PJN
ISSN 1680-5194

Pakistan Journal of Nutrition

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 13 (12): 716-721, 2014
ISSN 1680-5194

Effects of Physical Characteristics of Polyethylene Packaging Materials on Storage Stability of Preservative Free Plantain Chips

A.I. Peter-Ikechukwu, N.C. Ihediohanma, E.N. Bede, J.C. Ibeabuchi and U.O. Abaleke
Department of Food Science and Technology, School of Engineering and Engineering Technology, Federal University of Technology, Owerri, Nigeria

Abstract: The effects of the physical characteristics of polyethylene packaging materials on the storage stability (keeping quality) of preservative-free plantain chips at ambient temperature (30-37°C) were studied. Physical characteristics and proximate composition of the raw unripe horn plantain were determined to assess the suitability of the plantain in chips making and yield. The plantains were sliced to 2 mm thickness, blanched with hot water at 60°C, drained and salted to taste. The slices were fried to chips with an unbranded vegetable oil (commonly used by local producers) at 160-170°C for 3-5 min, drained, cooled and packaged in five different polyethylene bags labeled "A to E", sealed, respectively and kept on the shelve. Proximate analysis, microbial and sensory evaluations were carried out on the chips at intervals of two weeks for five weeks. Results showed that polyethylene bag “C" (6.0 µm thick, hazy and of high density) retained the sensory attributes, nutrient composition and had lower total viable, mould and yeast counts, followed by polyethylene "A" (4 µm thick, very transparent and of low density) while "E" (1.1 µm, very transparent and low density) was the least in all the parameters analyzed.

Key words: Plantain chips, polyethylene bags, storage stability (keeping quality)

INTRODUCTION

Plantains are fruits in the botanical sense, but are served as food vegetables, forming an integral part of the diet of millions of people around the globe (Montcel, 1987). According to Palmer (2000), plantains are grown mainly because of their nutritional benefits as well as their economic contributions, giving about 125 calories and being a good source of vitamin C and K. Plantains are highly recommended by doctors for patients with low level of potassium in their blood; malnourished children and those that need reduction of sodium in their diet (Landers, 2000). Plantains can be eaten raw as fruits when they are very ripe, or processed into biscuits and breads (Edema *et al.*, 2004; Ocheme *et al.*, 2010) or fried into chips.

In Nigeria, plantain chips are the most popular plantain product (Onyejegbu and Olorunda, 1995), being sold by hawkers and eaten as snack by all classes of human beings. Presently, the problems associated with the existence of the product in the market today are poor processing and of critical importance is the type of packaging materials used conventionally. The material is fairly permeable, fragile and very transparent, exposing the chip to air, easy moisture absorption, microbial infestation and other chemical changes that affect the texture and sensory qualities of the product. To crown it all, the polyethylene bag is only manually knotted instead of using a sealing machine to close-up the pack.

Good packaging confers product safety, boost consumer acceptability and help to prolong shelf-life of the product. However, due to poor packaging materials used for plantain chips, the shelf-life is shortened to one week approximately (by observation). This study therefore aims at studying the effects of the physical characteristics of some polyethylene materials on the storage stability (keeping quality) of preservative-free plantain chips for five weeks.

MATERIALS AND METHODS

Five different types of transparent polyethylene bags (commonly called Santana), matured unripe plantain, unbranded vegetable oil, annapuna salt (Unilever Brand) were purchase from Owerri main market Imo State Nigeria.

Analysis of the polyethylene materials

Thickness: Micrometer screw gauge was used to measure the thickness of each polyethylene film as described by Obafunmi *et al.* (2001). Ten different points on the single sheet of the polyethylene film were measured and the mean thickness was calculated.

Transparency test: The polyethylene bags were analyzed for their visual appearance and categorized as 'transparent' or 'hazy'. They were further classified based on their densities as described by Obafunmi *et al.* (2001) into low, medium and high densities.

Corresponding Author: A.I. Peter-Ikechukwu, Department of Food Science and Technology, School of Engineering and Engineering Technology, Federal University of Technology, Owerri

Tear and stretch tests: Obafunmi *et al.* (2001) and Balami *et al.* (2004) methods were adopted in carrying out tear and stretch tests. For tear test, 1 cm was cut out of the edge of each film. The cut was extended by hand pull and the result was categorized into easy to tear' and 'hard to tear'. A mark 3 cm was made on the edge of each of the films and held against a ruler for stretch test determination. The films were pulled by hand to observe if stretching occurred. The adjacent edges were tested to see whether the stretch was one directional or on both sides.

