

## 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 pouno flour during storage were studied. Yam flour (YF) and cassava flour (CF) were mixed at different proportions to produce yam-cassava pouno 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 ( $32 \pm 2^\circ\text{C}$ ) and relative humidity ( $76 \pm 3\%$ ) 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 ( $4.9 \times 10^4$  cfu/g) while that of sample (100% YF) packaged in PP was the highest ( $9.4 \times 10^4$  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 ( $3.7 \times 10^4$ sfu/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 ( $9.6 \times 10^4$ sfu/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 pouno 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 pouno, 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 prod-

uct made from whole yam tuber in West and Central Africa while instant pouno 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*, *Pseudomonas spp*, *Proteus sp* and *Staphylococcus 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 pondo 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 pondo 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 proc-

essors 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 pondo 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 pondo 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 °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 °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°C, 35 min), cut into chips (0.25 cm average thickness),

steeped in water ( $29 \pm 2$  °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 ( $\leq 425\mu\text{m}$ ) before packaging.

#### **Formulation of Yam-Cassava pouno 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  $30 \pm 2$  °C (Relative Humidity  $76 \pm 3\%$ ) 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 Nu-

trient 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 (Vanderzant 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 pouno 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 Pouno flour**

Table 1 shows the total plate count (sfu/g) of stored yam-cassava pouno 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  $4.9 \times 10^4$  cfu/g as from the 16<sup>th</sup> week which was constant through the 24<sup>th</sup> week.

Table 2 shows that fresh sample of yam-cassava pouno 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 pouno 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  $30 \pm 2$  °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 pondo flour during storage**

Storage Period (weeks)	High Density Polyethylene (HDPE)				Polypropylene Sack (PP)			
	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.  
YF= Yam Flour; CF= Cassava Flour

cfu/g = colony form unit /gram

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

Storage Period (week)	High Density Polyethylene (HDPE) sack				Polypropylene (PP) sack			
	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.  
unit/ gram YF= Yam Flour CF= Cassava Flour

NG = No Growth

sfu/g = spore form

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

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

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 Pondo flour during storage**

The result in Table 4 shows that yam cassava pondo 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 24<sup>th</sup> 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 pondo 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 pondo. 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 pondo 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 pouno**

Colour								
High Density Polyethylene (HDPE)				Polypropylene Sack (PP)				
Storage Period (weeks)	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 pouno 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 pondo**

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 pondo has better storage properties than pondo made of 100% yam flour.

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