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Storage Stability of a Nigerian Traditional Corn-Based Snack (*Kokoro*)

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Abstract: *A Nigerian traditional corn-based snack, Kokoro was produced by the traditional hand rolling method and with the use of a manual extruder. Samples from the market were designated as Control. The chemical composition of the samples was determined using standard laboratory procedures. Sorption isotherms were determined using static gravimetric method at different water activities (a_w) (0.22 - 0.85) and temperatures (20 – 40^{o}C). Data obtained were analyzed using Analysis of Variance and means were separated with Duncan's multiple range test. Ash, moisture, fat, Free Fatty Acid (FFA), calcium, zinc, iron, phosphorus and potassium contents for traditional hand rolled and manual extruded Kokoro samples ranged from 1.56-1.76%, 1.46 to 4.46%, 31.25-34.97%, 0.33 to 0.45% 68.92 to 71.02 mg/100g, 1.76 to 1.94 mg/100g, 4.89 to 6.11 mg/100g, 218.5 to 233.5 mg/100g and 288.0 to 317.0 mg/100g, respectively. The high fat content predisposes the Kokoro samples to rancidity. Peleg, Oswin and GAB sorption models gave the highest R^2 values (R^2>0.991), lowest % Error (%E) and Root Mean Square (RMSQ) values (%E < 0.4%, RMSQ < 1.05). The storage stability study showed that bacterial loads for hand rolled were significantly ($p<0.05$) higher than those of manually extruded Kokoro. The sorption isotherm studies revealed that the monolayer value which is indicative of the safest water activity ($a_{w)}$ for an acceptable and good keeping quality Kokoro was found to be 1.8 to 4.28 kg-solid/kg-water (dwb).*

Keywords: *Kokoro, Extrusion, Traditional snack, Food storage.*

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I. Introduction

Kokoro is a traditional maize-based, rod-like crunchy snack highly cherished and eaten freely in Southwestern Nigeria [1]. It is a predominantly carbohydrate-based snack made by deep-frying maize paste previously mixed with spices, salt, and sugar [2]. Freshly prepared *Kokoro* has an appealing brownish colour, crunchy, pleasant roasty aroma, and a 2-week shelf life [3], [4]. The snack is packaged in transparent low-density polythene bags and hawked in market places and motor parks.

The increasing popularity of *Kokoro*, the drudgery of the traditional process, and its inherent short shelf life underscore the need for research aimed at understanding the wholesomeness of *Kokoro* during storage. The storage life of a food commodity depends on a number of factors: quality of raw materials, processing method and condition, post-production handling, packaging, and storage conditions. Factors important in the shelf life of dry foods are temperature, product moisture content, moisture adsorption (described through isotherms), storage atmosphere, and packaging material. Some intrinsic physicochemical properties of carbohydrates, namely: water absorption capacity, oil absorption capacity, bulk density and swelling capacity influence the behaviour of food systems during processing and storage. An understanding of these properties in relation to *Kokoro* will aid the understanding of storage characteristics of the commodity. The objective of this study is to investigate the storage stability of *Kokoro* samples obtained from the traditional method and manually extruded samples

II. Materials and Methods

2.1 Materials

Bulk of white maize grain, ACR91 Suwan1-SRC, was obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria, and was used to produce *Kokoro* following the traditional production method used by the locals at Imasayi Town in Yewa North Local Government Area of Ogun State, Nigeria. The procedure is depicted in Figure 1.

2.2 Sample Preparation

10 Kg of dry white maize grains (moisture content 7-8%) were sorted, cleaned, winnowed, cooked (till partially tender), allowed to cool under room conditions overnight for about 14 hours and wet milled in a local attrition mill to obtain a maize mash. A mixture of 200gm milled fresh onion and 2gm table salt was added to the maize mash to obtain a maize mash-onion dough mix.

The dough mix was divided into two equal portions. The first portion was kneaded, cut into bits, rolled on wooden chopping board, formed into circular rings, and then deep-fried at 180^{o}C for 3 minutes in vegetable oil. The fried products, light-red coloured, were allowed to cool overnight for 14-16 hours and fried again to obtain the characteristic off-white golden cream colour of *Kokoro*. The second portion of the maize mash-onion dough mix was fed into a manual extruder and extruded at ambient temperature (32^{o}C) using three different dice shapes (flat, round and rod). The extruded mash was formed into circular ring shapes, deep-fried and allowed to cool and re-fried as described earlier.

