ±0.40^{b}
	PB	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	70 ±0.45^{ab}	69.0 ±0.40^{b}
Moisture (%)	LDPE	10.2 ± 0.13^{ab}	11.5± 0.23^{ac}	11.9±0.02^{cd}	12.0±0.02^{cd}
	HDPE	11.6 ±0.45^{bc}	11.8 ± 0.11^{ac}	12.0±0.03^{cd}	11.0±0.03^{cd}
	PB	10.2 ± 0.08^{a}	10.7 ± 0.35^{bc}	11.5± 0.02^{d}	10.0± 0.02^{d}

Values are given as means ± standard deviation.

Different letters in columns are significantly different ($p < 0.05$).

Table 2: Effect of Variation of Moisture Content with Location and packaging Materials for Location A (Sanga) (Yellow Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	30.5 ± 0.15^{ab}	30.6± 0.22^{ac}	26.5±0.14^{cd}	25.3±0.11^{de}
	HDPE	30.5 ± 0.15^{ab}	30.6± 0.22^{ac}	26.5±0.14^{cd}	25.3±0.11^{de}
	PB	30.5 ± 0.15^{ab}	30.6± 0.22^{ac}	26.5±0.14^{cd}	25.3±0.11^{de}
Relative Humidity (%)	LDPE	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	78 ±0.45^{ab}	77.1 ±0.40^{b}
	HDPE	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	78 ±0.45^{ab}	77.1 ±0.40^{b}
	PB	70.3± 0.14^{a}	68.8 ± 0.25^{abc}	78 ±0.45^{ab}	77.1 ±0.40^{b}
Moisture (%)	LDPE	11.1 ± 0.13^{ab}	11.5± 0.23^{ac}	12.0±0.02^{cd}	11.89±0.02^{cd}
	HDPE	11.6 ±0.45^{bc}	11.8 ± 0.11^{ac}	12.0±0.03^{cd}	11.20±0.03^{cd}
	PB	10.5 ± 0.08 ^{a}	10.7 ± 0.35^{bc}	11.5± 0.02^{d}	11.00± 0.02^{d}

Values are given as means ± standard deviation.
Different letters in columns are significantly different ($p < 0.05$).

Table 3: Effect of Variation of Moisture Content with Location and packaging Materials for Location B (KAGARKO) (White Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	28.0±0.20^{de}
	HDPE	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	28.0±0.20^{de}
	PB	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	28.0±0.20^{de}
Relative Humidity (%)	LDPE	71.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	72.3 ±0.45^{ab}
	HDPE	71.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	72.3 ±0.45^{ab}
	PB	71.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	72.3 ±0.45^{ab}
Moisture (%)	LDPE	11.4 ± 0.13^{ab}	11.5± 0.23^{ac}	11.9±0.02^{cd}	13.0±0.02^{cd}
	HDPE	11.3 ±0.45^{bc}	11.7 ± 0.11^{ac}	11.9±0.03^{cd}	12.10±0.03^{cd}
	PB	10.5 ± 0.08^{a}	10.5 ± 0.35^{bc}	11.0± 0.02^{d}	11.79± 0.02^{d}

Values are given as means ± standard deviation.
Different letters in columns are significantly different ($p < 0.05$).

Table 4: Effect of Variation of Moisture Content with Location and packaging Materials for Location B (KAGARKO) (Yellow Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	30.0±0.19^{de}
	HDPE	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	30.0±0.19^{de}
	PB	27.5 ± 0.15^{ab}	30.6± 0.22^{ac}	29±0.14^{cd}	30.0±0.19^{de}
Relative Humidity (%)	LDPE	73.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	70.2 ±0.11^{b}
	HDPE	73.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	70.2 ±0.11^{b}
	PB	73.8± 0.14^{a}	69.8 ± 0.25^{abc}	73.3 ±0.45^{ab}	70.2 ±0.11^{b}
Moisture (%)	LDPE	11.4 ± 0.13^{ab}	11.5± 0.23^{ac}	11.9±0.02^{cd}	14.0±0.02^{cd}
	HDPE	11.3 ±0.45^{bc}	11.7 ± 0.11^{ac}	11.9±0.03^{cd}	12.0±0.03^{cd}
	PB	10.2 ± 0.08^{a}	10.5 ± 0.35^{bc}	11.0± 0.02^{d}	11.50± 0.02^{d}

Values are given as means ± standard deviation.
Different letters in columns are significantly different ($p < 0.05$).

