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EFFECTS OF DIFFERENT PACKAGING MATERIALS ON THE KEEPING QUALITY OF *KULIKULI*

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ABSTRACT

The effects of different packaging materials: plastic material, aluminium foil, glass material, low density polyethylene bag (LDPB) and a blend of plastic materials and LDPB on the keeping quality of *kulikuli* was studied. The quality indices studied were peroxide value, free fatty acid, saponification value and sensory attributes using standard methods. The results of the study showed that at the end of first week of storage, stored snacks exhibited different variabilities in the quality parameters measured. Snacks stored in foil paper and in a blend of plastic and LDPB had significantly ($p<0.05$) lower levels of quality indices measured. However, snacks stored in glass material and LDPB had higher values. At the end of the third week of storage, snack samples showed increased fatty acids, peroxide and saponification values which ranged from 8.97 – 13.46 mg/100 g, 12.40 – 13.40 meqO_2/kg 84.15 – 44.80 mg KOH/g, respectively. Snacks stored in foil paper and in a blend of plastic and LDPB mantained lower levels of quality indices measured. Similarly, there were steady increase in free fatty acid, peroxide and saponification values of the snack samples with increasing storage time up to the seventh week of storage. Therefore, it can be deduced from this study that snacks stored in a blend of plastic and LDPB and foil paper alone up to three weeks maintained good product quality based on indices measured.

Keywords: Groundnut, *Kulikuli*, Packaging material, Keeping quality

INTRODUCTION

A snack is a portion of food often smaller than a regular meal, generally eaten between meals (Ocheme *et al*., 2014). In different parts of the world, various types of food are consumed as snacks. The distinguishing characteristic of snacks is that they are often small in quantity, and cannot be taken as main course dishes (James and Nwabueze, 2013). Snacks are often taken with beverages, all over the world. However, alarms are being raised over the rate of consumption of snacks especially by children. This is because most snacks contain a lot of refined sugar which is harmful to the health of the consumers.

Groundnut based local snack (*kulikuli)* is a common snack in West Africa countries (Ezekiel *et al*., 2011). The snack is dominant and popular in Northern part of Nigeria; its production and processing are mainly carried out by women as a source of family income (Ibrahim *et al*., 2012). Groundnut based snack is made from dry roasted groundnuts that is ground into a paste. Spices such as powdered pepper and other ingredients such as salt, sugar, onion are added (optional) to the paste and properly mixed together. The paste is stripped of excess oil with water and made into different shapes of choice. The oil removed during this process is then heated to fry the shaped paste until it solidifies, hard, crunchy and allowed to cool before packaging in materials such as nylon, plastic containers etc. The snack is a good source of protein, fat, crude fibre, minerals as well as some B-group vitamins (Desai *et al.*, 1999). The local snack is used as a spice in the production of *kilishi*, and other traditional dishes such as *dambu*. Also, it is used commercially as protein source in formulating feed for livestock and fish (Akano and Atanda, 2008).

Heat treatment such as roasting is one of the major problems that limits the shelflife and storage stability of food products including groundnut and its products. This makes the products to have shorter shelf life than the raw material (St. Angelo and Ory, 1975; St. Angelo *et al*., 1977; Yuki *et al*., 1978). During heat treatment such as roasting, there are physical and chemical changes that result into the hydrolysis of fatty acid and destruction of vitamin E which is a natural anti-oxidant, thereby making the fried-product susceptible to lipid oxidation (Damame *et al*., 1990; Hotz and Gibson, 2007; Reicks *et al*., 2014). Lipid oxidation in the snacks might lead to rancidity which shortens the shelf life; affects storage stability; texture and brings about off-flavor development. Furthermore, development of rancid flavour limits the large scale production of *kulikuli* snack which also impedes it commercialization.

