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EFFECT OF STORAGE ON MICROBIAL AND SENSORY QUALITIES OF PACKAGED YAM-CASSAVA "POUNDO" FLOUR

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ABSTRACT

Microbial load and Sensory quality of packaged yam-cassava poundo flour during storage were studied. Yam flour (YF) and cassava flour (CF) were mixed at different proportions to produce yam-cassava poundo flour and packaged using High Density Polyethylene (HDPE) and Polypropylene sack (PP) respectively. The samples were HDPE 100%YF, HDPE 90%YF: 10%CF, HDPE 85%YF: 15% CF, HDPE 80%YF: 20%CF and 100%YF, 90%YF: 10%CF, 85%YF: 15%CF and 80%YF: 20%CF. The samples were stored at ambient temperature (32 ± 2^{o}C) and relative humidity (76 ± 3%) for 24 weeks and were subjected to microbiological and sensory tests at 4 weeks interval. Results showed that the total plate count of sample (80% YF: 20%CF) packaged in HDPE was the lowest (4.9 x 10^4 cfu/g) while that of sample (100% YF) packaged in PP was the highest (9.4 x 10^4 cfu/g) at the end of the storage period. Fungal counts increased in all the packaged samples, as storage period increased. The lowest fungal counts (3.7 x 10^4sfu/g) were recorded in HDPE 80%YF: 20%CF, this is significantly different ($p<0.05$) from the value obtained in PP 100% YF which was the highest fungal counts obtained (9.6 x 10^4sfu/g). A bacterial species (*Bacillus subtilis*) and two fungal species (*Aspergillus niger* and *Fusarium solani*) were isolated and enumerated. Data obtained from sensory test (colour, aroma, texture and overall acceptability) decreased throughout the storage period but 80%YF: 20%CF packaged in HDPE was more acceptable. The findings of this study indicate that yam-cassava poundo flour from the blend of 80%YF: 20%CF packaged in HDPE is less susceptible to microbes and more acceptable in terms of sensory qualities during a storage period of 24 weeks.

Key words: microbial, sensory, yam-cassava poundo, package

INTRODUCTION

Yam (*Dioscorea rotundata*) is an important source of carbohydrate in the Sub-Saharan region, especially in the yam producing zones of West Africa (Akissoe *et al*., 2003). In yam growing areas of Nigeria, yams are converted to flour or utilized in different form as boiled yam, pounded yam, yam flour, roasted yam, yam flakes and chips. Pounded yam is a very popular food product made from whole yam tuber in West and Central Africa while instant poundo yam flour is the shelf stable form that is marketed. Pounded yam is made by peeling the yam, cutting it to pieces, boiling, pounding and kneading using mortar and pestle (Mordi *et al.,* 2004). Pounded yam is popularly called "Iyan" in Yoruba speaking areas of Nigeria (Olorunda *et al.,* 1981). Yam has been commonly pounded with other crops such as cassava, cocoyam, potato and plantain to improve taste and nutritional values.

Cassava *(Manihot esculenta*) is a multipurpose root crop that is primarily used as staple food in the tropical areas of the world especially in Nigeria and Ghana (Bokanga, 1992). Cassava can be processed into gari, fufu, lafun, tapioca, starch and cassava flour (Ene, 1992). Traditionally, yam is pounded with sweet cassava *"poundable cassava" (Manihot utilisima* Pohl) known as ''Isunikankiyan'' in western parts of Nigeria (Olorunda *et al.,* 1981). Deterioration of flour products are usually attributed to the type of packaging materials and pathogens such as bacteria, fungi and moulds (Okigbo, 2003). Flour foods can be infected by microorganisms which include Xerophilic moulds, *Aspergillus* species, *Bacillus spp, Pseudomona spp, Proteus sp* and *Staphyloccocus aureus* (WHO, 2001). Some bacteria are pathogenic organisms, which can cause certain diseases if ingested beyond level of body tolerance (Yusuf *et al.,* 1992). Some moulds produce toxin known as aflatoxins that cause diseases commonly known as aflatoxicosis which is neither infectious nor communicable (Bryan, 1988).