Table 5: Effect of Variation of Moisture Content with Location and packaging Materials for Location C (CHIKUN) (White Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	26.5±0.17^{de}
	HDPE	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	26.5±0.17^{de}
	PB	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	26.5±0.17^{de}
Relative Humidity (%)	LDPE	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.0 ±0.55^{b}
	HDPE	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.0 ±0.55^{b}
	PB	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.0 ±0.55^{b}
Moisture (%)	LDPE	11.7 ± 0.13^{ab}	12.5± 0.23^{ac}	12.6±0.02^{cd}	11.50±0.02^{cd}
	HDPE	11.8± 0.13^{ab}	11.7 ± 0.11^{ac}	12.9±0.03^{cd}	10.50±0.03^{cd}
	PB	10.1 ± 0.08 ^{a}	10.5 ± 0	11.0± 0.02^{d}	10.20± 0.02^{d}

Values are given as means ± standard deviation.
Different letters in columns are significantly different ($p < 0.05$).

Table 6: Effect of Variation of Moisture Content with Location and packaging Materials for Location C (CHIKUN) (Yellow Garri)

Storage Properties	Package type	Week 4	Week 8	Week 12	Week 16
Temperature (^{O}C)	LDPE	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	25.9±0.18^{de}
	HDPE	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	25.9±0.18^{de}
	PB	28.3 ± 0.15^{ab}	29.1± 0.22^{ac}	27.2±0.14^{cd}	25.9±0.18^{de}
Relative Humidity (%)	LDPE	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.00 ±0.58^{b}
	HDPE	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.00 ±0.58^{b}
	PB	75.8± 0.14^{a}	73 ± 0.25^{abc}	77.3 ±0.45^{ab}	79.00 ±0.58^{b}
Moisture (%)	LDPE	11.7 ± 0.13^{ab}	12.5± 0.23^{ac}	12.6±0.02^{cd}	12.50±0.02^{cd}
	HDPE	11.8± 0.13^{ab}	11.7 ± 0.11^{ac}	12.9±0.03^{cd}	11.78±0.03^{cd}
	PB	10.3 ± 0.08 ^{a}	10.5 ± 0	11.0± 0.02^{d}	11.05± 0.02^{d}

Values are given as means ± standard deviation.
Different letters in columns are significantly different ($p < 0.05$).

DISCUSSION

Temperature

The temperature of the study areas was determined and they range from (20.5^{o}C to 30.6^{o}C) as shown in Table 1 to 6 above. Statistical analysis in Table 3, 4, and 5, revealed that, there is a significant difference between the temperatures of the three locations i.e. A (Sanga), B (Kagarko) and C (Chikun). However, we recorded the lowest temperatures from week 1 to 4 (20.5^{o}C) and the temperature slightly increases to 26.5^{o}C across week 16 which shows that it is within the 27°C according to (Adejumo & Raji, 2012). This shows that the product, i.e., garri produced from TME 419 can be stored for a longer period of time without deterioration or spoilage. Though with little variation in location B and C as stated in the tables above. The results above clearly indicated a longer shelf-life stability of the garri stored in location A than B and C.

Relative humidity

The relative humidity of the study area was determined and it ranges from (68.8% to 78.0%) as show in Table 1 to 6 above. the storage conditions, temperature and relative humidity (27.5^{o}c, 73.8%) gave the lowest moisture content in both the packaging materials in the three location of the study area which gives a clear indication of longer shelf-life stability of the garri stored in those areas. Statistically, there is no significant difference in the relative humidity in the three locations. (Adejumo & Raji, 2012).

Moisture contents:

