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The Effect of Packaging Material on the Quality Attributes of stored Fried Maize Chips

Adedeji T.O. and Oluwalana, I.B.

Department of Food Science and Technology, Osun State Polytechnic, Iree, Nigeria
Department of Food Science and Technology, the Federal University of Technology, Akure, Nigeria

***Corresponding Author:** Adedeji T.O., Department of Food Science and Technology, Osun State Polytechnic, Iree, Nigeria temileyeadedeji2@gmail.com.*

Abstract

The fried maize based chips reconstituted into thick paste, spiced, manually moulded into stick and deep fried in hot vegetable oil at about 170^0c for 5 minutes were analysed. The chips were then stored in four different packaging materials at the temperature of 25^0C for the period of four months.The proximate, sensory evaluation and microbial load of an indigenous snack from fried maize were investigated. The sensory analysis revealed that that samples stored in the glass bottles was rated best by the panellist in the sensory attributes evaluated. The microbial analysis showed that the mean total viable count (TVC) log_{10} values for samples of the finished products increased with increased storage period with their values ranging from 0 to 15.0 $x10^2$ cfu/g. Mean fungi count log_{10} was 0.00 to 1.40 $x10^2$ while mean coliform count 0 to 1.00 x 10^2 log_{10} cfu/g was detected in the samples during storage. The moisture content of the samples ranged from 3.40 to 6.90%; fat content was 19.05 to 32.40%; fiber content was 1.74 to 2.75% while protein ranged from 5.85 to 9.20%. The ash and carbohydrate contents ranged from 1.80 to 2.30% and 50.60 to 63.40% respectively. Based on the specifications by International Commission for Microbiological Specification for Foods (ICMSF), the TVC counts of the finished products remained at low levels. However, there were observable presence of coliforms in samples stored in transparent cellophane, aluminums foil and plastic bottles at the end of the storage period.

Keywords: *Kokoro, physicochemical, microbial, sensory, properties*

Introduction

Kokoro, a fermented maize cake, is produced in Ogun State, Nigeria and mainly in three villages of Imashayi, Joga and Iboro; all in Yewa North Local Government Area. It is widely consumed in the South-western States of Nigeria as snacks to pass time especially between meals. It is also a substitute for *Kwuli-kwuli*; a popular groundnut cake. Both snacks complement fried grated and fermented cassava (Gari) when taken in cold water with or without sugar (Braima *et al*. 2012; Smallstarter 2013).

Kokoro is produced from maize in a 3- day intensive process. The production involves the boiling of whole dried maize for about an hour and then allowing it go through natural fermentation for 24 h. The fermented maize is milled and mixed with wet milled onion (*Allium cepa*) and salt (NaCl) to form paster. The paster is kneaded and fried slightly for 2–4 min, thereafter it is left overnight before being fried a second time for 1–2 min. The finished product is either packaged in cellophane or left open and sold on street trade and/or market places.The problem of the study is that fried maize based snacks absorb moisture from the environment and become softened which reduces its organoleptic properties such as taste texture flavor and odour. The significance of this study is to use packaging materials to improve the shelf life of the snacks. Kokoro is an ancient snack valued especially within the South western and North central regions of Nigeria comprising of over ten states. It is widely distributed as well. Packaging is the science, art and technology of enclosing, sale and use. It is also a means of achieving safe delivery of products in a sound condition to the final user (Fellow, 2009). Some of these packaging materials are plastic, glass (bottle) aluminum foil, brick carton, polythene e.t.c. Packages function as protection, transportation, sales, promotional services and guarantee (Fellow, 2009).Packaging and handling of the products before and during sales to consumers are also source of concern. Like most other ready to eat foods sold on streets, road sides and market places, kokoro is prone and subject to contamination (Oranusi and Olorunfemi 2011;

Oranusi and Braide 2012; Pricope *et al*. 2013; Aung and Chang 2014; Larsen *et al*. 2014).