Burning test: Small piece of each film was cut, held with a pair of tongs and ignited for 10 sec, respectively. The rate of burning, flame character and behaviour of each material during and after burning were observed, as well as the odour (Obafunmi *et al.*, 2001).

Air holding capacity and porosity of the seal: Air was pumped into each of the packaging films, sealed respectively and weighed with an electronic weighing balance and left to stand for one week. The films were reweighed to determine the weight loss as a result of escape of air from the seal.

Physical analysis of raw plantain: The length and breadth of the pulp (flesh) at the mid length of each finger of fully unripe matured false horn plantain (Musa species AAB group) were measured with a venire caliper. Weights were determined using digital top loading balance (Metter PC 400 Switzerland). Peel thickness was measured with micrometer screw gauge. The peel to pulp ratio was determined by:

$$\frac{\text{Weight of pulp}}{\text{Weight of peel}}$$

Preparation of raw unripe/plantain pulp flour plantain for analysis: The raw unripe horn plantain was peeled, sliced to 2 mm thickness using the slicing machine Sainsbury Slicer SWAN 20470 Brand, dried for 3 h in the hot box Gallenkamp oven at 105°C and ground into flour.

Production of plantain chips: The unripe false horn plantains were processed into chips according to the method of Onyejegbu and Olorunda (1995) which is shown Fig. 1.

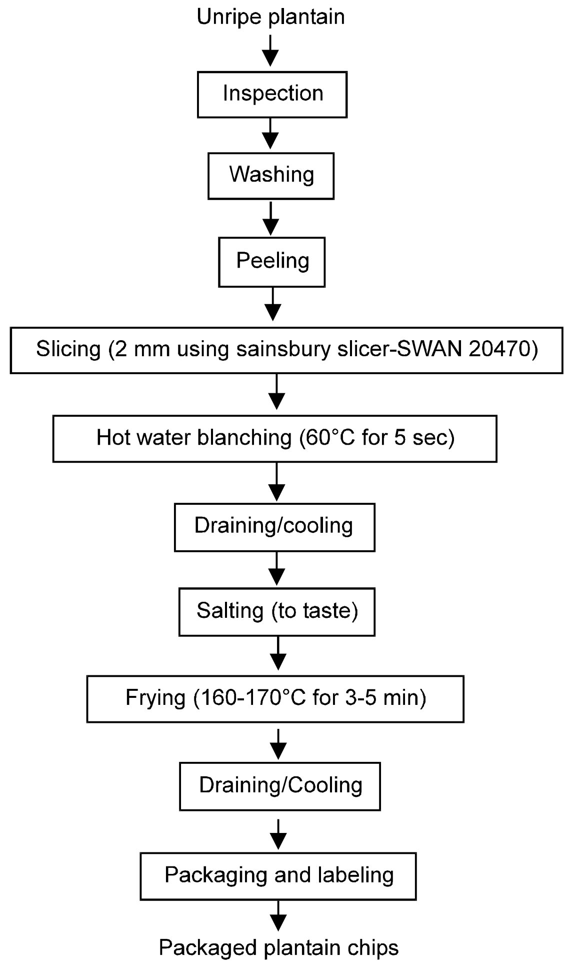

Fig. 1: Flow diagram for preservative-free plantain chips production

Proximate composition of plantain samples: The proximate compositions of raw unripe plantain flour, freshly prepared chips and stored clips were determined using methods (no.14.085, 14.086, 14.087 and 14.089) as described by AOAC (1990) for ash, crude protein, crude fibre and fat, respectively.

Moisture content was determined using oven moisture extraction method. Two grams of raw unripe plantain flour and chips (in duplicate) were dried respectively in hot box Gallenkamp oven at 105°C for 5 h to constant weight. The percentage moisture content was obtained using the mean values in each case as thus:

$$\text{Moisture content (\%)} = \frac{\text{weight loss of sample}}{\text{weight of sample}} \times \frac{100}{1}$$

where, Carbohydrate contents of both raw unripe plantain flour and chips were by difference (Onwuka, 2005).