The resulting *Kokoro* products obtained from both portions were packaged in Polyethylene bags set aside for analyses. Some *Kokoro* samples were purchased from an open market in the locality and served as control. Storage studies were achieved over 4-week duration at room temperature.

2.3 Sample Analysis

2.3.1 Chemical Analysis

Three replicate samples were removed from the finished products for chemical analysis. Samples were analyzed for proximate and mineral compositions [5]. Energy values were calculated by multiplying protein, fat, and carbohydrate by 4, 9, and 4, respectively [6].

2.3.2 Determination of Moisture Sorption Isotherm

The static gravimetric method as described by [7] and [8] was used to determine the equilibrium moisture content (EMC) of the *Kokoro* samples. The samples were dehydrated in a hot air oven for 8 h at 105±5°C [5] prior to further testing. Triplicate samples, 0.50 ± 0.001g each of the samples were weighed into moisture pans in the desiccators. Concentrated sulphuric acid used to make up a 250 ml of desiccant with de-ionised water was prepared at 20, 30, and 40°C, respectively using water activity and temperature tables of [9]. The acid was then dispensed into the desiccators according to their respective water activity values (Table 1). The desiccators were maintained at water activity values of between 0.1 and 0.8 and placed in a Genlab incubator (Model M75CPD) to maintain the required temperature level (20, 30, and 40^{o} C). Each of the samples was weighed every day using a digital balance until a constant weight was obtained in three consecutive recordings, then the sample was assumed to be at equilibrium (±0.001g). The EMC were calculated and subsequently the moisture adsorption isotherms were plotted for the samples. Also, the EMC data were fitted into Guggenheim, Anderson and de Boer (GAB), Oswin, Peleg, and Langmuir equations models (Table 2) using linear regression analytical procedure. These models were chosen because of their suitability for high carbohydrate foods, simplicity and ease of evaluation [10]. The degree of fitness to the models was evaluated by calculating coefficient of determination (R^2), root mean square error (RMSE) and mean percentage deviation (%E). The RMSE and % E are defined as shown below:

$$RMSE = \sqrt{\frac{\sum(M_{exp} - M_{pred})^2}{n}}$$

$$\% E = \frac{100}{n}\sum\left|\frac{M_{exp} - M_{pred}}{M_{exp}}\right|$$

Where M_{exp} is the experimental equilibrium moisture content, M_{pred} is the predicted moisture content and n is the number of observations.

2.3.3 Statistical Analysis

Data obtained from chemical analysis were subjected to statistical analysis using SPSS version 23. Mean values were subjected to analysis of variance (ANOVA) and significantly different treatment means were separated using Duncan Multiple Range Test (DMRT).

III. Results and Discussion

3.1 Chemical Analysis

Proximate composition of the laboratory-produced *Kokoro* and that obtained from the open market are shown in Table 3. Remarkable differences in the results indicated that nutrient composition was significantly ($p>0.05$) affected by the source of the product and extrusion method. However, the protein contents of all the products did not differ significantly ($p<0.05$), thus suggesting that the protein content of the product was not affected by the source and the extrusion method. Moisture content was higher in open market sourced *Kokoro* than the laboratory-produced one. However, the former had lower fat and ash contents than the latter.

Kokoro samples produced from traditional method of extrusion had significantly lower ($p>0.05$) moisture and ash contents but higher fat and carbohydrate contents.

Energy values ranged from 532 Kcal/100 g to 559 Kcal/100 g in the open market-sourced *Kokoro* and traditional extrusion produced one, respectively. The relatively lower food energy derivable from the open market sourced *Kokoro* was due to its low fat content. All laboratory-produced *Kokoro* had higher food energy values.

Marked variations were observed in the acid values of the products, the open market sample having the highest while the free fatty acid of the laboratory samples and open market were not significantly different ($p>0.05$) from each other. The traditional method sample had the highest value for the free fatty acids.

