Effect of frying conditions on storage stability of fried maize snack (kokoro)

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Abstract: Snacks can be produced from maize and other cereals and legumes. Kokoro is a popular traditional fried maize snack widely consumed among adults and children in South Western states of Nigeria. Short shelf life is associated with fried products including kokoro. Improving its shelf life therefore entails understanding the frying process, optimizing the frying condition and studying the storage stability of the fried product. This work was designed to study the storage stability of kokoro (produced at the recommended optimum processing condition) enriched with African yam bean (AYB) and evaluate its storage life. The kokoro was produced and packaged in polyethylene bags (100μm) and stored at ambient conditions (24 ℃±3 ℃ temperature and 61%±3% relative humidity). The product was stored for a period of fourteen weeks during which, the free fatty acid value and sensory evaluation parameters of the samples were determined weekly. Moisture adsorption isotherm characteristics of the product were also determined. The result obtained for the storage parameters showed that the product would maintain good qualities for a period of twelve weeks.

Keywords: African yam bean seed flour, fried maize snack (kokoro), free fatty acid value, moisture adsorption isotherm characteristics, Nigeria

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1 Introduction

Snacking is on the increase worldwide and this result primarily from factors such as increase in one person households, a higher proportion of working mothers and more school-aged children obtaining their own meals and refreshments. It is therefore necessary to produce a highly acceptable snack with high nutritional quality that could be useful in nutritional programs to combat malnutrition and nutrient deficiencies(Rosa et al., 2003). A snack is a small meal and snacking is the consumption of easy- to- handle food products in either solid or liquid form, with little or no preparation (Tettweiler, 1991). Snacking has become a common practice in the world at large.

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In Nigeria, snacks category range from the traditional snack produced from indigenous cereals and legumes such as maize and groundnut (*kulikuli*, *donkwa*, *guguru*, *Aadun*, *kokoro and so on*) to other snacks (biscuits, cookies) produced from wheat, rye, barley and other cereal of foreign origin (Okaka, 1997)**.** *Kokoro* is commonly consumed as traditional maize snacks in Nigeria especially in the South-Western region. It is produced by deep frying of maize dough mixed with other ingredients like salt/sugar and onions.

Maize (*Zea mays* L.) is the third most important cereal in the world after rice and wheat and ranks fourth after millet, sorghum and rice in Nigeria. Global statistics for cereal consumption indicate that the average total consumption in the African diet is 291.7 g/person/day, including an average maize consumption of 106.2 g/person/day (FAO, 2009). The major chemical component of the maize kernel is starch, which provides up to 72% to 73% of the kernel weight. Other carbohydrates are simple sugars present as glucose, sucrose and fructose in amounts that vary from 1% to 3% of the kernel. Generally, whole maize contains 362 kcal/100 g calories; 8.1% crude protein; 72% starch, 5% fat, 1.3% ash, 2% fiber; 60 ppm calcium, 35 ppm iron; 1.8 ppm Zinc (Ekpo, 2006). Maize could be processed into various forms namely: roasted, boiled, fermented, toasted, toasted and milled; toasted, milled and mixed with palm oil, depending on the region where it is produced. For instance, maize grains are prepared by boiling (*agbado*) or toasting and milling (*elekute*), or fermented and boiled as paste (*eko*), in Nigeria and *kenke* in Ghana, or as popcorn which is eaten all over West Africa (FAO, 1992). It could also be nixtamized, made into maize puree, ice cream, high fructose corn syrup, and used as bio-fuel, plastics, fabrics, adhesives and other chemical products. In Nigeria, products from maize include ogi, tuwo, donkunnu, masa, popcorn, aadun, cooked or boiled maize, roasted maize as well as *kokoro* (maize rings). Like most cereal-based foods, *kokoro* is rich in carbohydrate, but low in protein and deficient in some essential amino acids, particularly lysine. This makes the product nutritionally deficient. Therefore the need for inexpensive quality protein cannot be overemphasized.