Kulikuli as a cheap, readily available and an important snack in Nigeria has gained increased demand. However, due to its oil content, the snack is susceptible to rancidity and easily absorbs moisture from the storage environment due to poor packaging. These lead to off flavor development, depletion of nutrient content as well as softening of the product. The oxidation of unsaturated fatty acids is the main reaction responsible for the degradation of lipids and lipid based foods (Muik *et al*., 2005; Morales *et al.*, 2011). It is an important quality characteristic of the food industry. Molecular oxygen under favourable conditions of light, moisture and metal presence reacts with lipid double bonds (most especially unsaturated fatty acid) leading to the formation of free radicals and the so-called auto-oxidation reaction takes place. The oxidation of fats primarily means deterioration of their quality and safety for consumption, and as a result economic loss can be expected. In addition, oxygen species that have carcinogenic effects are created during the oxidation, and they can lead to distortion of the cardiovascular system and can decrease the safety of the snack (Pezzuto and Park, 2002). These present threat to the quality of the product most especially when intended to be produced in commercial quantity. Many methods of analysis have been developed to access the extent of oxidative deterioration, which are related

to the measurement of the concentration of primary or secondary oxidation products or of both.

The processes of lipid oxidation and deterioration progress in oils and their products can be quantified through chemical tests such as free fatty acids, iodine value, peroxide value, active oxygen test, saponification value, oxidative stability index, hexanal value among others (Shadi and Zhong, 2005; Grujić *et al*., 2011).

Kulikuli snacks are locally packaged inside low density polyethylene bags and ordinary papers. The snacks are usually exposed to direct sunlight and other environmental conditions during retail operation. These predispose the product to uncontrollable chemical reactions, notably lipid peroxidation and subsequent development of rancidity. There is dearth of research on the use of different locally available packaging materials for their storability. This is in spite of the wide acceptability of the snack among the consuming populace. To achieve its commercialization there is need to address the outlined limiting factors. Therefore, this study evaluated the potentials of different packaging materials on the keeping quality of the snack.

MATERIALS AND METHODS

Materials

Source of Raw Material

Groundnut, pepper, onions, salt as well as different packaging materials (polyethylene bag**,** plastic container, glass container and aluminum foil) were purchased from Kure Ultramodern Market Minna, Nigeria. The experiment was conducted at the Animal Production Department laboratory of the school of Agriculture and Agricultural Technology, Minna, Niger State.

Procedure for *Kulikuli* Production

Three kilogram (3 kg) of groundnut was roasted for 10 min at 120 ^{o}C and shelled, winnowed, ground into a paste. The paste was then mixed with 56.58 g of sliced onions, 45.80 g of salt, 36.24 g of pepper and 550 ml of water for extraction of oil. After working the paste in a laboratory mortar, it was drained of excess oil. The resultant cake was chopped and shaped into flat and cylindrical crew shapes of nearly uniform diameter (0.005 m). Shaped cakes were then deep-fried in the excess oil until they solidify, brown, crispy and crunchy. The cruchy snack were removed from the frying pan and kept in a perforated basin to drain the accompanying oil. The snakes were then allowed to cool for 30 min and packaged into different materials for the study (Fig. 1) (Ezekiel *et al*., 2011).