The objective of this study was designed to understand the impact of packaging materials on the proximate, sensory composition andmicrobial load which are responsible for the qualityand potential health benefits of the snack. In this work, different materials were employed for packaging the snacks so as to determine the suitable packaging materials for the product. Also, the microbial load of the freshly processed and stored snacks were determined. This will ensure the safety of the snack and add value to the product.

MATERIALS AND METHODS

Sample Preparation

Preparation involves the use of maize (*Zea mays*). The grains are washed and boiled for about an hour (depending on the hardness/how dry the grains are). The water used for boiling is decanted and grains steeped overnight to ferment. Fermented grains are sieved from steep water and milled without the addition of water. Salt (NaCl) and wet milled onion (*Allium cepa*) are added and mixed with the milled grains. The mixture is molded into small balls about the size of a medium sized orange. The balls are cut into small sizes and kneaded to produce thin circular or straight snack about 24 cm long, these are slightly fried in ground nut oil for 2–4 min to a light-brown semi-finished product. They are covered in basket/basin overnight before a second (final) frying for 1–2 min to make the product ready for consumption as a light-brown/dark-brown crispy snack. The products are then packaged in transparent cellophane.

Methods

Proximate Analysis of samples

The chemical compositions of the samples were determined according to the procedure outlined by the Association of Official Analytical Chemists (AOAC 1980). The kokoro samples were analyzed for moisture content, carbohydrate, protein, lipid, ash and fiber. Moisture content was obtained by drying samples in moisture dish in an oven at 105°C until constant weights was obtained. For Ash content, pre-dried samples obtained from moisture content analysis were ashed in furnace at 550°C overnight. Crude protein value was obtained from nitrogen which was earlier determined by MicroKjedalh method and by multiplying by 6.25 (conversion factor for nitrogen to protein). Crude fat was obtained by exhaustively extracting 2.0 g of each sample in a Soxhlet apparatus using petroleum ether (b.p. 40–60°C) as the extractant. Determination of crude fibre was done by trichloroacetic acid method (Oladipo and Jadesimi 2012) while carbohydrate content was obtained by difference from the combined percent of moisture, protein, ash and fat from 100 (Nwanze et al. 2006).

Microbiological Characteristics

Bacterial counts (SPC) were estimated by plating suitable buffer dilutions using nutrient agar and incubating the petri plates at 30 °C for 48 h (BIS 1980a), yeast and mold counts were estimated using MEA agar with incubation temperature of 25 °C for 72 h (BIS 1980a) and coliform counts using violet red blue Agar and incubation at 30 °C for 24–48 h (BIS 1980a). The counts were expressed as colony forming units (cfu) per gm of *snacks*.

Sensory Evaluation

Fried maize based snack was packed in the three packaging materials was transferred to well cleaned glass bowls, tempered to ambient temperature and served to a panel of judges chosen from Osun State Polytechnic, Iree in a sensory evaluation laboratory. The panelists were asked to evaluate the sensory quality in terms of colour and appearance, body and texture, flavour and overall acceptance using a 9 - point Hedonic scale, in which a score of 1 indicated ‘dislike extremely’ and a score of 9 indicated ‘like extremely’ (Amerine et al. 1965).

Statistical Analysis

The various data of physico-chemical, microbiological and sensory evaluation were subjected to 2x3x7 factorial design analysis and the statistical significance of effect of various treatments and their interactions was determined by SPSS package (Version 11.0).

RESULTS AND DISCUSSION

Effect of Packaging Materials on the Proximate Constituents of Stored Fried Maize Based Snack