The moisture content of a food product is a very important parameter in determining the shelf stability of the product. The moisture contents of *Kokoro* from the use of manual extruder are below the 10 – 14% recommended for snack products [11]. High moisture contents result in low snack crispiness and acceleration of oxidative rancidity [12]. Low moisture contents enhance product shelf life [13]. This implies that the low moisture content of the *Kokoro* samples, makes it less liable to microbial attack and would have longer shelf stability.

The ash content is a measure of the amount of minerals present in a sample. The ash contents obtained for *Kokoro* samples in this study are within the range (0.95 – 1.89%) as reported for *Kokoro* made from maize and deffated groundnut [2].

The fat content of *Kokoro* samples within the range 20.92 – 31.72% were reported for *Kokoro* from maize, soyflour and ginger [12]. The Acid value is an index of hydrolytic rancidity and a measure of the amount of free fatty acid present in a fat or its products. Samples with low acid value deteriorate faster, have poor sensory properties and low shelf stability [14] , [15]. Thus, traditional laboratory *Kokoro* samples will likely go rancid faster than other samples. The free fatty acid values obtained from this study is low indicating that the *Kokoro* samples will not produce off flavours and the storage quality will not be adversely affected when stored over a four-week period.

3.2 Mineral Compositions

Table 4 shows the mineral composition of the laboratory processed and open market *Kokoro* samples. The geometric shapes of the different manually extruded samples did not affect significantly ($p>0.05$) the calcium and zinc content of the samples. The zinc and iron contents of open market and flat sample are not significantly ($p>0.05$) different from each other. The phosphorus and potassium of the three *Kokoro* samples are significantly different from each other with the open market sample having the highest content of potassium (317mg/100g) while the traditional sample has the highest value for phosphorus (233.5mg/100g).

3.3 Sorption Isotherm

The plots of EMC against water activity at 20, 30 and 40^{o}C of *Kokoro* snacks produced in the laboratory using the traditional method and that obtained from the local market are shown in Figures 2, 3 and 4.

The moisture adsorption isotherms show that, at lower water activities, EMC increased almost linearly with water activity, the increase becomes geometrical at higher water activities for the two samples. A similar trend was reported by [16] for tapioca and *lafun*. Water molecules, at low water activities are adsorbed only at the surface sites.

At higher water activities, there is gradual dissolution of soluble components completely in solution [17]. The sorption isotherm curves for *Kokoro* samples showed type II sigmoid curve according to BET classification [18] and there was inversion (crossover) of isotherms at intermediate and higher water activities. The EMC for open market *Kokoro* were higher than that of traditional produced *Kokoro*, which could be due to the presence of higher levels of sugar. The EMC of *Kokoro* decreased as storage temperature increases at all water activities. The decrease in EMC as temperature increased could be because, at higher temperatures, the activation energy of the water molecules changes to higher energy levels, the bonds become less stable and break away from water-binding sites of foods [19]. Similar trends for same temperature effects have been reported by [16] and [20] for *lafun* and yam flour (*elubo*), respectively. At any particular EMC value, lower storage temperatures result in lower water activity (a_w), which improves stability of the flour. Thus an increase in storage temperatures could lead to microbial growth.

Peleg, GAB and Oswin adequately described the moisture adsorption isotherms of *Kokoro* due to their higher R^2 values. However, the use of R^2 does not imply that the models fit the experimental data accurately. Therefore, the mean relative percent deviation (P (%)) and root mean square error (% RQMS) values are necessary to make conclusive judgment. Based on the P (%) values, Peleg, Oswin and GAB models could adequately describe the experimental adsorption data of *Kokoro*. The mean P (%) of the models is below 10%, which is indicative of good fit [21]. Hence, Peleg, Oswin and GAB models satisfactorily predict the sorption data of the *Kokoro* samples.

Monolayer moisture estimates from the GAB model decrease with increasing storage temperature. This could be due to reduction in the number of active sites in food materials due to chemical and physical damage caused by increased storage temperature [16].