Determination of free fatty acid (FFA) of the chips: Twenty-five milliliters of diethyl ether was mixed with 25 mL alcohol and 1 ml phenolphthalein (1%) was added. The solution was neutralized with exactly three drops of 0.1M NaOH with constant shaking until a pink colour which persisted for 15 sec was obtained. The procedure was adopted for each sample and in duplicate and result was obtained thus:

$$\text{Acid value} = \frac{X \times 5.61}{\text{weight of sample}}$$

$$\text{FFA\% (as oleic acid)} = \frac{X \times 2.82}{\text{weight of sample}}$$

Where, X = volume of 0.1 m NaOH required for the test

Microbiological evaluation: Serial dilution, pour plating and colony counting methods as described by Harrigan and MacCance (1976) and Uzuegbu and Eke (2001), were adopted in the microbiological evaluation of total viable counts, moulds and yeasts counts, respectively using nutrient agar and potato dextrose agar for the plantain chips samples stored for five weeks.

Sensory evaluation: Sensory evaluation was conducted using twenty member panelists, drawn randomly from staff and students of the Federal University of Technology Owerri, who were trained for the test. A nine point hedonic scale was used with 1-like extremely and 9-dislike extremely. The panelists were given a reference sample 'R' (freshly prepared plantain chips) which was used (as control) to compare each of the labeled samples (A-E). The parameters tested for were colour, aroma/taste, texture, crispiness and overall acceptance (Ihekoronye and Ngoddy, 1985; Onwuka, 2005).

Statistical analysis of data obtained: Data obtained from sensory evaluation were statistically evaluated using analysis of Variance (ANOVA) and least significant difference (LSD) for mean separation (Steel and Torrie, 1980) at $p \geq 0.05$.

RESULTS

The result of the characterization of the packaging materials (Table 1) showed packages 'A, D and E' to be low density polyethylene materials, very transparent, though with varying thicknesses (A = 4.1, D = 3.2, E = 1.1 µm). Polyethylene A and D are resistant to tear and stretch (strain and stress) and saved products stored in them from mechanical damage, while 'E' stretches and tears easily. Package A is referred to as 'glass' because of its texture and appearance. It is also none porous and has high thickness. Packages 'B' and 'C' are high density polyethylene bags, hazy in appearance and with thicknesses, 1.4 and 6.0 µm, respectively. 'B' stretches on one direction while 'C' does not, but both do not tear easily.

Physical measurement of the plantain fruit, pulp and chips (Table 2) related that the pulp and peel components of the plantain constituted 62 and 38% respectively, which is 2:1 ratio.

Proximate composition of the plantain chips stored for five weeks in individual polyethylene bags (Table 4) showed increase in moisture content in all the packages. However there was variation in the increment amongst the polyethylene bags, which showed the level of their porosities. Chips packaged in polyethylene 'C' had the least (8.50%), followed by 'A' (9.0%) while 'E' had the highest (14.56%) on the fifth week.

The result of microbial evaluation of the plantain chips packaged and stored for five weeks (Table 5) showed increase in the microbial growth with increase in the storage period. The number of growth of mould, yeast and total viable count varied and showed direct proportionality to the thicknesses of the respective polyethylene bags, hence their porosities. Polyethylene, 'C' had the least microbial growth.

Sensory evaluation of the stored plantain chips (Table 6) showed that sample 'C' was significantly different from all the other samples ('A', 'B', 'D' and 'E') in the sensory attributes in week one and three respectively. Sample C was preferred to the others. The panelists found it difficult to taste the chips by week five which reflected in the nil score for aroma/taste and overall acceptance. But in terms of texture and crispness (by hand feel) sample C was still rated higher than the rest.

Table 1: Physical analysis of polyethylene packaging materials

Polyethylene	Thickness	Transparency	Tear test	Stretch test	Character of flame	Burning test behaviour	Odour after burning	Density
A	4.1 µm	Very Transparent	Not easy to tear	Does not stretch	Bottom blue, yellow top and some white smoke	Melts and drops	Burnt paraffin wax	Low density (glass)
B	1.4 µm	Hazy	"	Stretch is in one direction	"	"	"	High density
C	6.0 µm	Hazy	"	Does not stretch	Dark yellow flame with blue base	"	"	High density
D	3.2 µm	Very transparent	Not easy to break	"	Yellow mauve with blue base	Melts and burns quickly and leaves irregular charred base	Burnt vinegar (acetic) acid	Low density
E	1.1 µm	Very transparent	Very easy to tear	Stretches in one direction	Blue flame with yellow top	Melts and froths the drips are non-crushable	Burning hair	Low density

Polyethylene 'E' is the commonly used type by local procedures of plantain chips

DISCUSSION

The physical characteristics of the polyethylene bag A referred to as glass gave it a good barrier against moisture, air and microbial infiltration. However, their very transparent nature could lead to light transmission to the product, as reported by Adeniji (2005), that 'transparency of polyethylene leads to transmission of light which acts as a catalyst for oxidation of lipids leading to rancidity'.