The proximate composition of the fried snack changed during storage at 30 °C (for 3months) varied with the type of packaging material. The statistical means of the proximate composition with the packaging material are presented in Table 1. The proximate composition of kokoro reported in this work with the exception of percentage fat, fiber and ash contents is lower than the composition reported for whole maize grain (Oke 1965). This could be attributed to losses in nutritional composition due to leaching often associated with steeping of grains for fermentation (Akobundu and Hoskins 1982; Osungbaro 2009; Sanni et al. 2001). The moisture content reported for the fresh samples are very low. Low moisture content is a reflection of low water activity (a^w) which in turn reduces microbial proliferation rate and a necessary factor in the extension of shelf life and effective storage of products.As the storage progressed, there was a slight increase in moisture as indicated by the lower mean values. This may be influenced by the packaging material used, the increase being more in (TC) packed product (mean moisture value 10.2%) followed by aluminium foil (14.3%) and (PB) (18.4%) (Table 1). This was due to higher water vapour permeability of (TC) than the other threematerials. Kumar et al. (1975) and Goyal and Srinivasan (1988) reported that laminates containing aluminium foil provided good protection against moisture losses because of superior moisture barrier properties of the foil. Loss of moisture observed with (TC) was higher than (AL) and (PB) used in this study.The results obtained showed that the bacterial counts of all the samples stored did not exceed the maximum recommended standards by the International Commission on Microbiological Specification of Foods (ICMSF, 1986; 2002; 2005). According to this agency, the acceptable limit of mesophilic aerobic bacteria in dried food products should not exceed a maximum of 10^3 cfu/g.The fat content (ether extract) of kokoro samples is very high. This could be explained by the use of groundnut oil in the frying of kokoro. Similarly, the carbohydrate content of samples in AL and PB were lower compared to other samples. Losses associated with leaching during steeping of grains for fermentation could be responsible for the low contents of carbohydrate in kokoro. Fat and carbohydrate are energy dense content of food, kokoro is thus a rich source of energy. The percentage of crude protein of the samples in PB and GB were lower than the other samples.This may be attributable to continued disappearance of basic amino acids in the product (Namiki 1988). The ash content of the kokoro samples was very high. This could be attributed to the onion and salt content of kokoro.

Table1.*Effect of packaging materials on the proximate constituents of stored fried maize based snack (%)*

Month	PackagingMaterials	moist	protein	Fat	Ash	Fibre	CHO
0	TC	6.70 ±1.00	7.01 ±0.21	19.05±0.13	2.20±0.09	2.27±0.06	62.77±0.08
	AF	6.65 ±0.89	9.20 ±0.33	23.55±0.25	2.30±1.00	1.82±0.95	57.22±1.07
	PB	6.51 ±0.75	6.65 ±	32.09±0.13	2.10±0.08	2.75±0.04	49.80±0.05
	GB	3.40 ±0.98	6.68 ±0.76	24.27±0.32	1.92±0.05	1.87±1.02	61.86±0.09
1	TC	6.75±0.56	6.68±0.35	19.10±1.23	2.15±0.07	2.25±0.40	63.07±1.35
	AF	6.70±0.60	9.00±0.15	23.62±1.14	2.28±0.09	1.80±0.45	56.60±1.89
	PB	6.58±0.75	6.50±0.40	32.14±0.09	2.05±0.10	2.55±0.35	50.21±2.23
	GB	3.47±1.02	6.34±0.50	24.50±1.05	1.90±0.05	1.85±0.51	61.94±1.54
2	TC	6.80±0.35	6.50±0.07	19.15±1.65	2.20±0.09	2.21±0.14	63.14±1.65
	AF	6.75±0.53	8.82±0.23	23.75±1.07	2.31±0.05	1.75±0.10	56.62±1.98
	PB	6.60±0.64	6.25±0.32	32.21±0.98	2.10±0.12	2.32±0.95	50.52±1.65
	GB	3.50±1.23	6.10±0.12	24.65±1.00	2.00±0.15	1.90±0.66	61.85±1.84
3	TC	6.90±0.61	6.35±0.55	19.20±0.96	2.12±0.13	2.10±0.24	36.83±1.45
	AF	6.80±0.76	8.74±0.61	23.80±1.02	2.20±0.10	1.50±0.16	56.96±1.02
	PB	6.70±0.82	6.40±0.50	32.35±0.64	2.05±0.87	2.20±0.20	50.60±0.65
	GB	3.52±1.34	6.00±0.42	24.70±0.85	1.89±0.95	1.81±0.18	62.08±0.92
4	TC	6.95±0.55	6.20±0.15	19.25±1.05	2.10±0.54	2.01±0.16	63.40±1.28
	AF	6.85±0.70	8.52±0.33	23.85±0.56	2.15±0.52	1.45±0.20	57.18±1.45
	PB	6.74±0.86	6.01±0.21	32.40±0.42	2.00±0.32	2.15±0.12	50.70±1.82
	GB	3.55±1.43	5.85±0.05	24.75±0.65	1.80±0.41	1.74±0.10	62.31±1.25