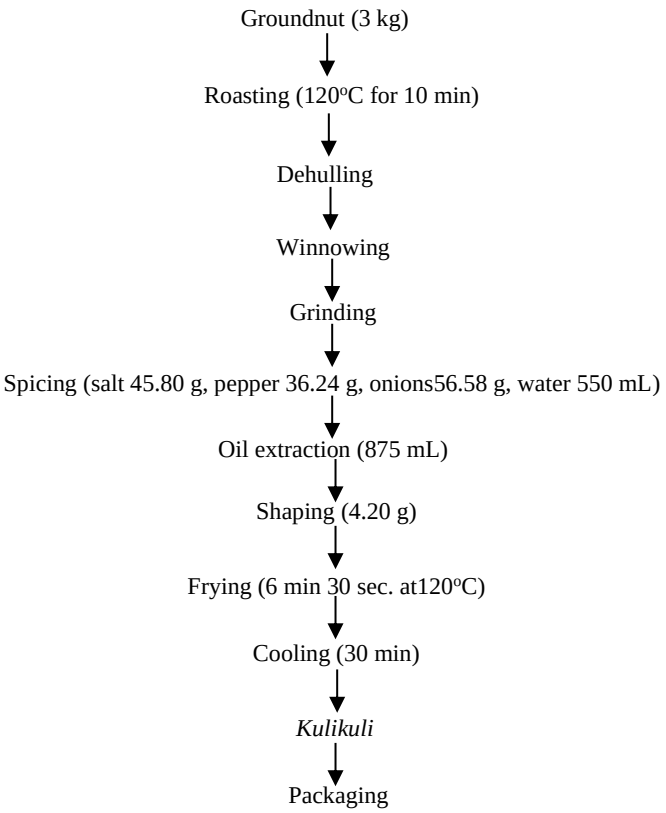

Figure 1: Flow chart for the production of *kulikuli*

Methods

Free Fatty Acid Test

To determine the concentration of free fatty acid in the samples, 25 ml of ethanol was measured and 25 ml of ether was added, then four drops of phenolphthalein were added to the solution. Potassium hydroxide (0.1 mL) was then added to the solution in the beaker. This solution is called the neutral solvent. The *kulikuli* was pounded and 0.5 g was measured and put in a beaker, 25 ml of the neutral solvent was added to the weighed sample and mixed thoroughly. Two drops of phenolphthalein indicator were added then the solution was titrated against potassium hydroxide, while titrating, the colour turns pink and fades away. The titration continued until the pink colour did not fade away after shaking for fifteen seconds. Then the volume of potassium hydroxide used was recorded. This experiment was carried out at intervals of one week for one month. Free fatty acid was determined using the following equation (Onwuka, 2005):

$$FFA = \frac{TV - m\,(KOH)0.1 \times 56.10}{w} \quad (1)$$

Where; FFA = free fatty acid; TV = titre value; M = molarity; W = weight

Peroxide Value Test

One gram (1 g) of the pounded sample was weighed and put in a conical flask, then 25 mL of 2:1 v/v of glacial acetic acid and chloroform solvent were added. One (1) mL of 10% of potassium iodide was added to the solution then the solution was allowed to stand in the dark for ten minutes. Thirty (30) mL of distilled water was added then the solution was titrated against 0.02 M sodium thiosulphate using 1 mL of 1% starch solution as indicator. A blank determination was carried out in the same way. The peroxide value was determined using the following equation (Onwuka, 2005):

$$pv = \frac{1000(v_1 - v_2) \times m}{w} \quad (2)$$

Where; PV = peroxide value; V_1 = volume of the blank sample; V_2 = volume of the titer value; M = molarity; W = weight of sample.

Saponification Test

One gram (1 g) of each sample was poured into different conical flasks, then 5 mL of ethanol and 25 mL of 0.5% potassium hydroxide were added to each sample; mixed thoroughly and kept in the heater for thirty minutes. Then samples were brought out to cool for 10 min and 1 mL of phenolphthalein was dropped into each conical flask as an indicator which turned the solution blackish. The solution was then titrated against 0.5% M hydrochloric acid solutions until it became faint. A blank solution was prepared in the same way. The volume of hydrochloric acid used was recorded. The saponification was determined using the following equation (Onwuka, 2005):

$$S = \frac{blank - tv \times m \times 56.10}{w} \quad (3)$$

Where: S = saponification; TV = titration value; M = molarity; W = weight

Sensory Attribute Test

Sensory tests were conducted with 20 semi-trained panellists made up of a population of staff and students of Federal University of Technology, Minna who declared themselves as regular consumers of *kulikuli*. Samples were randomly coded and analyzed for texture and and overall acceptability, using a 9-point structured hedonic scale (1 = dislike extremely to 9 = like extremely) (Iwe, 2002). Necessary precautions were taken to prevent carry-over flavour during the tasting by ensuring that panelists pass a piece of lemon fruit in their mouths or rinse with water after each stage of sensory evaluation.

Statistical Analysis

The data obtained from the analysis were subjected to one-way analysis of variance (ANOVA) and separation of the mean values was carried out using Duncan Multiply Range Test at 5% (Steel and Torrie, 1989).