Attempt has been made at manufacturing poundo yam in Nigeria to provide a product that could be reconstituted into elastic, very dense paste after cooking at boiling temperature. The quality of the product was generally judged to be inferior to local preparations due to some unpublished complaints by local consumers that the instant poundo yam was not as cohesive as the traditional pounded yam "*Iyan*" (Mordi *et al.,* 2004). Texture is one of the three main acceptability factors used by consumers to evaluate food while the other two are colour and aroma (Bourne, 1990). Food processors therefore place a lot of importance on development of products that have the textural attributes desired by consumers since foods can be rejected or accepted on the basis of textural quality (Bourne, 1990). In order to improve the texture of poundo yam, cassava flour (a cheaper source of carbohydrate) is blended with yam flour to give a product which is more acceptable in terms of textural quality. The most common accessible packaging material for flour product in Nigeria is polyethylene and polypropylene bags or sacks. Thus, the objective of this study is to assess the microbial and sensory qualities of stored yam-cassava poundo flour (varied quantities of yam flour and cassava flour) packaged in polyethylene and polypropylene sacks, respectively.

MATERIALS AND METHODS

Materials

Yam tubers (*D. rotundata)* were purchased from Osiele market in Abeokuta, Nigeria. Freshly harvested cassava roots *(Manihot utilisima* Pohl) (sweet variety) which has poundable quality were obtained from Obada-Owode Ogun state, Nigeria.

Production of Yam and Cassava flour

The yam tubers were washed, peeled, thoroughly washed with clean water and chipped (thickness: 0.2 - 0.3 cm). The chips were soaked immediately in 0.5% sodium metabisulphite solution for 30 min. The chips were transferred into heated water (90 - 100 ^{o}C) for 20 min. After the pregelling stage, the chips were spread out on a perforated stainless steel tray to drain off the water and dried in a cabinet dryer at 60 ^{o}C for 6 h. The method described by Iwuoha *et al*., (1997) was modified in the laboratory for production of cassava flour. Cassava roots were washed, peeled, boiled (30-100^{o}C, 35 min), cut into chips (0.25 cm average thickness), steeped in water (29 ± 2 °C, 24 h with a 6 hourly change of steep liquor); the spent liquor was decanted, the cassava chips were dried in cabinet dryer at 60 °C for 10 h. The dried yam and cassava chips respectively were weighed at intervals to obtain a constant weight of 7.5% moisture content then milled and sieved (≤425μm) before packaging.

Formulation of Yam-Cassava poundo flour

The yam flour and cassava flour were mixed in four different blends as follows:

- 100% yam flour to 0% cassava flour (100%YF)
- 90% yam flour to 10% cassava flour (90%YF:10%CF)
- 85% yam flour to 15% cassava flour (85%YF:15%CF)
- 80% yam flour to 20% cassava flour (80%YF:20%CF)

Each of the blended products (200 g) was weighed and packed into two different packaging materials: (i) High Density Polyethylene (HDPE) and (ii) Polypropylene sack (PP) respectively, sealed and stored at ambient temperature 30 ± 2 °C (Relative Humidity 76 ± 3%) for 24 weeks. Total plate count, fungi count and isolation of microorganisms and sensory evaluation were determined at initial and at 4 weeks interval for 24 weeks for each blend.

Isolation and Enumeration of Microorganisms

Twenty-five grammes from each sample were aseptically weighed into 90 ml of 0.1% (w/v) sterilized peptone water in a beaker and allowed to stand for 5 min with occasional stirring with the aid of sterile glass rod. Portions (1ml each) of Serial decimal dilutions of 10^{-2} to 10^{-4} were plated on Nutrient Agar (Biotech) was used for determination of total viable bacterial count and Potatoes Dextrose Agar (Biotech) supplemented with 0.01% chlorophenicol for total viable fungal count. Dilutions of 10^{-2} to 10^{-4} were plated and incubated at 30 °C for 3 days**,** the colonies that developed were enumerated and expressed as colony forming unit per gram (cfu/g) for bacteria and spore forming unit per gram (sfu/g) for fungi (Harrigan and McCance, 1976). Isolation and identification of the microorganisms were carried out for quantitative determinations using colonies (Vanderzannt and Splittstoesser, 1992). The fungi isolates were identified based on examination of the colonial heads and presence or absence of foot cells or rhizoids as described by (Bounds *et al.,* 1993).