Monolayer moisture describes the sorption capabilities of the food materials; it is the minimum moisture content covering the hydrophilic sites on surfaces of food materials and an important data for achieving minimum quality loss over time. Therefore, at any given temperature, the safest water activity of food material is that which corresponds to the monolayer moisture. Since the monolayer moisture content for Trad Lab *Kokoro* is lower than those of the Open Market samples, it might not provide sufficient binding sites for water molecules and might store for a longer period at temperatures up to 40°C. The Open market samples might provide more binding sites for water molecules and may be least stable at storage temperatures of 30°C and 40°C respectively, due to their high monolayer and moisture content at these temperatures [22]. This might be due to the hydrophobic and hydrophilic effect of salts, sugar, and onions on the *Kokoro* samples.

IV. Tables and Figures

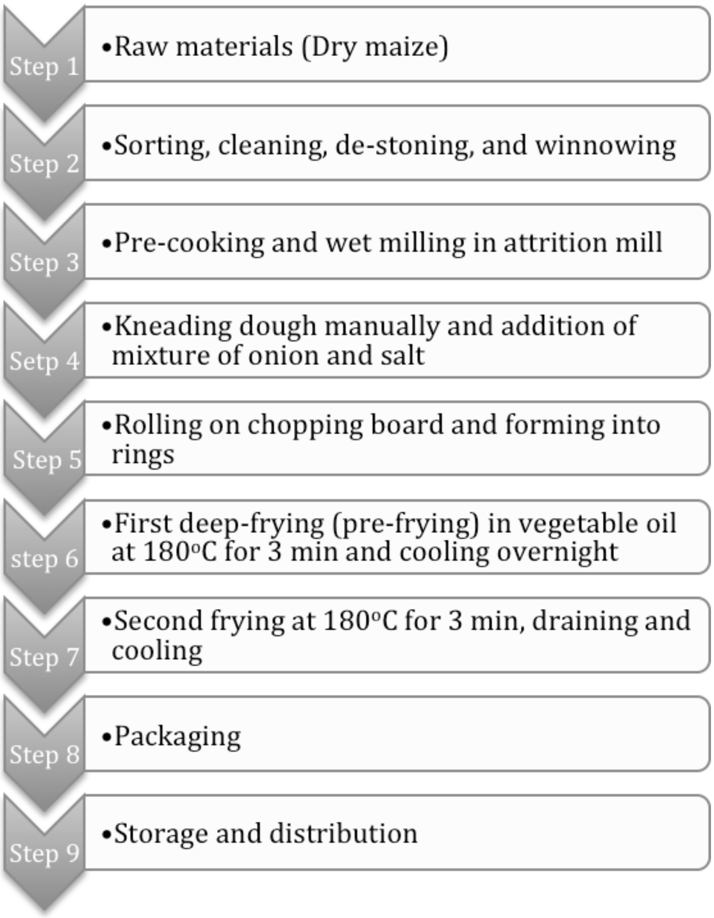

Figure 1: Flow chart for traditional production of *Kokoro*

Table 1. Desiccants preparation for 20, 30 and 40 ^{o}C

Water activity	Conc. H_2SO_4/250ml water (ml) at:		
	$20^{o}C$	$30^{o}C$	$40^{o}C$
0.80	71.29	71.29	71.13
0.70	86.28	86.79	86.92
0.60	99.36	100.71	101.07
0.50	111.65	112.72	113.15
0.40	123.30	124.55	125.11
0.30	135.92	137.30	137.91
0.20	149.08	150.35	150.94
0.10	167.61	168.99	169.63

Table 2. Linear forms of the sorption models used to fit the experimental values

Models*	**Equations****
GAB	$M = \frac{M_o bca_w}{(1 - ca_w)(1 - ca_w + bca_w)}$
Oswin	$M = C(a_w/1 - a_w)^n$
Peleg	$M = C_1 a_w{}^{c^3} + C_2 a_w{}^{c^4}$
Langmuir	$M = \frac{CM_o^2 a_w}{M_o(1 + a_w)}$

*GAB = Guggenheim, Anderson and de Boer equation
**M = equilibrium moisture content (% dry basis)
a, b, c, n = constant parameters
a_w = water activity
Mo = monolayer moisture content