Keywords: ***TC*** *rep transparent cellophane,* ***AF*** *rep aluminium foil,****PB*** *rep plastic bottle,* ***GB*** *rep glass bottle. Mean (n=3) ± standard deviation*

Effect of Packaging Materials on the Microbiological Load of Stored Fried Maize Based Snack

The mean microbial load (cfu/g) of samples during storage is presented in Table 2. It shows that TC and AF had higher microbial counts compared to other samples. The kokoro products from all the samples had mean counts of 0–2 $\log_{10}$.Packaging material had a prominent effect on the increase in microbial counts (Table 2). The decrease was faster in TC and ALfollowed by PB and GB at ambient temperature. The increase in bacterial counts during storage was due to increasing water activity. The water activity of less than 0.90 is not suitable for growth of bacteria (Sawhney et al. 1997). Prajapati et al. (1986) also reported that as the storage period increased, water activity values of *peda* increased which multiplied the growth of bacteria. Ravindrakumar et al. (1997) also observed that there was an increase in microorganism population during storage of *khoa*.

Table2. *Effect of packaging materials on the microbial load of stored fried maize based snack (cfu/g)*

Month	Packaging Materials	TVC	TCC	TYC	TMC	TFC
0	TC	0	0	0	0	0
	AF	0	0	0	0	0
	PB	0	0	0	0	0
	GB	0	0	0	0	0
1	TC	1.6 $x10^2$	0	0.2x $x10^2$	1.0x $x10^2$	0.4$x10^2$
	AF	1.4x $x10^2$	0	0.3x $x10^2$	0.6$x10^2$	0.3$x10^2$
	PB	1.2x $x10^2$	0	0.5x $x10^2$	0.5$x10^2$	0.2$x10^2$
	GB	1.0x $x10^2$	0	0.07x $x10^2$	0.03$x10^2$	0
2	TC	3.4x $x10^2$	0	1.6x $x10^2$	1.0$x10^2$	0.8$x10^2$
	AF	2.6x $x10^2$	0	1.5x $x10^2$	0.6$x10^2$	0.7$x10^2$
	PB	2.4x $x10^2$	0	1.3x $x10^2$	0.5$x10^2$	0.6$x10^2$
	GB	2.0x $x10^2$	0	1.00x $x10^2$	0.88$x10^2$	0.12$x10^2$
3	TC	7.2x $x10^2$	0	4.0x $x10^2$	1.8$x10^2$	1.4$x10^2$
	AF	5.6x $x10^2$	0	3.2x $x10^2$	1.4$x10^2$	1.0$x10^2$
	PB	5.0x $x10^2$	0	3.0x $x10^2$	1.2$x10^2$	0.8$x10^2$
	GB	3.2x $x10^2$	0	2.0x $x10^2$	1.0$x10^2$	0.2$x10^2$
4	TC	15.0x $x10^2$	1.0x $x10^2$	6.4x $x10^2$	6.0$x10^2$	1.6$x10^2$
	AF	12.0x $x10^2$	0.5x $x10^2$	6.0x $x10^2$	4.0$x10^2$	1.5$x10^2$
	PB	10x $x10^2$	0.2x $x10^2$	5.0x $x10^2$	3.4$x10^2$	1.40$x10^2$
	GB	5.2x $x10^2$	0	2.0x $x10^2$	2.9$x10^2$	0.3$x10^2$