Sensory Evaluation

The samples for sensory evaluation were prepared from each mixture by stirring 100 g of the samples in 500 ml of boiling water. The paste was stirred continuously for 10 min in stainless bowl on cooker until fine dough is formed. A preference test of yam-cassava poundo packaged in HDPE and PP during storage, was conducted by a trained panel of 50 judges drawn randomly from the University of Agriculture, Abeokuta community using a nine point hedonic scale (9 = like extremely to 1= dislike extremely) as described by Watts *et al*., (1989) for colour, texture, aroma and overall acceptability.

Statistical Analysis

Data obtained for sensory evaluation were subjected to analysis of variance (ANOVA) while Post hoc separation of means was by Duncan's Multiple Range Test to establish if there were significant differences at $p<0.05$

between the sample (SPSS, Version 11, USA).

RESULTS AND DISCUSSION

Microbial load of Yam-Cassava Poundo flour

Table 1 shows the total plate count (sfu/g) of stored yam-cassava poundo flour. The microbial growth was observed and recorded at 4 week interval for 24 weeks with initial value of 1.0 to 2.2 $\times 10^4$ cfu/g. Total plate count of sample packaged in HDPE and PP increased throughout the storage period, total plate count for samples in HDPE ranges from 1.0 to 5.9 $\times 10^4$ cfu/g. Highest value of 5.9 $\times 10^4$ cfu/g was observed in samples packaged in HDPE 100%YF and lowest value of 4.9 $\times$ 10^4 cfu/g was observed in sample packaged in HDPE 80%YF: 20%CF, this result is in accordance with Okagbue, (1986) who recorded lower bacteria count for flour products stored in HDPE films. Also the total plate count of samples packaged in PP ranged from 1.3 to 9.4 $\times 10^4$ cfu/g, the highest value of 9.4 $\times 10^4$ cfu/g was also observed in 100%YF and lowest value of 8.4$\times 10^4$ cfu/g was observed in sample 80%YF: 20%CF packaged in PP at the end of the storage period. Generally, microbial load in all packaged samples increased at the end of 24 weeks of storage. This could be attributed to their relative permeability to atmospheric gases such as oxygen, carbon dioxide and water vapour. Previous report (Turtle, 1991) showed that the permeability characteristics of the packaging materials evaluated indicate that total plate count and fungal count of samples packaged in PP is higher than samples packaged in HDPE. However, sample 80%YF:20%CF packaged in HDPE had the lowest bacterial count of 4.9 x 10^4 cfu/g as from the 16th week which was constant through the 24th week.

Table 2 shows that fresh sample of yam-cassava poundo flour had no fungal growth; however, fungi count increased by the week in all the samples during the 24 weeks of storage. At the end of the storage period, fungal count was higher in all the samples packaged in PP when compared with samples packaged in HDPE. However, the fungal count was higher in 100%YF PP at the end of the storage period. It was also recorded that the fungal count in the yam-cassava poundo flour increased from 1.1 $\times 10^4$ sfu/g to 4.0 $\times$ 10^4 sfu/g between weeks 4 and 24 in samples packaged in HDPE while in PP the value ranged from 2.0 $\times 10^4$ sfu/g to 9.6$\times 10^4$ sfu/g. Generally, fungal count increased throughout the storage period, probably due to storage conditions i.e. temperature 30 $\pm$ 2 ^{o}C and RH 76 $\pm$ 3% which are conducive for the growth of mesophile organisms. This is in agreement with the findings of Roshita *et al.,* (2005) presumably due to the permeability of the packaging materials (Turtle, 1991). However, sample packaged in HDPE 80%YF: 20%CF had the lowest fungi count at the end of 24 week.

