African Journal of Food Science Vol. 4(5), pp. 258 - 263, May 2010
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 © 2010 Academic Journals

Full Length Research paper

Effects of packaging material on the quality of "pupuru" flour during storage

O. A. Daramola[1], M. A. Idowu[1*], O. O. Atanda[1] and C. R. B. oguntona[2]

[1]Department of Food Science and Technology, University of Agriculture, Abeokuta, Nigeria.
[2]Department of Nutrition and Dietetics, University of Agriculture, Abeokuta, Nigeria.

Accepted 2 April, 2010

"Pupuru" is a fermented cassava product dried by smoking. This study, investigated the effects of packaging material on the quality of "pupuru" flour stored at ambient condition (30.5 ± 3°C; RH 76.5 ± 3%) for 24 weeks. Pupuru flour was packaged in polyvinyl chloride (CP), low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP). Uncovered polyvinyl chloride (UCP) was used as control. Stored samples were analyzed for changes in chemical (moisture content, pH, total titratable acidity (TTA), starch and amylose) and functional properties at two weeks interval, while pasting viscosity, microbiological (total plate (TPC) and fungi counts) and sensory qualities were determined at 4 weeks interval during storage. Packaging significantly (p > 0.05) affected the chemical, functional, microbiological and sensory qualities of "pupuru" flour during storage. Moisture content, TTA and TPC increased linearly with storage period (R^2 = 0.76 - 0.99), while all other chemical, functional and pasting properties of "pupuru" flour decreased significantly (p > 0.05) except pasting time (5.60 - 5.46 min). The samples packaged in HDPE were more acceptable than those in other packaging materials and had the longest estimated shelf life.

Key words: Packaging material, quality, pupuru flour, storage, "pupuru".

INTRODUCTION

"Pupuru" is commonly consumed by the people living in the riverine areas of the western, southern, eastern and the middle belts of Nigeria, where it is also known as "Ikwurikwu" (Shittu et al., 2003; Aboaba et al., 1988). Opeke et al. (1986), reported that processing of cassava to "pupuru" is a major income earning venture and plays a significant role in ensuring food security for some people in Nigeria. The method of smoking the fermented cassava roots makes "pupuru" processing unique as the fermented cassava mash is molded into balls and dried using smoke heat which is believed to impact some characteristic flavour and aroma to this product (Shittu et al., 2003; Aboaba et al., 1988). As increase in our population cause more demand for food, more people may have to depend on "pupuru" to supplement their carbohydrate intake (Aboaba et al., 1988). Currently, "pupuru" processing is entirely traditional and the product consumption is more confined to the indigenous areas (Shittu et al., 2003). Some constraints that were identified during survey of "pupuru" balls revealed that dry "pupuru" balls are left open on drying racks which encourages moisture re-absorption and the balls becomes mouldy within few weeks of preparation, it was also discovered that the dry "pupuru" balls are heavy and it is often difficult to convey large numbers to the market as this increase the transportation cost. Daramola (2003) monitored the quality of "pupuru" produced by some indigenous processing plants in Ondo State, Nigeria and found that dry "pupuru" balls had high moisture content which can predispose them to fast deterioration during storage. This particular problem was solved by further pulverizing the scrapped dried ball and roasting on open pan to give "pupuru" flour with lower moisture content, making it more suitable for longer storage. However, an appropriate packaging material for "pupuru" flour is yet to be identified. Packaging is a means of providing the correct environmental conditions for food during storage and the choice of materials for packaging depends on the

*Corresponding author. E-mail: idowumchl@yahoo.com.

nature of the product, the storage and handling conditions (temperature, humidity, risk of physical deterioration) among other factors(Brown, 1992). Ekwu and Ikegwu (1998), packaged cocoyam flour in closed plastic bowl, open plastic plates, polyethylene bag and jute bag and stored for 5 months in a rodent proof cage. It was discovered that packaging material had significant effect on the functional properties, and the best packaging material reported was polyethylene bag. Fadamiro and Odeyemi (1998), also reported that polythene-in-polythene bags were better than polythene-in-hessian and polythene-in-paper containers for the storage of cocoa powder at 15, 25 and 40°C over a period of three months storage and weight loss was found to increase with increase in temperature of storage; While Idowu (2005), reported a higher moisture uptake and greater vitamin C and colour losses for okra (orunla) powder stored at 40°C than those stored at 30°C.