Keywords: *TVC rep total viable count, TCC rep total coliform count, TYC rep total yeast count, TMC rep total mold count, TFC rep total fungi count. Mean (n=3) ± standard deviation*

However, the fried snacks stored in transparent cellophane, aluminium foil, plastic bottle, and glass bottle had counts within the acceptable limits recommended by ICMSF (1986).The fungal counts of all the cashew nut stored in allpackaging material used that were analyzed arewithin the acceptable limit. The counts were considerably high since no microorganism should be recovered in any food meant for human consumption (FAO, 1979; 1993; WHO, 2003). The generally observed high microbial counts in this study could be attributed to differences in thickness of storage materials used which affect the moisture content of the fried snack and the microbial populations (Irtwange and Oshodi, 2009) and the influence of environmental factors which have been shown to play a significant role in affecting the quality of food products (Owhe-oreghe and Afe, 1993; Abdullahi *et al*., 2005; Shamsuddeen and Ameh, 2008; Shamsuddeen *et al*., 2008; Oyeyi and Lum-nwi, 2008; Wada-kura *et al*., 2009). The increase in the number of fungi and bacteria might be attributed to increase in moisture content of cashew nuts which allow proliferation to occur. This is because the successful growth of these microorganismsdepends upon them getting an adequate supply of moisture (Mansrelt, 1964; FAO, 1979; Adams and Moss, 2000; Kawo and Abdulmumin, 2009). This could allow pathogens to develop by multiplying to levels where they could cause food poisoning (Abdullahi *et al*., 2005). With the highest recorded moisture content of 6.95% in snack stored in TC at 0 month (6.95%) compared with TC at 4^{th} month (6.70%), there is a good possibility of bacterial multiplication. The results of this work suggest that the storage medium, the method of storage and packaging material had significant effect on quality of the fried snacks. The mean yeast and mold counts in TC, AF were 5.0 and 2.0 log $_{10}$ cfu/g, 3.4 and 2.9at the end of the storage period respectively (Table 2). Goyal and Srinivasan (1988) reported that glass bottle proved to be the best in checking the growth of microorganisms followed by the multilayered packaging materials consisting of poster paper/aluminium foil.

Effect of Packaging Materials on Sensory Characteristics of Fried Maize Based Snack during Storage

Changes in sensory scores of fried maize based snack packaged in different packaging materials and stored at 30° is presented in Table 3. The sensory scores decreased, but remained well within acceptable limits during storage period. The color and appearance score decreased (Table 3) because the color of the snack slowly changed. The decrease in color and appearance was due to oxidation of brown compounds resulting in slight fading of color. The product slightly got dried up due to evaporation of moisture which also resulted in decrease in color and appearance scores.

The effect of packaging material on the fried snack and their interaction was only marginal. It means whatever decrease in scores could be attributed to the effect of duration of storage. The flavor scores were also affected but only marginally. The flavor scores awarded to the snack stored in TC, AF, PB, GB were 8.5, 9.2 and 11.1, 12.5 respectively at the end of the storage period (Table 2). Flavor score was maximum in glass bottle packaging (GB). It has better barrier properties to moisture and volatile flavor compounds. In plastic bottle, the available oxygen content might contribute to growth of aerobes affecting the flavor. Similar results were also observed by Goyal and Srinivasan (1989) and Ravindrakumar *et al.* (1997) in *khoa*.

The textural scores decreased during storage caused by increase of moisture. With regard to the effect of packaging materials, more texture related changes took place in TC and AC at 30 °C as reflected by the mean scores of 9.0 and 10.2 respectively. In TC packed snacks, the changes took place to a greater extent than AF and PB (Table 3). The reason for decrease in texture score could be due to increase in moisture and solubilization of sugar as reported in sensory evaluation.