Table 3 shows that a bacterial specie (*Bacillus subtilis*) and two fungal species (*Aspergillus niger* and *Fusarium solani*) were isolated in samples packaged in HDPE and PP. *Streptococcus lactis, Staphylococcus epidermidis, Staphylococcus aureus, Pseudomonas aeruginosa, Aspergillus flavus, Cladosporium sp, Rhizopus stolonifer* were not isolated from packaged samples throughout the storage period. In addition, the *Bacillus subtilis, Aspergillus niger* and *Fusarium solani* isolated during storage could be due to their ability to tolerate and survive in slightly high humid environment, previous reports support these findings (Ogiehor and Ikenebomeh, 2006).

Table 1: Total plate count of packaged yam-cassava poundo flour during storage

	High Density Polyethylene (HDPE)				Polypropylene Sack (PP)			
Storage Period (weeks)	100%YF x 104 cfu/g	90%YF: 10%CF x 104 cfu/g	85%YF: 15%CF x 104 cfu/g	80%YF: 20%CF x 104 cfu/g	100%YF x 104 cfu/g	90%YF: 10%CF x 104 cfu/g	85%YF: 15%CF x 104 cfu/g	80%YF: 20%CF x 104 cfu/g
0	1.0	2.2	2.2	1.8	1.3	2.2	2.2	1.8
4	1.1	2.4	2.5	1.9	2.5	2.8	2.9	2.9
8	2.1	2.6	2.9	2.3	3.2	3.9	3.4	3.7
12	2.9	3.2	3.7	3.8	4.7	4.0	4.8	4.9
16	4.7	4.9	4.9	4.9	6.9	5.9	5.9	5.8
20	5.6	5.3	5.0	4.9	8.9	7.0	7.0	7.0
24	5.9	5.6	5.3	4.9	9.4	8.8	9.0	8.4

Each value is the mean of triplicate values. cfu/g = colony form unit /gram
YF= Yam Flour; CF= Cassava Flour

Table 2: Fungi count of packaged yam-cassava poundo flour during storage

	High Density Polyethylene (HDPE) sack				Polypropylene (PP) sack			
Storage Period (week)	100%YF x 104 sfu/g	90%YF: 10%CF x104 sfu/g	85%YF: 15%CF x 104 sfu/g	80%YF: 20%CF x 104 sfu/g	100%YF x 104 sfu/g	90%YF: 10%CF x 104 sfu/g	85% YF: 15% CF x 104 sfu/g	80%YF: 20%CF x 104 sfu/g
0	NG	NG	NG	NG	NG	NG	NG	NG
4	1.1	1.2	1.7	1.9	3.2	2.0	2.3	2.6
8	2.0	2.0	2.1	2.2	4.1	3.3	3.5	3.7
12	2.1	2.4	2.6	2.6	6.4	5.8	5.3	5.9
16	2.3	2.5	2.7	2.7	7.8	6.7	7.4	7.0
20	2.8	2.8	2.8	2.8	8.9	7.8	8.3	8.3
24	4.0	3.7	3.8	3.7	9.6	8.9	9.5	9.4

Each value is the mean of triplicate values. NG = No Growth sfu/g = spore form unit/ gram YF= Yam Flour CF= Cassava Flour

Table 3: Microorganisms isolated from yam-Cassava poundo flour during storage in different packaging materials

Bacterial Group	*Microorganisms*	HDPE	PP
	Bacillus subtilis	+	+
	Streptococcus lactis	-	-
	Staphylococcus epidermidis	-	-
	Staphylococcus aureus	-	-
	Pseudomonas aeruginosa	-	-
Fungi Group	*Aspergillus niger*	+	+
	Aspergillus flavus	-	-
	Fusarium solani	+	+
	Cladosporium sp	-	-
	Rhizopus stolonifer	-	-

HDPE = samples packaged in High Density Polyethylene PP = samples packaged in Polypropylene Sack + = Isolated / present; - = Not isolated / absent

Changes in Sensory Qualities of Yam-Cassava Poundo flour during storage

The result in Table 4 shows that yam cassava poundo stored well for 12 weeks, since there was no significant difference (p>0.05) in colour of HDPE packaged samples as all the values (8.50 to 8.70) obtained for colour could be translated to be 'like extremely' on the hedonic scale. However, at week 20 to 24th week, the colour of the samples ranged between 6.8 to 7.0 in HDPE packaged samples which can also be translated to be 'like moderately' on the hedonic scale. At week 24, the value of colour of PP packaged samples ranged from 5.80 to 5.95 which means 'like slightly'. The sample packaged in HDPE 80%YF: 20%CF had the highest value of 7.0 for colour while the lowest value of 5.8 was obtained in PP100% at the end of 24 weeks storage period.