Presently in Ondo state of Nigeria, "pupuru" flour is often packaged in polyvinyl chloride container (covered plastic) and stored at ambient temperature (30 ± 3°C). This packaging material does not protect the "pupuru" flour properly from contamination by insect, pests, microbes, dust and environmental moisture. Therefore, this work was designed to evaluate the effects of different packaging materials on the chemical, functional, microbial and sensory qualities of "pupuru" flour during storage.

MATERIALS AND METHODS

Pupuru processing

The traditional method of "pupuru" production as described by Shittu et al. (2001) was employed. Fresh cassava roots, *Manihot esculenta* (TMS 30572) were peeled, soaked (5 days), decorticated, dewatered, molded into balls and smoke dried on a raised platform, laid with meshed surface constructed from raffia material, locally known as "Aka" (18 h). The cooled "pupuru" balls were scrapped, pulverized, roasted at high temperature (100 - 120°C for 20 min), milled in hammer mill, and packed in different packaging materials.

Storage studies

200 g of "pupuru" flour was placed in each of the following packaging materials: Uncovered polyvinyl chloride container (UCP) (13 cm × 15.6 cm), Covered polyvinyl chloride container (CP) (13 cm × 15.6 cm), Low density polyethylene (LDPE) film (16 cm × 19 cm), High density polyethylene (HDPE) film (16 cm × 19 cm), and Polypropylene (PP) (19.5 × 20 cm). LDPE and HDPE were sealed manually with Jencons sealing machine, while PP (Hessian sack) was sealed with needle and thread. The packed samples were stored at ambient temperature (30.5 ± 3°C; RH 76.5 ± 3%) for 24 weeks. Stored samples were analyzed for moisture content, pH, total titratable acidity, free sugar, starch, amylose, water binding capacity, swelling power and solubility at two weeks interval while pasting viscosity, total plate count, fungi count and sensory evaluation were determined at 4 weeks interval during storage. The estimated shelf life of each packaged sample was determined as described by Gacula (1975). The equation Y=a + b (x), where Y is the assumed shelf life, a, is the intercept and b is the gradient, while x is the cut off value. The cut off value used were: moisture content (12 - 13%) (FAO, 1992) and total plate count of 5 × 10^5 cfu/g (FAO, 1979). Functional properties were plotted against the storage period on a linear regression curve to solve for (x) values.

Chemical analysis

The moisture content, pH, and TTA were determined according to AOAC (2000). Starch content was determined by the method of Kayisu et al. (1981), while amylose content was done by the method of Juliano (1971).

Determination of functional properties

Water binding capacity was done according to the procedure described by Anderson (1982). The swelling power and solubility were determined by method of Takashi and Seib (1982) while pasting characteristics was determined by the method of Wu et al. (1995).

Microbial analysis

Total plate count and fungi count were determined as described by Atanda and Akano (1997). 1 g of each sample was added to 9 ml sterile distilled water and vortexed. This formed the initial dilution from which subsequent ten fold dilutions were made and used for analysis. Portions 0.1 ml of different serial decimal dilution was spread plated on nutrient agar for total plate count and potato dextrose agar for fungi count.

Sensory evaluation

Sensory evaluation was carried out by reconstituting "pupuru" flour in boiling water at a ratio 1:2 (Flour: Water) until a consistent paste was obtained. A panelist consisting of 50 judges were asked to indicate their preference for the samples using a 9-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely, respectively (Iwe, 2002).

Data analysis

All the data were reported as means of three replicates with standard deviation, variance and regression analysis, means were separated by Duncan's multiple range test to establish if there were significant differences between the samples (SAS, 1999).

RESULTS AND DISCUSSION

The results of the regression equation showing changes in chemical composition of "pupuru" flour over the storage period in different packaging materials are shown in Table 1. The moisture content increased significantly ($p < 0.0.5$) as the storage period increased irrespective of the packaging material. Moisture content was highest in uncovered polyvinyl chloride container (11.00 - 15.60%) and lowest in high density poly ethylene film (11.00 - 13.80%) during the 24 weeks of storage at ambient

Table 1. Regression equations showing the effect of packaging material on chemical composition of stored "pupuru" flour.