Table3.*Effect of packaging materials on sensory characteristics of fried maize based snack during storage*

Month	Packaging Materials	Colour	Flavour	Taste	Textural	Overall Acceptability
0	TC	9.0±0.2	8.5±0.1	9.1±0.2	9.0±0.1	9.0±0.3
	AF	10.0±0.2	9.2±0.1	10.4±0.3	10.2±0.4	10.0±0.3
	PB	11.2±0.1	11.1±0.2	11.6±0.1	11.1±0.3	11.5±0.5
	GB	12.4±0.4	12.5±0.4	12.7±0.5	12.6±0.6	12.9±0.8
1	TC	8.5±0.1	8.0±0.1	8.5±0.2	8.7±0.2	8.5±0.1
	AF	9.4±0.2	9.0±0.1	9.4±0.2	9.6±0.3	9.2±0.2
	PB	10.2±0.1	10.2±0.4	10.4±0.3	10.2±0.2	10.7±0.4
	GB	11.1±0.7	11.3±0.6	11.5±0.8	10.8±0.5	11.6±0.6
2	TC	8.1±0.1	7.8±0.2	8.0±0.1	8.3±0.2	8.0±0.1
	AF	8.7±0.2	8.5±0.2	8.7±0.2	9.0±0.1	8.5±0.1
	PB	9.3±0.3	9.4±0.3	9.6±0.4	9.6±0.2	9.8±0.2
	GB	10.0±0.5	10.2±0.5	10.3±0.5	10.5±0.5	10.4±0.3
3	TC	7.7±0.1	7.5±0.1	7.5±0.2	8.0±0.2	7.7±0.2
	AF	8.2±0.1	8.0±0.1	8.0±0.2	8.6±0.2	8.2±0.2
	PB	8.5±0.3	8.7±0.2	8.6±0.1	8.9±0.3	9.3±0.1
	GB	9.0±0.6	9.2±0.4	9.0±0.4	9.5±0.5	9.7±0.3
4	TC	7.5±0.2	7.3 ±0.3	7.1±0.1	7.6±0.1	7.5±0.1
	AF	7.8 ±0.2	7.6 ±0.2	7.5±0.1	7.8±0.2	7.8±0.1
	PB	7.9 ±0.1	8.1 ±0.1	7.8±0.2	7.9±0.1	8.4±0.2
	GB	8.1±0.5	8.2±0.4	8.0±0.6	8.1±0.4	8.5±0.5

Keywords: *Mean (n=3) ± standard deviation*

Because of these changes, overall acceptance of the fried snackwas also affected. The overall acceptance scores gradually decreased, yet at the end of storage period of 4th month at 30 °C but the products remained acceptable. Mean overall acceptance score was probably determined by textural changes taking place at storage temperature. The statistical mean scores of overall acceptance of the fried snackspacked in TC, AF, PB, GB were 9.0, 10.0, 11.5, 12.9 respectively. The lowest overall acceptance score was awarded to TC where there was increase in moisture more than other packaging materials. There was not much loss of flavour and texture in PB and GB. Hence, the same have been considered superior because they have better barrier properties than TC and AF.

Conclusion

In conclusion,the study evaluates the effect of packaging materials on proximate, sensory and microbiological quality of the stored fried maize based snack.The samples examined in this study can be said to be nutritionally rich (contain adequate basic food nutrients). The sample in glass bottles (GB) was the best packagingmaterial due to the fact that low microbial load was detected during storage follow by plastic bottle (PB) material.

RECOMMENDATION

Steeping of grain overnight allows for fermentation, consequently pH reduction. Fermentation improves the keeping quality and safety of fermented foods. The steeping process also allows for the softening of the maize kernel, improves milling and product quality. It also reduces cooking and food preparations period. It increases some nutrients (Odunfa 1994; Afoakwa *et al*. 2007), however, via leaching some other nutrients loss are often inevitable (Osungbaro 2009; Aminigo and Akingbala 2004).

Another major source of contamination could be the packaging materials (cellophane) which have been reported to be opened for use by blowing air into it with the bare mouth thereby introducing germs (Oranusi and Olorunfemi 2011).

Commercialization may however demand some levels of fortification to make the product nutritionally richer (addition of vitamin A and other approved nutrients).

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