African Yam Bean (AYB) (*Sphenostylisstenocarpa*) is one of the less utilized legumes that are gradually going into extinction (Klu et al., 2001). It is nutrient-dense, but classified as neglected underutilized species (NUS) legume (Anon, 2007). Its utilization varies from cooked bean to fermented sauce (Arisa and Ogbuele, 2007). It is grown throughout Tropical Africa, most commonly in Central and Western Africa, especially in Eastern Nigeria. It is also reported to be cultivated in Ivory Coast, Ghana, Gabon, Congo, Ethiopia and parts of East Africa (Wokoma and Aziagba, 2001). It grows well in acid and highly leached sandy soils of the humid lowland tropics where other major food legumes do not flourish. It suffers less of pest damage than the other legumes both in cultivation and storage and it has the potential to meet year-round protein requirement if grown on a large scale (Adewale et al., 2010).

AYB has attracted research interest because of its nutrient content. Amino acid analyses indicate that the lysine and methionine levels in the protein are equal to or better than, those of soybean, while most of the other essential amino acids corresponds to WHO/FAO recommendation (Evans and Boulter, 1974). Despite the availability and the nutritional importance of AYB, it is still underutilized. AYB has been processed into flour and paste used locally for “moinmoin” (cooked paste) and “akara” (fried bean balls). There is still limited information on the food uses of AYB seeds.

Deep fat frying is an established process of food preparation worldwide. Deep fat frying is defined as a process of cooking and drying using hot oil and it involves heat and mass transfer. Deep fat frying has been used for many centuries for cooking meat, fish and vegetables (Vitrac et al.,2000) and also for some snack foods including *kokoro*. The quality of fried product depends on frying conditions as well as food and oil types used. Despite acrylamide scar and other limitations associated with frying, fried foods is still a choice of many people because of its unique flavor and satiety value. Therefore, optimizing the frying parameters to obtain an optimum condition that gives the most acceptable sensory attributes is essential for the purpose of reproducibility and recommendation to cottage industries.

Idowu and Aworh (2014) studied the use of AYB seed flour to enrich *kokoro* and established the optimum frying conditions for its production. However, there is need to study the storage stability of the enriched *kokoro*. *Kokoro*, being a fried product, has the problem of short shelf life, earlier authors have reported shelf life of about 3-4 weeks (Henshaw and Ihedioha, 1992; Uzo-Peters et al., 2008). The shelf life of the product can be improved upon through selection of good quality raw materials, and the product’s stability during storage and storage of the products at its appropriate storage condition was studied.

The main objective of this study therefore, was to observe the storage stability of *kokoro* (produced at recommended optimum processing condition) enriched with AYB.

2 Materials and methods

Maize variety (BR 9928-DMR-SY) was procured from International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria, while the African yam bean was sourced from local market and classified at the IITA genetic resource centre as variety Tss 30. Refined vegetable oil, salt and onions were obtained from a retail market in Bodija, Ibadan, Oyo State, Nigeria.

2.1 Preparation of samples

Enriched *kokoro* was prepared at optimum processing conditions recommended by Idowu and Aworh (2014). These optimum conditions were frying temperature of 155 ℃ and frying time of 11.5 min using 30% AYB flour inclusion in the flour blend. Maize samples (of 8.18% moisture content) were sorted, milled and sieved using 750 μm mesh size and packaged in high density (100 μm) polyethylene bags to prevent the flour from absorbing moisture. The African yam bean seeds were also sorted, weighed, washed, dehulled manually and dried at 60 ℃ in an oven. The seeds were milled using hammer mill (model ED-5 Thomas Wiley, England) and sieved with 500 μm mesh size. Parts of the maize flour were substituted with 30% African yam bean seed flour (AYBSF) by weights. The blend was properly mixed in a blender to obtain a homogenous sample and packaged separately in airtight plastic containers till needed. *Kokoro* was prepared by dividing the maize-AYBS flour blend into two equal parts. The first half was mixed with measured quantity of salt and onions and the second half was mixed in hot water to make a paste. The two halves were then mixed together by continuous stirring using a wooden stick for about 3 min to obtain a homogenous dough. The dough was allowed to cool to a temperature of 40 ℃ and kneaded on a chopping board. The kneaded dough (of about 22% moisture content) was shaped into uniform sizes (of about 15 cm) using a locally fabricated extruder and deep-fried in hot oil (specific gravity 0.918) at temperature of 155 ℃ and time of 11.5 min. The process was replicated. The fried *kokoro* samples were drained, left to cool and packaged in polyethylene bags (100μm) and stored at ambient conditions (24 ℃±3 ℃ temperature and 61%±3% relative humidity). The product was stored for a period of fourteen weeks; the free fatty acid value and sensory evaluation characteristics of fresh and stored samples were obtained at weekly interval. Adsorption isotherm characteristics of the products were also determined.