Chemical composition	Packaging material	Storage equation (Y)	R^2
Moisture content (%)	UCP	0.1889X + 11.0670	0.9932
	CP	0.1555X + 11.0040	0.9984
	LDPE	0.1412X + 10.6590	0.9848
	HDPE	0.1255X + 10.7040	0.9833
	PP	0.1784X + 10.9530	0.9944
pH	UCP	-0.0230X + 3.8978	0.8530
	CP	-0.0245X + 3.8505	0.9028
	LDPE	-0.0237X + 3.8873	0.8745
	HDPE	-0.0232X + 3.8740	0.8677
	PP	-0.0235X + 3.9087	0.8661
TTA (%)	UCP	0.0063X + 0.2146	0.7617
	CP	0.0085X + 0.2335	0.9120
	LDPE	0.0080X + 0.2059	0.8227
	HDPE	0.0070X + 0.2171	0.8043
	PP	0.0057X + 0.2164	0.6981
Starch content (%)	UCP	-1.6168X + 61.9750	0.7849
	CP	-1.3293X + 60.9410	0.6238
	LDPE	-1.1021X + 63.4140	0.8957
	HDPE	-1.0968X + 64.4850	0.9740
	PP	-0.9743X + 61.6470	0.5590
Amylose content (%)	UCP	-0.4846X + 21.5780	0.8335
	CP	-0.5443X + 22.5990	0.8081
	LDPE	-0.5339X + 21.8480	0.8572
	HDPE	-0.4857X + 21.7060	0.8447
	PP	-0.4864X + 21.6390	0.8544

UCP- uncovered polyvinyl chloride; CP-covered polyvinyl chloride; LDPE-low density polyethylene film; HDPE-high density polyethylene film; PP-polypropylene film.

condition (30.5 ± 3°C; RH 76.5 ± 3%). The initial moisture content of "pupuru" flour was 11%, which was below the recommended safe level (12 - 13%) for storage of cassava flour (FAO, 1992). The increase in the percentage moisture content of stored flour can be attributed to the hygroscopic properties of the flour (Butt et al., 2004) and might be due to the fact that at a high humidity (mean relative humidity 76.5 ± 3%), the vapour pressure may have increased which aids water absorption into the samples (Akindahunsi and Oboh, 2000). Polyethylene films generally have good barrier against moisture (Ukpabi et al., 1998), but low density polyethylene had higher water vapour permeability compared with high density polyethylene. The result agrees with the earlier findings of Fasasi (2003), who observed higher moisture in low density polyethylene than in high density polyethylene during the storage of African Breadfruit seed flour at room temperature for 12 weeks. The pH slightly decreased (3.74 - 3.21) while the total titratable acidity showed the reverse trend as it increased (0.28 - 0.46%) over the storage period of "pupuru" flour irrespective of the packaging material. The trend shown by pH and total titratable acidity during the storage period is indicative of incipient accumulation of organic acids (Ukhun and Ukperbor, 1991). The starch (64.86 - 54.10%) and amylose (22.40 - 19.01%) contents decreased as the storage period increased irrespective of the packaging material. Most of these changes were more pronounced in samples packaged in uncovered polyvinyl chloride container than those in other packaging materials and could be due to differences in the protective barrier offered by the packaging materials.

Table 2 showed the regression equations of functional properties of "pupuru" flour stored in different packaging materials over a period of 24 weeks at ambient condition. The water binding capacity (353.20 - 164.19%), swelling power (14.82 - 10.06 g/g), and solubility (10.00 - 3.00%) decreased significantly ($p < 0.0.5$) as the storage period increased irrespective of the packaging material, but the changes were more noticeable in samples packaged in uncovered polyvinyl chloride.

The regression equations showing the pasting properties of "pupuru" flour over the storage period in different packaging materials are shown in Table 3. The

Table 2. Regression equations showing the effect of packaging material on functional properties of stored "pupuru" flour.

Functional properties	Packaging material	Storage equation (Y)	R^2
Water binding capacity (%)	UCP	-7.6834X + 358.540	0.9889
	CP	-7.3076X + 364.540	0.9822
	LDPE	-7.1168X + 369.460	0.9734
	HDPE	-6.7912X + 372.380	0.9608
	PP	-7.4315X + 360.610	0.9851
Swelling power (g/g)	UCP	-0.2009X + 14.5830	0.9798
	CP	-0.1788X + 14.5440	0.9761
	LDPE	-0.1680X + 15.0290	0.9842
	HDPE	-0.1705X + 14.9350	0.9824
	PP	-0.1746X + 14.6870	0.9881
Solubility (%)	UCP	-0.2508X + 8.7284	0.9932
	CP	-0.2629X + 9.4362	0.9761
	LDPE	-0.2821X + 9.6669	0.9696
	HDPE	-0.2987X + 9.7354	0.9224
	PP	-0.2565X + 8.8458	0.8959

UCP- uncovered polyvinyl chloride; CP-covered polyvinyl chloride; LDPE-low density polyethylene film; HDPE-high density polyethylene film; PP-polypropylene film.