RESULTS AND DISCUSSION

Results

Table 1: Free fatty acid, peroxide and saponification values of *kulikuli* at the end of first week of storage

Packaging material	Free fatty acid (mg/100 g)	Peroxide value ($meqO_2$ /kg)	Saponification value (mg KOH/g)
Plastic material	3.93±0.03^{e}	2.40±0.36^{b}	16.80±0.26^{b}
Aluminium foil	5.61±0.05^{d}	1.20±0.26^{c}	11.22±0.02^{d}
Glass material	6.62±0.03^{b}	4.20±0.36^{a}	25.22±0.09^{a}
LDPB	7.07±0.03^{a}	2.80±0.30^{b}	11.50±0.05^{c}
Plastic + LDPB	6.50±0.04^{c}	0.60±0.20^{d}	5.61±0.04^{e}

*Values followed by same superscript alphabet are not significantly different at (P < 0.05) along the columns. Values are Mean ± SEM of triplicate determination.
Key: LDPB = Low Density Polyethylene Bag.

Table 2: Free fatty acid, peroxide and saponification values of *kulikuli* at the third week of storage

Packaging material	Free fatty acid (mg/100 g)	Peroxide value ($meqO_2$ /kg)	Saponification value (mg KOH/g)
Plastic material	10.10±0.03^{d}	12.80±0.26	364.65±0.03^{b}
Aluminium foil	8.97±0.04^{e}	13.00±0.36	112.20±0.04^{d}
Glass material	13.46±0.03^{a}	13.40±0.20	448.80±0.02^{a}
LDPB	11.22±0.04^{c}	12.40±0.36	336.60±0.05^{c}
Plastic + LDPB	12.34±0.04^{b}	12.60±0.36	84.15±0.04^{e}

*Values followed by same superscript alphabet are not significantly different at (P < 0.05) along the columns. Values are Mean ± SEM of triplicate determination.
Key: HDPB = Low Density Polyethylene Bag

Table 3: Free fatty acid, peroxide and saponification values of *kulikuli* at the fifth week

Packaging material	Free fatty acid (mg/100 g)	Peroxide value ($meqO_2$ /kg)	Saponification value (mg KOH/g)
Plastic material	12.34±0.04^{d}	13.00±0.26^{b}	729.27±0.06^{b}
Aluminium foil	12.34±0.05^{d}	13.00±0.36^{b}	168.30±0.26^{e}
Glass material	21.32±0.03^{a}	14.80±0.36^{a}	757.35±0.04^{a}
LDPB	15.71±0.04^{c}	13.00±0.36^{b}	701.25±0.04^{c}
Plastic + LDPB	17.95±0.03^{b}	14.80±0.30^{a}	224.40±0.05^{d}

*Values followed by same superscript alphabet are not significantly different at (P < 0.05) along the columns. Values are Mean ± SEM of triplicate determination.
Key: LDPB = Low Density Polyethylene Bag

Table 4: Fatty acid, peroxide and saponification values of *kulikuli* at the seventh week

Packaging material	Free fatty acid (mg/100 g)	Peroxide value ($meqO_2$ /kg)	Saponification value (mg KOH/g)
Plastic material	14.59±0.04[e]	15.20±0.46[c]	1093.95±0.0[b]
Aluminium foil	15.71±0.03[c]	18.20±0.36[a]	336.60±0.04[e]
Glass material	30.29±0.03[a]	18.20±0.36[a]	1009.80±0.04[c]
LDPB	20.19±0.03[d]	15.00±0.36[c]	1122.00±0.05[a]
Plastic + LDPB	22.44±0.03[b]	16.60±0.26[d]	368.55±0.03[d]

*Values followed by same superscript alphabet are not significantly different at (P < 0.05) along the columns. Values are Mean ± SEM of triplicate determination
Key: LDPB = Low Density Polyethylene Bag.

Table 5: Texture of *kulikuli* samples taken at week intervals for one month

Week	Plastic material	Aluminium foil	Glass Material	LDPB	Plastic + LDPB
1	8.07±0.15	7.97±0.25	8.07±0.15	8.07±0.15	8.07±0.15
2	8.07±0.00	8.07±0.00	8.07±0.00	8.17±0.80	8.0 7±0.00
3	6.40±0.00	6.50±0.01	6.70±0.00	6.40±0.00	6.40±0.00
4	6.40±0.14	6.40±0.14	6.40±0.14	6.40±0.14	6.40±0.14

Data are means ± standard error of duplicate determination.
Means with common superscripts in the row are not significantly different at $p \geq 0.05$.
Key: LDPB = Low Density Polyethylene Bag.