2.2 Analytical procedures

2.2.1 Determination of free fatty acid value

Measurement of rancidity in the product was carried out by determining free fatty acid (FFA) (%) in extracted fat of the samples. The fat was extracted with hexane using an automated method (Soxtec system HT2) (AACC, 2005).

Diethyl ether (25 ml) was mixed with 25 ml alcohol and 1 ml phenolphthalein solution (1%) and carefully neutralized with 0.1 M sodium hydroxide. About 1 g of the extracted oil was dissolved in the mixed neutral solvent and titrated with aqueous 0.1 M sodium hydroxide shaking constantly until a pink colour that persists for 15 s was obtained.

$$Acid\ value = \frac{Titre\ value\ (ml)\times 5.61}{Weight\ of\ sample\ used} = 2 \times FFA \text{.......1}$$

FFA is usually calculated as oleic acid. one ml of NaOH=0.0282g oleic acid.

Progress of lipid deterioration was evaluated by using FFA value for 84 d at regular (7 days) interval. This will help to suggest the appropriate shelf life for the products.

2.2.2 Determination of adsorption isotherm characteristics of the sample

The samples were dehydrated in a glass desiccators containing phosphorus pentoxide (P_2O_5) for about 3 days. The adsorption isotherm was determined by the static gravimetric method at 20 ℃, 30 ℃ and 40 ℃ (to simulate the temperatures of marketing and distributing these products in Nigeria). Triplicates of the samples of known weight (2 g) were placed above saturated salt solutions (analytical grade-Merck) Dessicant<0.001, $LiCl_2$ 0.12, $MgCl_2$ 0.34, K_2CO_3 0.49, $Mg(NO_3)_2$ 0.55, $NaNO_2$ 0.65, NaCl 0.76, $CdCl_2$ 0.82, K_2CrO_4 0.88, KNO_3 0.94 and Na_2HPO_4 0.99(Bell and Labuza, 2000; Labuza, 1968) separate tightly closed glass jars of 12 cm diameter and kept in ventilated incubators (Model SG 93/06/369, United Kingdom). Samples were weighed (balance, sensitivity ±0.0001 g) at 24 h interval until constant weight was reached. Equilibrium was acknowledged when three consecutive weight measurements showed difference less than 0.001 g. The moisture content of each sample was determined by the air oven method by means of triplicate measurements. Samples' weights were determined using a Mettler balance (model AJ150, Greifensee, Switzerland). Formalin (analytical grade) was placed inside the high relative humidity (>65%) dessicators to protect samples from microbial spoilage (Jamali et al., 2006; Moreira et al., 2005). All moisture contents were expressed as a percentage of non-dry weight because fat is known to exhibit no sorption of water below RH 90% (De Jong et al.,1996). The moisture content at which constant weight was reached was recorded as the equilibrium moisture content of the samples. The equilibrium moisture content at each water activity is the mean value of three replications. The equilibrium moisture content was plotted against water activity to give the moisture adsorption isotherm.

2.2.3 Determination of sensory properties

The sensory properties of samples were determined by a ten-member semi-trained panel selected and screened with respect to their interest and ability to differentiate food sensory properties described byIwe (2002). Sensory evaluation room was well illuminated and the booths were well partitioned to avoid distraction or interference by other panelists. The samples were rated on a nine point hedonic scale ranking 1 for 'dislike extremely' and 9 for 'like extremely'. The average values of the sensory attributes (appearance, taste, crispness, aroma and overall acceptability) were obtained and replicated.

2.3 Statistical analysis

Data generated from the study were subjected to Analysis of Variance (ANOVA) using SPSS (version 17). Means were separated using LeastSignificant Difference and all data were statistically analysed at p=0.05.