Table 3. Regression equations showing effect of packaging material on pasting properties of stored "pupuru" flour.

Functional properties	Packaging material	Storage equation(Y)	R^2
Peak viscosity (RVU)	UCP	-11.5210X + 239.490	0.8097
	CP	-10.4440X + 248.570	0.8889
	LDPE	-6.6714X + 250.770	0.9291
	HDPE	-5.0075X + 247.840	0.9540
	PP	-7.1841X + 244.370	0.8925
Final viscosity (RVU)	UCP	-10.5000X + 242.740	0.9058
	CP	-9.6996X + 248.560	0.9279
	LDPE	-6.9146X + 254.410	0.9063
	HDPE	-5.8057X + 253.130	0.9208
	PP	-7.1118X + 251.960	0.9260
Set back viscosity (RVU)	UCP	-5.9311X + 64.198	0.9328
	CP	-2.0829X + 62.051	0.8338
	LDPE	-1.7561X + 64.880	0.9678
	HDPE	-1.1382X + 65.203	0.9528
	PP	-1.8821X+63.692	0.9372
Pasting time (Min)	UCP	0.0014X + 5.7000	0.0011
	CP	-0.0225X + 5.6818	0.2437
	LDPE	-0.0164X + 5.6550	0.0957
	HDPE	-0.0336X + 5.6593	0.5270
	PP	-0.0021X + 5.6779	0.0043
Pasting temperature (°C)	UCP	-0.0946X + 81.238	0.0250
	CP	-0.2086X + 81.259	0.2374
	LDPE	-0.0946X + 81.238	0.0250
	HDPE	-0.1614X + 81.211	0.1088
	PP	-0.0914X + 81.359	0.0399

UCP- uncovered polyvinyl chloride; CP-covered polyvinyl chloride; LDPE-low density polyethylene film; HDPE-high density polyethylene film; PP-polypropylene film.

Table 4. Regression equations showing the effect of packaging material on the microbial load of stored "pupuru" flour.

Functional properties	Packaging material	Storage equation (Y)	R^2
Total plate count (X10^5) cfu/g	UCP	2.4952X - 4.0682	0.9173
	CP	1.9154X - 3.6979	0.8922
	LDPE	1.1545X - 2.1582	0.8996
	HDPE	0.9623X - 1.9382	0.8830
	PP	2.2914X - 3.9929	0.9081
Fungi count (X10^5) sfu/g	UCP	1.5964X - 3.4257	0.8655
	CP	1.2163X - 2.8375	0.8135
	LDPE	0.6859X - 1.5368	0.8420
	HDPE	0.5677X - 1.3332	0.8095
	PP	3652X - 2.9882	0.8506

UCP- uncovered polyvinyl chloride; CP-covered polyvinyl chloride; LDPE-low density polyethylene film; HDPE-high density polyethylene film; PP-polypropylene film.

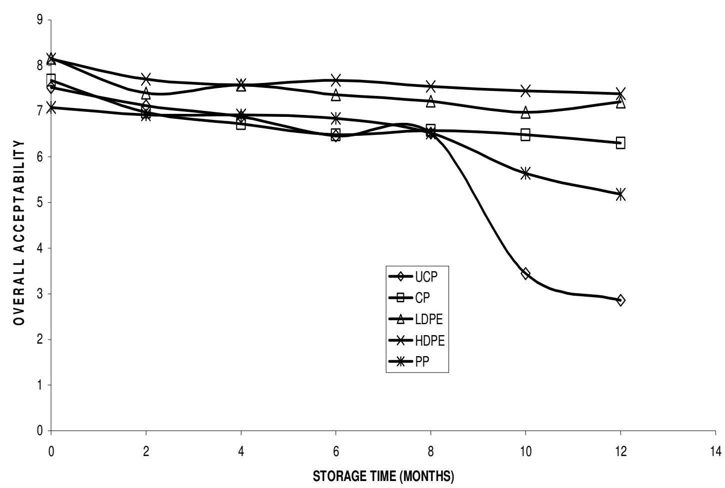

Figure 1. Changes in sensory quality of "pupuru" flour during storage.
UCP- uncovered polyvinyl chloride; CP-covered polyvinyl chloride; LDPE-low density polyethylene film; HDPE-high density polyethylene film; PP-polypropylene film.