In Table 4, the mean sensory score of texture of yam- cassava poundo of all the packaged samples showed that there were significant differences (p<0.05) among samples. The texture of sample packaged in HDPE 80%YF: 20%CF had the highest value of 6.85 (like moderately) while sample packaged in PP100% had the lowest value of 5.60 (like slightly) at the end of 24 weeks of storage.

Table 5 shows the mean sensory score of aroma of stored yam cassava poundo. There was significant difference (p>0.05) among the values obtained for all packaged samples at the end of 24 weeks of storage which ranged from 5.6 to 6.8. The aroma of sample packaged in HDPE was not significantly different (p<0.05) from each other at the end of 24 weeks, with HDPE 80%YF: 20%CF having the highest value of 6.80 (like moderately). The aroma of sample packaged in PP was not significantly different (p<0.05) from each other at the end of 24 weeks, with PP 80%YF: 20%CF having the highest value of 5.75 (like slightly).

In Table 5, the mean sensory score of overall acceptability for yam-cassava poundo showed that there were significant differences (p>0.05) in the values obtained for all the packaged samples as storage period increased. The highest value was obtained for sample packaged in HDPE 85%YF: 20%CF as 6.85 (like moderately) while the lowest

Table 4: Effect of packaging materials and storage time on the colour and texture of stored yam-cassava poundo

Colour

	High Density Polyethylene (HDPE)				Polypropylene Sack (PP)			
Storage Period (weeks)	100%YF	90% YF: 10%CF	85%YF: 15%CF	80%YF: 20%CF	100% YF	90% YF: 10%CF	85%YF: 15%CF	80%YF: 20%CF
0	8.50a	8.55a	8.60a	8.80a	8.50a	8.55a	8.60a	8.80a
4	8.50a	8.55a	8.60a	8.70a	8.30a	8.40ab	8.20a	8.00a
8	8.50a	8.55a	8.60a	8.70a	7.25b	7.30b	7.40b	7.50ab
12	8.25a	8.30a	8.40a	8.50a	7.00b	7.05b	7.10b	7.25b
16	7.85ab	7.85b	7.90b	8.05a	7.10b	7.20b	7.30b	7.10b
20	6.80b	6.85c	6.90c	6.95b	6.75b	6.80bc	6.85c	6.90b
24	6.85b	6.90c	6.95c	7.00b	5.80c	5.85c	5.90d	5.95c

Texture

	High Density Polyethylene (HDPE)				Polypropylene Sack (PP)			
Storage Period (weeks)	100% YF	90%YF: 10%CF	85%YF: 15%CF	80%YF: 20%CF	100% YF	90% YF: 10%CF	85%YF: 15%CF	80%YF: 20%CF
0	8.40a	8.50a	8.55a	8.60a	8.50a	8.55a	8.60a	8.40a
4	7.80b	8.55a	8.60a	8.70a	8.25a	8.30a	8.40a	8.50a
8	7.70b	7.85ab	7.90b	7.95b	7.70b	7.75b	7.80b	7.85b
12	7.40c	7.75b	7.80bc	7.85b	6.60c	6.65c	6.70c	6.80c
16	7.10cd	7.45bc	7.50cd	7.55b	6.20c	6.30c	6.35c	6.40c
20	6.70d	7.20bc	7.35d	7.45b	6.00c	6.05c	6.10c	6.15c
24	6.70d	6.75c	6.75e	6.85c	5.60d	5.70d	5.75d	5.80d

Means with same letters in the same column are not significantly different ($p < 0.05$),
YF: Yam Flour CF: Cassava Flour

value were obtained in sample packaged in PP 100%YF as 4.90 (neither like nor dislike) for overall acceptability at the end of 24 weeks.