3 Results and discussion

3.1 Effect of storage on free fatty acid (FFA) value of AYB-maize *kokoro*

The results of the free fatty acid (FFA) values of the snacks stored at ambient conditions (temperature-24°C and relative humidity-61%) are presented in Figure 1. It showed that the FFA contents increased with increase in the period of storage. The increase obtained in the value of free fatty acid is an indication of onset of rancidity. However, the FFA obtained during the storage period did not exceed the 1.2%-2.1% limit, which was reported by (Idowu et al., 2010; Pearson, 1976) to be the minimum limit for odour to be acceptable. This implies that the snack will maintain a good quality for a storage period of 12 weeks. After the period of twelve weeks, minimum limit for odour to be acceptable was exceeded.

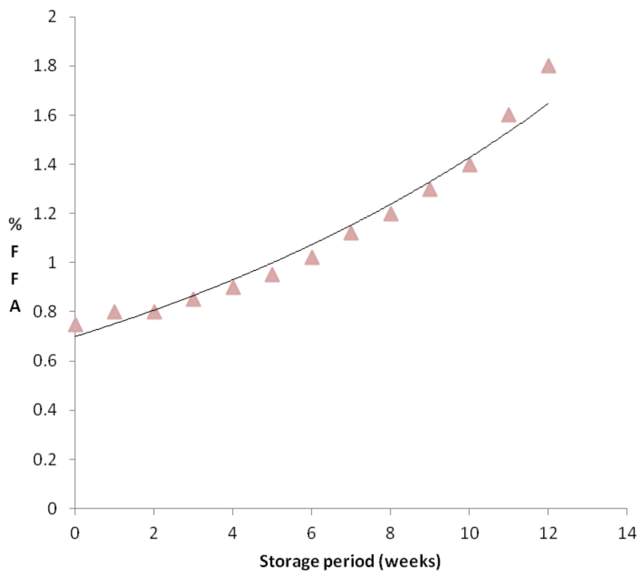

Figure 1 Free Fatty Acid (FFA) value against storage period of *kokoro* produced from blends of maize and African yam bean seed flours

3.2 Adsorption isotherm characteristics of the AYB-maize *kokoro*

The adsorption isotherm of *kokoro* samples produced showed a sigmoid type II curve, characteristic of starchy food and consistent with Brunauer-Emmet-Teller (BET) classification. The adsorption isotherm result suggested that the equilibrium moisture content of the sample decreased with increase in storage temperatures (20 ℃, 30 ℃ and 40 ℃) at any given water activity as shown in Figure 2. Similar trends were reported for Akara Ogbomoso made from blends of cowpea and soybean (Falade et al., 2003). Monolayer moisture content for “formulated” *kokoro* ranged between 2.05% -3.25% (dry basis).