Table 6: Sensory score for general acceptability for one month at week interval

Week	Plastic material	Aluminium foil	Glass Material	LDPB	Plastic + LDPB
1	7.23±0.10	7.26± 0.00	7.30±0.00	7.03±0.00	7.33±0.00
2	7.93±0.13	7.93±0.13	7.93±0.13	7.93±0.13	7.93±0.13
3	7.93±0.00	7.90±0.10	7.93±0.00	7.92±0.01	7.93±0.00
4	6.53±0.20	6.53±0.20	6.53±0.20	6.53±0.20	6.53±0.20

Data are means ± standard error of duplicate determination.
Means with common superscripts in the row are not significantly different at $p \geq 0.05$.
Key: LDPB = Low Density Polyethylene Bag.

Table 1 revealed the free fatty acid, peroxide value and saponification value of snack samples at the end of one week of study. The result showed that snacks packaged in different materials were significantly ($p<0.05$) different in the parameters measured. Snacks packaged in low density polyethylene and glass materials were significantly ($p < 0.05$) high in free fatty acid; while snacks in plastic and alluminium foil materials had the lowest free fatty acids, 3.93 mg/100 g and 5.61 mg/100 g, respectively. Similar trend was observed in the peroxide value where snacks packaged in glass were significantly ($p < 0.05$) high in peroxide value, followed by snacks packaged in low density polyethene bag and plastic materials, resprctively. However, snacks stored in a combination of packaging materials and alluminium foil were significantly ($p<0.05$) low in peroxide values, 0.60 $meqO_2$ /kg and 1.20 $meqO_2$ /kg, repectively. Snacks packaged in glass and plastic materials were significantly ($p < 0.05$) high in saponification value while those packaged in a combination of packaging material and alluminium foil were significantly low in saponification values, 5.61 mg KOH/g and 11.22 mg KOH/g, respectively. The relatively high free fatty acid, peroxide and saponification values of snacks stored in glass container could be attributed to the fact that transperent glass as packaging material for lipid and lipid based foods provides less protection against the destructive effect of light during storage compared with other packaging materials. This results further comfirm that light accelerates the oxidative process in glass stored foods resulting in the onset and development of lipid oxidation in lipid based foods (Abramovich and Adam, 2005; Ozkan *et al*., 2007; Raza *et al*., 2009; Grujić *et al*., 2011). However, the peroxide values of the snacks at the end of first week of storage (0.60 – 4.20 $meqO_2$/kg) are far less than maximal acceptable value of >10 mmol O_2/kg oil, as allowed by appropriate regulation (Anonymous, 2011). It can be deduced that foil packaging material gave better control of spoilage parameters by providing high protection against the destructive effect of light during storage.

Table 2 shows the free fatty acid, peroxide and saponification values of the snack samples at the end of third week of storage. The results showed that snacks packaged in different materials significantly ($p<0.05$) differed in the parameters measured. At the end of the third week of storage, snack samples showed increased fatty acids, peroxide and saponification values which ranged from 8.97 – 13.46 mg/100 g; 12.40 – 13.40 $meqO_2$/kg; and 84.15 – 44.80 mg KOH/g, respectively. Despite increase in the chemical parameters of the samples studied, different packaging materials used in this study had no effect on the peroxide value of the snacks at the end of the third week of storage. *Kulikuli* snacks packaged in a glass material and in a combination of plastic and LDPB, and LDPB alone were high in free fatty acids; while, snacks in aluminium foil and plastic packaging materials were significantly ($p<0.05$) low in FFAs 8.97 mg/100 g and 10.10 mg/100 g, respectively. In saponification value, like the FFAs values, snacks packaged in glass material had the highest value (448.80 mg KOH/g), followed by snacks in plastic and LDPB materials where they had 364.65 mg KOH/g and 336.60 mg KOH/g, respectively. *Kulikuli* snacks stored in a combination of plastic and LDPB packaging material had the lowest saponification value (84.15 mg KOH/g) and this was followed by snacks stored in alluminium foil (112.20 mg