The changes observed in colour, texture and aroma of the cooked samples from yam -cassava poundo flour packaged in PP than in HDPE at the end of the storage period could be attributed to the moisture permeability property of the PP packaging materials (Fellows, 2000) and microbes (Onuh and Egwujeh, 2005). At the end of the 24 weeks storage period, attributes of the sample packaged in HDPE 80%YF: 20%CF were most preferred in terms of colour, texture, aroma and overall acceptability. This finding is in agreement with the earlier report of Obiegbuna and Ejiga (2004) that sweet potato flour (a similar root crop) packaged in HDPE has a longer shelf-life than those packaged in PP. Therefore, these findings could also be a confirmation that HDPE is a better packaging material than PP for processed root/tuber flour.

Table 5: Effect of packaging materials and storage time on the aroma and overall acceptability of stored yam-cassava poundo

Aroma

	High Density Polyethylene (HDPE) sack				Polypropylene (PP) Sack			
Storage Period (weeks)	100% YF	90% YF: 10% CF	85% YF: 15%CF	80%YF: 20%CF	100% YF	90%YF: 10%CF	85% YF: 15%CF	80% YF: 20% CF
0	8.50a	8.55a	8.60a	8.70a	8.50a	8.55a	8.60a	8.60a
4	8.50a	8.55a	8.60a	8.60a	8.40a	8.50a	8.55a	8.60a
8	8.40a	8.50a	8.55a	8.40a	7.40b	7.50b	7.55b	7.40b
12	8.10ab	8.25a	8.30a	8.40a	7.00b	7.05bc	7.10bc	7.25b
16	7.80ab	7.85ab	7.90ab	7.95ab	6.70b	6.75c	6.80c	6.85c
20	7.40b	7.45bc	7.50b	7.55b	6.20c	6.30c	6.35d	6.40c
24	6.70c	6.80c	6.80c	6.80c	5.60c	5.70d	5.70e	5.75d

Overall Acceptability

	High Density Polyethylene (HDPE) sack				Polypropylene (PP) sack			
Storage Period (weeks)	100% YF	90% YF: 10% CF	85% YF: 15% CF	80%YF: 20%CF	100%YF	90% YF: 10%CF	85%YF: 15%CF	80%YF: 20%CF
0	7.65a	7.35a	7.85a	8.65a	6.60a	7.30a	7.85a	8.65a
4	7.30ab	7.20ab	7.55a	8.35a	5.70b	6.00b	6.50b	7.40b
8	7.10ab	7.05ab	7.15b	7.75b	5.65b	5.95b	6.60b	6.90c
12	6.70b	6.95ab	6.85b	7.60b	5.60b	5.70bc	6.25bc	6.85c
16	6.60b	6.95ab	6.80b	7.60b	5.55b	5.40c	5.80c	6.40d
20	6.45c	6.80b	6.65c	7.55b	5.05c	5.20cd	5.60c	6.20d
24	6.40c	6.20c	6.55c	6.85c	4.90c	5.10d	5.30d	5.85e

Means with same letters in the same column are not significantly different ($p < 0.05$),
YF: Yam Flour CF: Cassava Flour

CONCLUSION

The study has revealed that the bacterial and fungal growths in the sample packaged in HDPE 80%YF: 20%CF were lower than those of polypropylene sack (PP) thus High Density Polyethylene (HDPE) is a better packaging material for storage of yam-cassava flour. The study on sensory properties indicated that a blend of 80% yam flour and 20% cassava flour packaged in High Density Polyethylene (HDPE) had the highest scores in terms of colour, texture, aroma and overall acceptability at the end of 24 weeks storage period. In addition, yam-cassava poundo has better storage properties than poundo made of 100% yam flour.

REFERENCES

Akissoe, N.H., Hounhouigan, J.D. Mestres, C., Nago, M. 2003. How blanching and drying affect the colour and functional characteristics of yam (*Dioscorea cayenesis-rotundata*) flours. *Food Chem.* 82: 257-264.

Bokanga, M. 1992. Cassava fermentation and the industrialization of cassava food Production in Proceedings of the Fourth Symposium, International Symposium for Tropical Root Crops – African Bulletin ISTR.C- AB: 197- 201.

Bounds, H.C., Boyd, F.M, Nafmah, J.R.A. 1993. Laboratory exercise in general microbiology (1st ed.). Cambridge University Press: 20-66.