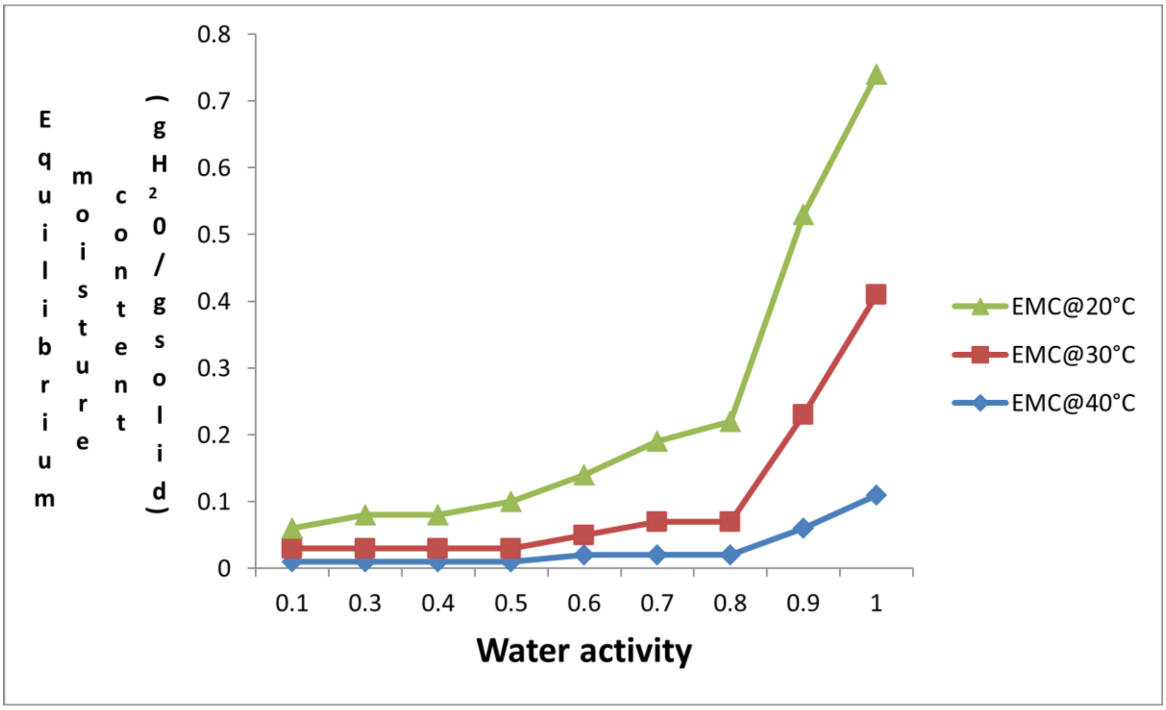

Figure 2 Moisture Adsorption Isotherm of AYB-Maize snack food in the temperatures 20 ℃, 30 ℃ and 40 ℃.

3.3 Sensory evaluation of the stored snacks

The result of the sensory qualities of AYB-maize *kokoro* stored (at temperature, 24 ℃ and relative humidity, 61%) for twelve weeks is shown in Table 1. The quality attributes of the snack samples were judged based on the hedonic scale ranking for sensory evaluation. The hedonic scale ranking ranged from 1 (dislike extremely) to 9 (like extremely) with higher ranking representing better sensory qualities. Higher scores were obtained for freshly prepared samples than the stored samples. The scores obtained for the samples decreased with storage time. This implies that sensory quality attributes of the snack decreased with increase in the period of storage. This is expected because freshly prepared food samples always tastes better than stored food samples. However, there were no significant differences ($p \geq 0.05$) among fresh sample and stored samples in terms of appearance, taste, crispness, aroma and overall acceptability until after 3 weeks of storage. The hedonic score obtained for all the sensory attributes were still above hedonic score-5 up to the twelfth (12^{th}) week. This implies that the products could be stored for a period of twelve weeks under ambient storage condition (temperature – 24 ℃ and relative humidity – 61%) without unacceptable changes in the sensory qualities. This is an improvement over the traditional processing of *kokoro*, whose shelf life was reported by Henshaw and Ihedioha (1992) to be 30 d when stored at ambient condition in low density polyethylene. This improvement may be attributed to use of good quality raw materials and optimization of processing conditions employed.

Table 1 Sensory qualities of stored snack produced from blends of African yam bean flour and maize flour

Storage Period (weeks)	Appearance	Taste	Crispness	Aroma	Overall acceptability
0	7.9a	7.6a	7.8a	7.5a	8.1a
1	7.8a	7.6a	7.7a	7.5a	8.0a
2	7.7a	7.6a	7.5a	7.2a	7.8a
3	7.7a	7.6a	7.4ab	7.1b	7.7ab
4	7.2abc	7.5a	7.3ab	6.9bc	7.6ab
5	7.1abc	7.3a	7.3ab	6.8c	7.6ab
6	7,4ab	7.2a	7.2ab	6.7c	7.4b
7	7.2abc	7.0ab	7.2ab	6.7c	7.4b
8	7.6a	6.9ab	7.0ab	6.7c	7.3bc
9	7.1abc	6.8ab	7.0ab	6.6c	7.0c
10	6.9bc	6.8ab	6.6bc	6.2d	6.8d
11	6.9bc	6.7ab	6.5bc	6.2d	6.7d
12	6.6d	6.1b	5.9c	6.2d	6.2e

Values with the same letter along the column are not significantly different at p>0.05

4 Conclusions

Storage stability of *kokoro* enriched with African yam bean seed flour and produced at recommended optimum processing condition was evaluated. Free fatty acid value, adsorption characteristics and sensory qualities of the stored samples showed that the snack could maintain good quality for a period of twelve weeks. The results obtained for the parameters tested during the storage study of the snack show that the “formulated kokoro” exhibited a better shelf life than the shelf life reported for commercial kokoro. This innovation therefore may be a very good prospect for commercialization.

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