The hazy appearance of 'B' and 'C' will offer protection of the product packaged in them from light transmission. The air retention of 'C' is high; showing that it is none porous and so will resist moisture and air transmission to the product.

The pulp to peel ratio was 2:1 and this is important to commercial processors of plantain chips because it will indicate the quantity of pulp expected from a given quantity of plantain fruit, which will in 'turn give estimate of the amount of chips that could be obtained. The yield of chips was 33%; similar result was reported by Ogazi (1990).

Proximate compositions of plantain pulp and freshly prepared chips (Table 3) showed a similar result to that reported by Ketiku (1973) in terms of crude protein, fat, ash and moisture. The crude protein content of the chips was higher than that of pulp. This may be due to protein modification or loss of moisture during frying which eventually increased other nutrient compositions. The increase in fat content could be as a result of uptake of fat during frying. Also, water absorption during blanching caused tissue changes, whose effect led to higher uptake of fat as reported by Arthey and Dennis (1991). The crude fibre content was 3.0% as against 7.3% given by Thompson (1995) on fresh weight basis. The differences may be as a result of geographical location, weather, topography, soil condition, fertilizer and climate changes. The carbohydrate content of the chips was higher (84.99%) than the pulp 31.26% and this corresponds to USDA 1963 report. The higher percentage of carbohydrate may be due to moisture loss during frying from 58.5% (pulp) to 5.0% (chips), giving rise to the concentration of soluble matters.

The result of proximate analysis showed that the thicknesses of the polyethylene bags 'C' and 'A' conferred a level of barrier to moisture transmission and consequent absorption by the chips packaged in them. According to Onyejegbu and Olorunda (1995), low thickness of packaging material is not adequate to protect products (chips) from moisture and air passage. Crude protein and crude fibre remained practically constant while fat decreased slightly. The decrease in fat may be related to interaction between fatty acids and atmospheric oxygen, being more in transparent polyethylene bags due to transmission of light rays to the chips leading to oxidative rancidity as reported by Adeniji (2005).

Free fatty acid content of the chips increased on storage, being much in 'A' and least in 'C' because of their

Table 2: Physical measurement of plantain fruit and chips

Weight of plantain fruit (g)	383
Weight of peel (g)	146.06
Weight of pulp (g)	236.65
Length of whole plantain fruit (cm)	30.08
Breath of whole plantain fruit (cm)	11.60
Thickness of whole plantain fruit (cm)	6.00
Thickness of peel (cm)	5.00
Weight of pulp slices (g)	232.30
Weight of chips (g)	114.08
Percentage yield of chips	33

Average of the sample measurements

Table 3: Proximate composition of plantain pulp and freshly prepared chips

Proximate composition	Pulp (%)	Unblanched fresh chips (%)
Crude protein	1.24	2.26
Fat	2.50	4.15
Moisture	58.50	5.00
Ash	3.53	2.00
Crude fibre	3.0	1.60
Carbohydrate	31.23	84.99
FFA	-	0.68

Average of two determinations (replicates)

Table 4: Proximate composition and FFA of stored plantain chips for five weeks

Weeks	Package	Moisture (%)	Carbohydrate (%)	Crude fibre (%)	Ash (%)	Fat (%)	Crude protein (%)	FFA (%)
1	A	5.50	83.81	1.30	3.40	5.00	0.99	0.39
	B	7.00	80.29	1.25	3.35	8.00	0.11	0.56
	C	5.10	83.29	1.20	3.20	8.20	0.11	0.40
	D	6.00	82.03	1.20	3.06	7.60	0.11	0.54
	E	8.50	79.43	1.35	2.86	6.95	0.91	0.56
3	A	6.95	84.37	1.13	2.35	4.30	0.90	1.69
	B	10.50	77.46	1.20	2.50	7.74	1.10	1.29
	C	6.00	81.07	1.20	2.63	8.00	1.10	1.12
	D	8.50	79.60	1.20	2.40	7.20	1.10	1.58
	E	11.86	79.27	1.15	1.52	5.30	0.90	2.14
5	A	9.00	85.21	1.00	1.41	2.50	0.88	2.25
	B	11.00	78.83	1.00	1.14	7.03	1.00	1.86
	C	8.50	79.96	1.00	1.78	7.76	1.00	1.63
	D	9.56	79.74	1.00	1.52	6.98	1.00	1.86
	E	14.56	77.54	1.85	0.95	3.25	1.85	2.71