peak, final and setback viscosities, pasting time and temperature were 245.25 - 166.64 RVU, 254.42 - 187.18 RVU, 65.41 - 31.40 RVU, 5.60 - 5.46 min and 82.25 - 79.50°C, respectively. All the pasting properties decreased significantly ($p < 0.0.5$) as the storage period increased irrespective of the packaging material, except the pasting time which shows no significant difference. The rate of change was more prominent with samples packaged in uncovered polyvinyl chloride container than other packaging materials.

Table 4 showed the result of the microbial load of "pupuru" flour in different packaging materials at ambient temperature for 24 weeks. Samples in uncovered polyvinyl chloride container had the highest microbial load, while the lowest microbial load was observed in high density polyethylene film. The microbial load of pupuru flour over the storage period increased with increase in moisture content. This is because moisture is extremely important in bringing about deterioration of foods, the moisture absorbed by pupuru flour is physically bound and this makes it very susceptible to fungal attack (Igbeka, 1987).

The overall acceptability of "pupuru" during storage generally decreased and revealed that the attributes in samples packaged in high density polyethylene film were more acceptable than the other packaged samples, while samples in uncovered polyvinyl chloride was least preferred. The decrease in solubility, water binding capacity, swelling power and pasting properties of "pupuru" has implications on textural characteristics of reconstituted "pupuru" flour and this may be responsible for the decrease in overall acceptability (Figure 1) of "pupuru" as storage increased. Furthermore, product deterioration during storage could be as a result of combined effect of moisture and microbial proliferation in the product (Bothast et al., 1991). Butt et al. (2003) reported that packaging materials with high moisture permeability may predispose its content to high rate of deterioration.

Regression analysis showed that the moisture content and total plate count varied linearly with storage period, with R^2 values ranging from 0.98 - 1.00 and 0.88 - 0.92, respectively. The estimated shelf life of "pupuru" flour based on moisture content was found to be 10 weeks (uncovered polyvinyl chloride), 11 weeks (polypropylene), 12 weeks (covered polyvinyl chloride), 16 weeks (low density polyethylene) and 18 weeks (high density polyethylene). On the other hand, the estimated shelf life of "pupuru" flour packaged in uncovered polyvinyl chloride, polypropylene, covered polyvinyl chloride and low density polyethylene film based on total plate count were found to be 4 weeks, 6 weeks, 9 weeks, and 12 weeks, respectively, while "pupuru" flour packaged in high density polyethylene film gave the longest estimated shelf life of 14 weeks. This indicates that total plate count may be more sensitive to deterioration in "pupuru" flour than moisture content.

Conclusion

This study shows that packaging could influence significantly not only the chemical, functional, microbiological and sensory qualities of "pupuru" flour, but also its shelf life. The samples packaged in high density polyethylene gave the highest estimated shelf life and it is considered to be the best packaging material for "pupuru" flour at ambient condition.

REFERENCES

Aboaba OO, Nwachukwu SU, Opesanwo NA (1988). Microorganisms Associated with Cassava Fermentation for "Pupuru" Production. J. Food. Agric., 2(1): 39-41.

Akindahunsi AA, Oboh G (2000). Effect of changes in Relative Humidity on the Storage Stability of Micro-Fungi Fermented Gari. In: Proceedings of 24th Annual Conference of Nigerian Institute of Food Science and Technology. pp. 47-49.

Anderson RA (1982). Water Absorption and Solubility and Amylograph Characteristics of Raw Cooked Grain Products. Cereal Chem., 59:265.

Atanda OO, Akano DA (1997). The Incidence of Different Types of Microorganisms and Aflatoxin Content of Dry "Tatase" Pepper (*Capsicum annuum* L.) Stored for Sale in Dry Season. Niger. J. Microbiol. 11.36-38

AOAC (2000). Official Method of Analysis. Association of Official Analytical Chemists 17th edn. Arlington Virginia.

Bothast RJ, Anderson RA, Warner K, Kwolek WF (1991). Effect of Moisture and Temperature on Microbiological and Sensory Properties of Wheat Flour and Corn Meal during Storage. Cereal Chem., 42(3): 187-190.