KOH/g). Abramovich and Adam (2005) and Grujić *et al*. (2011) asserted that the exclusive use of peroxide number is not a good index for the early stages of fat oxidation but, one of the the major numerous tests during examination of oil sustainability. However, monitoring of changes in peroxide value under different conditions is a helpful indicator for comparing the effect of different storage conditions on rate of oxidative development process in lipid and lipid based foods. The peroxide range (12.40 – 13.40 meqO_2/kg) at the end of third week of storage is slightly above the recommended <10 meqO_2/kg; however, the range here is below 30 – 40 meqO_2/kg recommended for rancid food products. The greater the saponification value the more short and medium fatty acids are in the product (Grujić *et al*., 2011). In this study, snacks stored in glass material had the highest value (448.80 mg KOH/g) while snacks stored in a conbination of plastic and LDPB had the lowest value (84.15 mg KOH/g). This implies that glass material predisposes the snacks to high chances of multiple lipid oxidation compared to other packaging materials most especially a conbination of plastic and LDP and foil paper. Therefore, for a good quality stored snacks up to three weeks, it is advisable to use a combination of plastic and LDPB or alluminium foil paper.

At the end of the fifth week of storage studies, snacks packaged in plastic and alluminium foil exhibited mild increases in their FFAs values from 10.10 mg/100 g at the end of third week to 12.34 mg/100 g at the end of fifth week and from 8.97 mg/100 g at the end of third week to 12.34 mg/100 g at the end of fifth week respectively (Tables 2 and 3). However, snacks stored in glass material, a combination of plastic and low density polyethelene bag and LDPB exhibited high increases at the end of fifth week of storage. Similar trend of increase was recorded at the end of the third week of storage (Table 2). The same pattern of increase was exhibited in the saponification value of the snacks, where glass and plastic packages had high values; while, snacks stored in alluminium foil had significantly ($p<0.05$) low value (168.30 mg KOH/g).

There was a steady increase in free fatty acid, peroxide and saponification values of the snack samples with increasing storage time (Table 4). *Kulikuli* stored in glass material exhibited high rise in free fatty acid and peroxide values at the end of seventh week of storage. The rise was from 6.62 mg/100 g at the end of first week to 30.29 mg/100 g at end of seventh week and from 4.20 meqO_2/kg at the end of first week to 18.20 meqO_2/kg at end of seventh week of storage, respectively. Also, there was a sharp increase in the peroxide value of snacks stored in alluminium foil (18.20 meqO_2/kg) at the end of seventh week which intially exhibited low levels at the end of the first (1.20 meqO_2/kg), third and fifth week (13.00 meqO_2/kg) of storage. This suggests that, alluminium foil has lost it potentials as a barrier against movement of volatile compounds, gases and moisture with increasing storage time. Furthermore, there were sharp increases in the saponification values of the snacks compared with moderate increases in free fatty acids and peroxide values all through the duration of this study. It can be deduced from the results that, snacks packaged in plastic, glass and low density polyethelene materials had significantly ($p<0.05$) high parameters measured. This implies their non-suitability as pacakaging materials for *kulikuli* over extended time of storage. Equally, the peroxide values all through the duartion of this study did not come close to the recommended rancid rage (30 - 40 meqO_2/kg).

The texture and general acceptability of the snack samples packaged in different materials are shown in Tables 5 and 6. The results taken at week interval over one month of storage revealed that, packaging matrials used in this study exhibited similar potentials in preserving textural and general acceptability of the *kulikuli* samples over the duration of the study.

CONCLUSION

Locally available packaging materials used in this study showed significant variabilities in *kulikuli's* free fatty acid, peroxide and saponification values over a seven week storage time. *Kulikuli* stored in a blend of plastic and LDP and foil paper alone for up to three weeks gave favourable results in terms of product quality. Prolonged storage beyond the three weeks gave significant increases in quality paremeters outside the recommended range; however, not rancid. Packaging matrials used in this study exhibited similar potentials in preserving the textural and general acceptability of the snack over one month period.

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