Polyethylene A: 4.1 µm thick; B: 1.4 µm thick; C: 6.0 µm thick; D: 3.2 µm thick: E: 1.1 µm thick

Table 5: Microbial evaluation of stored plantain chips (cfu/g)

		Polyethylene samples				
SP (wks)	Micro-organism	A	B	C	D	E
1	Mould	$2x10^1$	$2.5x10^1$	$0.7x10^1$	$3.0x10^1$	$3.7x10^1$
	Yeast	$0.66x10^2$	$0.75x10^2$	$0.47x10^2$	$0.87x10^2$	$1.0x10^2$
	Total viable count	$1.3x10^1$	$1.6x10^1$	$1.0x10^1$	$2.0x10^1$	$2.1x10^1$
3	Mould	$2.8x10^1$	$2.8x10^1$	$1.0x10^1$	$3.2x10^1$	$3.9x10^1$
	Yeast	$0.82x10^2$	$1.3x10^2$	$0.8x10^2$	$1.2x10^2$	$1.5x10^2$
	Total viable count	$1.5x10^1$	$1.8x10^1$	$1.3x10^1$	$2.2x10^1$	$2.4x10^1$
5	Mould	$3.0x10^1$	$3.2x10^2$	$1.3x10^1$	$1.3x10^1$	$4.2x10^1$
	Yeast	$1.2x10^2$	$1.5x10^2$	$1.18x10^2$	$1.43x10^2$	$1.9x10^2$
	Total viable count	$1.9x10^1$	$2.3x10^1$	$1.5x10^1$	$2.6x10^1$	$2.8x10^2$

Average of duplicate cultures. SP: Storage period, Polyethylene A: 4.1 μm thick; B: 1.4 μm thick; C: 6.0 μm thick; D: 3.2 μm thick; E: 1.1 μm thick

Table 6: Sensory evaluation of stored plantain chips

Weeks	Polyethylene bags	Crispness	Texture	Aroma/taste	Colour	Overall acceptance
1	A	1.55^b	1.60^b	1.85^b	2.20^b	2.25^c
	B	1.85^c	1.80^d	1.90^c	2.20^b	2.20^b
	C	1.25^a	1.25^b	1.45^b	1.70^a	1.65^{ca}
	D	1.55^b	1.60^b	1.85^b	2.20^b	2.25^c
	E	1.90^c	1.80^d	1.90^c	2.75^d	2.60^c
	LSD	0.09	0.03	0.01	0.09	0.03
3	A	2.00^b	3.05^b	2.65^b	3.20^a	2.20^{ab}
	B	2.50^d	4.00^e	3.55^c	3.45^b	3.25^{ab}
	C	1.55^a	4.25^a	2.60^a	3.20^a	3.45^{ab}
	D	2.40^c	3.70^c	2.95^b	3.50^c	3.50^{ab}
	E	2.80^c	3.85^d	4.15^d	5.50^d	5.50^b
	LSD	0.04	0.13	0.11	0.03	2.10
5	A	3.45^b	3.10^b	-	3.15^a	-
	B	4.10^d	3.70^c	-	5.40^c	-
	C	3.35^a	2.85^a	-	3.25^a	-
	D	3.75^c	3.90^c	-	4.15^b	-
	E	4.80^e	5.25^c	-	5.70^d	-
	LSD	0.10	0.18	-	0.15	-

Polyethylene A: 4.1 μm thick; B: 1.4 μm thick; C: 6.0 μm thick; D: 3.2 μm thick; E: 1.1 μm thick
Blank columns had no scores; the parameters were not tested for by panelists
Values with different superscripts are significantly different from the others

differences in texture and transparency. Package 'A' though considerably thick (4.1 μlm) reflected light rays which promoted rancidity leading to increased level of fatty acids.

The increase in the microbial growth signified increase in metabolic activities of the organisms, caused by the availability of moisture and oxygen. The number of growth of mould, yeast and total viable count varied and showed direct proportionality to the thicknesses of the respective polyethylene bags, hence their porosities. Polyethylene, 'C' had the least microbial growth, showing that the high thickness and density were adequate for the protection of the chips from penetration of microorganisms (Onyejegbu *et al*., 1995). However, the general microbial result was negligible when compared to 200 cfu/g reported to be the tolerable counts in foods (ICMSF, 1978).