Brown WE (1992). Plastics in Food Packaging: properties design and fabrication. Publisher Marcel Dekker Inc., p. 50.

Butt MS, Ali A, Pasha I, Hasim A, Dogar S (2003). Effect of Different Stability of Breakfast Cereal. Int. J. Food Safety, 2:1-5.

Butt MS, Nasir M, Akhtar S, Sharifik (2004). Effect of Moisture and Packaging on the Shelf Life of Wheat Flour. Int. J. Food Safety, 4: 1-4.

Daramola OA (2003). Qualities of Pupuru from Some Indigenous Processing Locations in Ondo State. Unpublished B.Sc Thesis, University of Agriculture, Abeokuta, Nigeria. p. 55.

Ekwu FC, Ikegwu JO (1998). Effect of Packaging Materials and Storage Period on the Functional and Microbial Load of Cocoyam Flour. Proceeding of the 22nd Annual NIFST Conference. pp. 266-267.

Fadamiro HY, Odeyemi OO (1998).Effect of temperature and packaging materials on storage of Cocoa (*Theobroma cacao* (*L.*). Appl. Trop. Agric. 3(2): 99-103.

FAO (1979). Food and Nutrition Paper 14/4. Manuals of Food Quality Control (Microbiological Analysis), FAO, Rome. Italy.

FAO/WHO (1992). Codex Standard for Edible Cassava Flour-African RegionalStandard, CODEX STAN, FAO, Rome.

Fasasi OS (2003). Effect of Different Packaging Materials on the Chemical Composition of African Breadfruit Seed (*Treculia Africana*) Flour during Storage at Room Temperature. In: *Proceedings of 27th* Annual Conference of Nigerian Institute of Food Science and Technology. pp. 153-154.

Gacula MC (1975). The Design of Experiments for Shelf Life Study. J. Food Sci., 40:399-403.

Idowu MA (2005). An investigation into some factors affecting quality and storage characteristics of "orunla" {okra (*Abelmoschus esculentus*)} powder. PhD thesis, Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso Nigeria. p.193.

Igbeka JC (1987). Simulation of Moisture Profile in Stored Gari. J. Food and Agric. 1:5-9.

Iwe MO (2002). Sensory Method and Analysis. Published by Rojoint Communication Services (Ed.), Enugu. pp. 49-72.

Juliano BO (1971). Varietal Differences in Amylose Content of Rice Starch. Cereal Sci. 16:334-338.

Kayisu K, Hood LF, Vansoest PJ (1981). Characteristics of Starch and Fibre of Banana Fruit. J. Food Agric. 46(6): 1885-1890.

Opeke LK, Laogun EA, Onayemi OO, Adetiloye PO, Williams TO (1986). The Place of Cassava in Household Food Security and Nutrition: A Rapid Case Study of Owo Local Government Area, Ondo State, Nigeria. A Report on the Existing Storage and Processing Technology in the Southern Nigeria. UNICEF/IITA. pp. 75-87.

SAS (1999). Statistical Analysis System. Inc Cary, NC, USA.

Shittu TA, Lasekan OO, Sanni LO, Oladosu MO (2001). The Effect ofDrying Methods on the Functional and Sensory Characteristics of Pupuru-AFermented Cassava Product. Asset Series 1(2):9-16.

Shittu TA, Oyewole OB, Olawuyi O, Daramola O (2003). Processing Technology of Pupuru: A Survey of Practices and Product Quality in the South West of Nigeria. ASSET Series B. 2(2):17-27.

Takashi S, Seib PA (1982). Paste and Gel Properties of Prime Corn and Wheat Starches With or Without Nature Lipids. Cereal Chem. 65:474.

Ukhun ME, Ukpebor IE (1991). Production of Instant Plantation Flour, Sensory Evaluation and Physio-Chemical Changes During Storage. Food Chem. 42: 287- 299.

Ukpabi UJ, Omodamiro RM, Oti E (1998). Feasibility of Using Sealed polyethylene Film in Prolong Storage of Gari. In: *Proceedings of 22nd* Annual Conference of Nigerian Institute of Food Science and Technology. pp. 280-281.

Wu H, Yue S, Sun H, Corke H (1995). Two Genotypes of Amaranthus cruetus of Agricultural Significance in China. Starch/starke 47(8):295-297.