The moisture content was determined on the weekly basis for the sixteen weeks period of the research and it ranges from (10.0% to 14.0%) as shown in Table 1 to 6 above. It was determined on the basis of location, time packaging materials and the type of garri (white and yellow). The results reveal the differences in the storage location in which location A (Sanga) has the lowest moisture content ranging from 10.2% to 12.0% for white garri and 10.5% to 12.0% for yellow garri. For location C, (Chikun) has the lowest moisture content of 10.1% to 12.9% for white and 10.3% to 12.9% for yellow while for location B (Kagarko) has 10.5% to 13.0% for white garri and 10.2% to 14.0 for yellow garri. Therefore, location A and C are the safest for storage of garri (TME 419) on the basis of location and time. The moisture content was within the recommended moisture range of 12.0% for garri product and within the range reported in literatures for garri (Charles *et. al*., 2005, Shobha *et al.*, 2012, Falade *et al.,* 2014 and Oluwamukomi, 2015). However, the statistical analysis revealed that, there is no significant difference in the moisture content of the three locations of the study area as shown in Table 1 to 6 but there was significant difference in the moisture content of the garri stored in the packaging materials across the locations. The Plastic Bucket (PB) has low moisture content in both white and yellow garri as shown in the tables above while the low-density polyethylene bags and high-density polyethylene bags have more moisture content value as shown in the table above for both white and yellow garri.

Based on the outcome of this research, quality attributed to garri from TME 419 can be significantly influenced by the different packaging materials used in the storage and the storage conditions (properties) These findings also reveals that all packaging materials used for the storage of garri, stored the garri well for the period of this study, but plastic bucket was still the best in keeping the quality attributes throughout the storage period, as the average moisture content was as low as 10.2% at the end of the sixteen weeks. Furthermore, the plastic bucket cannot easily take in or absorb moisture vapour into the product under the storage environment. The low moisture content will

prevent the growth and development of micro-organism in the garri stored in the plastic bucket.

CONCLUSION

Based on the outcome of this research, the following conclusions were made:

i. The quality attributed to garri from TME 419 can be significantly influenced by the different packaging materials used in the storage and the storage conditions (properties).
ii. The storage conditions, temperature and relative humidity (27.5^{o}C, 73.8%RH) gave the lowest moisture content in both the packaging materials in the three location of the study area which gives a clear indication of longer shelf life and stability of garri.
iii. All the packaging materials used for the storage of garri, stored the garri well for the period of this study, but plastic bucket was still the best in keeping the quality attributes throughout the storage period as the average moisture content was as low as 10.2% at the end of 16 weeks.
iv. The low moisture content will prevent the growth and development of microorganism in the garri stored in the plastic bucket.
v. A well processed garri (TME 419) can last up to six (6) months or beyond during storage.
vi. The storage of garri (TME 419) with plastic bucket (PB) at ambient conditions (24oC to 27oC, 73%RH) is suitable for maintaining the nutritional quality and to improve the shelf life of the product.

RECOMMENDATIONS

Consequent on the findings of the study, the following recommendations are made

i. The cassava variety TME 419 should be properly processed into garri and stored with good packaging materials, either plastic bucket (PB) or high density polyethyethylene (HDPE) bags.
ii. The garri 'TME 419' should be subjected to a longer period of storage for at least six months to give more room for determination of microorganism.
iii. The PH and the level of hydrocyanic contents in the garri 'TME 419' should also be investigated

AUTHOR CONTRIBUTION
AUTHOR 1

Conceptualization: The lead author gave a reasonable contribution in regard to the basic idea and knowledge of the research. The Ideas came as a result of the problems faced (The problem of storage that affects quality and quantity of garri product and the shelf-life stability.) by the farmers and individuals that are involved in the farming and processing of cassava most especially the popular variety (TME 419) used in the study areas (Sanga, Kagarko and Chikun LGA's of Kaduna State, Nigeria.)

Methodology: The materials and method used in the analysis was also the effort and idea of the lead author.

Formal analysis: The data were collected and taken to the laboratory for analysis. Were all involved in the data collection, curation investigation and also the supervision of all the process of the research work.

Funding Acquisition and writing: the lead author plays a vital role in the acquisition of funds from **TETFUND** via the institution and with the support of the other authors. The major aspect of the writing and review was done by the lead authors though greatly supported by the other authors.

He was responsible for supervising other activities delegated to other team members in regards to processing and analysis.

AUTHOR 2

He contributed greatly in the actualization of the concept and the funding acquisition. He plays a vital role in the data curation, writing and the editing of the final draft.

The major validation of the research work was done by the second author and in the processing of the cassava variety (TME 419) into garri for proper storage.

The operation of the instrument and the collection of the raw data for storage properties/conditions was done by the second author with the help of every member of the team. He is the major technical man in the whole research process.

AUTHOR 3

He played a significant role in the statistical analysis and the project administration. He did a lot in the supervision of the research work in the three different location of the study areas and in the validation and curation of the data.

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