The preference for sample "C" to the others sensory-wise, could be due to the thickness, density and hazy nature of the polyethylene bag which protected the chips from light and moisture transmission and corresponding microbial penetration. The result also corresponds to Onyejegbu and Olorunda (1995) report that the density of polyethylene bags has effect on the chips while Adeniji (2005) added that transparencies of polyethylene bags have effect on the chips due to transmission of light rays.

Conclusion: High density polyethylene bags with high thickness and hazy appearance can be used to package and store plantain chips (preservative-free) on shelve at ambient temperature for more than three weeks, if properly sealed and the chips will retain the nutritional compositions. Proper sealing (closure) will help to reduce the rate of moisture absorption from the environment (air) and this will go a long way to retain the crispiness of the chips. However, the chips must be properly cooled before packaging and sealing to avoid heat build-up which will affect the crispiness (a major attribute of its quality) despite the tendency to accelerate oxidation rancidity. Therefore, hygienic pre-processing, proper frying, cooling, use of polyethylene packaging materials with adequate sealing characteristics and a good sealing machine will result to plantain chips with longer shelf life.

REFERENCES

Adeniji, T.A., 2005. Effect of fluorescent light and packaging materials on the Shelf life of plantain and banana chips during storage. Afr. J. Appl. Zool. and Environ. Biol., 7: 19-22.

A.O.A.C., 1990. Official Methods of Analysis (4th edn.) S. Williams Association of Official Chemist Clarington, V. A. USA.

Arthey, D. and C. Dennis, 1991. Preparation Procedures in Vegetable Processing V.C.H. Publ. INC. New York. pp: 59-69.

Balami, Y.A., P.T. Bolaji, F. Hamza, E.J. Bahago, G. Komolafe, S.C, Onyeiwu and A. Hassan, 2004. Practical Manual on Food Technology, Nutrition and Dietetics for Schools and Industries. 2nd edn. National Science and Technology Forum Kaduna Polytechnic, Nigeria.

Edema, M.O., L.O. Sanni and A. Sanni, 2004.Evaluation of plantain flour blends for plantain bread production in Nigeria. Afr. J. Biotechnol., 4: 911-918.

Harrigan, W.F. and M.E. MacCance, 1976. Laboratory Methods in Food and Dairy Microbiology. Academic press. London.

I.C.M.S.F., 1978. International Committee on Microbiological Specifications of Food Microorganisms in Foods. 2nd edn. Their Significances and Methods of Enumeration. Toronto. Toronto press.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated food science and Technology for the Tropics. Macmillan publ. Ltd London and Basingstoke, pp: 386.

Ketiku, A.O., 1973. Chemical composition of unripe (green) and ripe plantain (M. paradisiacal). J.S.U. Food Agric., 24: 703-707.

Landers, G.T., 2000. Valorization project of banana crop in Rwanda In project TCP/RW A/4503(A). Proceedings from the first mission. FAO Rome, Italy. pp: 67-80.

Montcel, H.T., 1987. Basic concept in plantain and Banana, Macmillan Publ. Land. and Basingstoke, pp: 94-102.

Obafunmi, M.O., P.T. Bolaji and E.S. Abbo, 2001. Food packaging and storage. In Laboratory Manual on food technology, Nutrition and Dietics for schools and industries. 2ndedn. pp: 92-100.

Ocheme, O.B., O.O. Oloyede and A.H. Mahmud, 2010. Production and Evaluation of bread using blends of wheat flour and fermented plantain flour. Nig. Food J., 28: 284-293.

Ogazi, P.O. 1990. Pilot scale dehydration on plantain pulp for flour production. Nig. Food J., 8: 40-45.

Onwuka, G.I., 2005. Food analysis and instrumentation, Theory and Practice, Naphthali print. pp: 63-88.

Onyejegbu, C.A. and A. Olorunde, 1995. Effect of raw material processing Conditions and packaging on the quality of plantain chips. J. Sci. Food and Agric., 68: 279-283.

Palmer, J.K., 2000. The banana; In the biochemistry of fruits and their products. London, Academic press vol. 2 (AC. Hulme ed.) pp: 67-70.

Steel, A.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics Biometric approach, 2nd edn. Auckland New Zealand; McGraw Hill.

Thompson, A.K., 1995. Banana processing in South Gowes (edu) Banana and Plantains, Chapman and Hall, London, UK., pp: 612.

Uzuegbu, J.O. and O.S. Eke, 2001. Practical course in Food Microbiology, Osprey publ. Owerri Nigeria. pp: 29-40.