Bourne, M.C. 1990. Basic principles of food texture measurement. AVI Van Nostrand Reinhold, New York. 331-341.

Bryan, F.L. 1988. Risks of practices, procedures and processes that leads to outbreak of food-borne diseases. *Journal of Food Protection*. 51: 663-673.

Ene, L.S.O. 1992. Prospects for processing and utilization of root and tuber crops in Africa. Proc. 4th Symposium, ISTRC – AB.: 7 – 15.

Fellows, P.J. 2000. Food processing technology: principle and practice. 2nd ed. Woodhead publishing Ltd. and CRC press LLC. 462-510.

Harrigan, W.F., McCance, M.E. 1976. Laboratory methods in foods and dairy microbiology. Academic press, London. 416.

Iwuoha, C.I., Banigo, E.O.I., Okwelum, F.C. 1997. Cyanide content and sensory quality of cassava (*Manihot esculenta* Crantz) root tuber flour as affected by processing. *Food Chemistry*. 58 (4): 285-288.

Mordi, J.I., Daodu, A.M., Joaquim, A.A., Ozumba, A.U. 2004. Physicochemical properties of 'Ripomeal' a pounded yam flour substitute. In: proceedings of the 28th Annual Conference/ Annual General Meeting of Nigerian Institute of Food Science and Technology (NIFST), held at University of Ibadan, Ibadan, Nigeria. 12th-14th October, 2004. 251-252.

Obiegbuna, J.E., Ejiga, J.E. 2004. Proximate composition functional and sensory properties of boiled *Prosopis africana* endocarp -cassava starch blends. In: Proceedings of the 28th Annual Conference/Annual General Meeting of Nigerian Institute of Food Science and Technology (NIFST), held at University of Ibadan, Ibadan, Nigeria. 12th-14th October, 2004. 253-254.

Ogiehor, I.S., Ikenebomeh, M.J. 2006. The effects of different packaging materials on the shelf stability of garri. *African Journal of Biotechnology,* 5(22): 2412-2416.

Okigbo, R.N. 2003. Fungi association with peels of post harvest yams in storage, Global *Journal of Pure and Applied Sciences,* 9(1): 19-23.

Okagbue, R.N. 1986. Microbial content of some flours in Zaria markets. *J. of Agric. Res.,* 43(213): 107-112.

Olorunda, A.O. Aworh, O.C., Numfor, F.A. 1981. Predicting quality of cassava products with the aid of chemical and rheological properties. *J. Food Technol.*, 16: 447-450.

Onuh, J.O., Egwujeh, S.I.D. 2005. Sensory and Microbial quality of stored sweet potato (*Ipomea batatas*) flour. In: proceedings of the 29th Annual Conference/ Annual General Meeting of Nigerian Institute of

Food Science and Technology (NIFST), held at Ebonyi State University, Abakaliki, Nigeria. 11th-13th October, 2005. 284-285.

Roshita, I., Azizah, O., Nazamid, S., Russly, A. 2005. Effect of several packaging films on biochemical characteristics and microbiological counts of shredded cabbage at different storage conditions. *Journal of Food Agriculture and Environment,* 3(2): 20-27.

Turtle, B.I. 1991. Progress in food packaging technology international Europe: 265-268.

Vanderzannt, C., Splittstoesser, D.F. 1992. Compendium of methods of the microbiological examination of foods. Am Publish Association, Washington DC. 3 ed. 596.

Watts, B.M., Ylimaki, G.L., Jeffery, L.E., Elias, L.G. 1989. Hedonic tests. In Basic Sensory Methods for Food Evaluation. International Development Research Center (IDRC), Ottawa, Canada, P. 66-71.

World Health Organization (WHO), 2001. WHO surveillance programme for control of food borne infections and intoxications In Europe. 7th Report, 1993 – 1998. FAO/WHO collaborating centre, Berlin.

Yusuf, I.Z., Umoh, V.J., Ahmad, A.A. 1992. Occurrence and survival of enterotoxigenic *Bacillus cereus* In some Nigerian flour based foods. *Food Control,* 3: 149 – 152.

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