Table 3. Proximate composition, free fatty acid and acid value of traditional, laboratory processed and open market *Kokoro* samples^{+}

Source of *Kokoro*	Extrusion method**	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Carbohydrate (%)	Energy value (Kcal/100g)	Acid value (mgKOH /gOil	FFA (mg KOH/g Oil)
Laboratory	Traditional method	1.46^{d*}	34.33^{a}	3.22	1.64^{b}	59.35^{a}	559.25	0.90^{c}	0.45^{a}
	ME-Flat	3.30^{c}	32.19^{b}	3.24	1.57^{b}	59.69^{a}	541.43	1.53^{ab}	0.36^{b}
	ME- Round	3.92^{b}	32.67^{b}	3.31	1.76^{a}	58.34^{a}	540.63	1.40^{b}	0.39^{ab}
	ME-Rod	3.93^{b}	34.97^{a}	3.15	1.64^{b}	56.3^{b}	552.57	1.37^{b}	0.33^{b}
Open market		4.46^{a}	31.25^{b}	3.22	1.56^{b}	59.52^{a}	532.21	1.69^{a}	0.34^{b}
±SEM		1.17	1.54	0.06	0.08	1.41	0.653	0.30	0.05

$^{+}$Values are means of triplicate determinations.
*Mean values with different superscripts within the same column are significantly different ($p<0.05$).
±SEM, Standard error of the mean
**ME- *Kokoro* obtained via manual extrusion.

Table 4. Mineral composition (mg/100g) of traditional, laboratory processed and open market *Kokoro* samples^{+}

Source of *Kokoro*	Extrusion method**	Ca	Zn	K	Fe	P
Laboratory	Traditional method	70.02^{bc*}	1.76^{a}	289.00^{a}	4.89^{a}	233.50^{e}
	ME-Flat	69.91^{b}	1.89^{ab}	294.00^{b}	5.12^{b}	218.50^{a}
	ME- Round	71.02^{c}	1.91^{b}	297.03^{c}	5.86^{c}	220.30^{b}
	ME-Rod	70.12^{c}	1.94^{b}	308.00^{d}	6.11^{d}	230.30^{d}
Open market		68.92^{a}	1.89^{ab}	317.00^{e}	5.12^{b}	227.60^{c}
±SEM		0.75	0.07	11.33	0.53	6.44

$^{+}$Values are means of triplicate determinations.
*Mean values with different superscripts within the same column are significantly different ($p<0.05$).
±SEM, Standard error of the mean.
**ME- *Kokoro* obtained via manual extrusion.

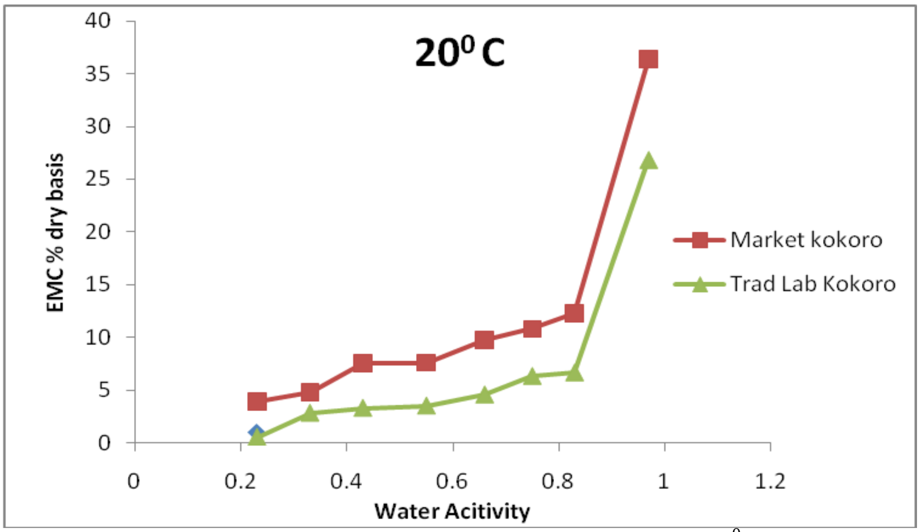

Figure 2: Graph of EMC versus Water Activity at 20^{0}C

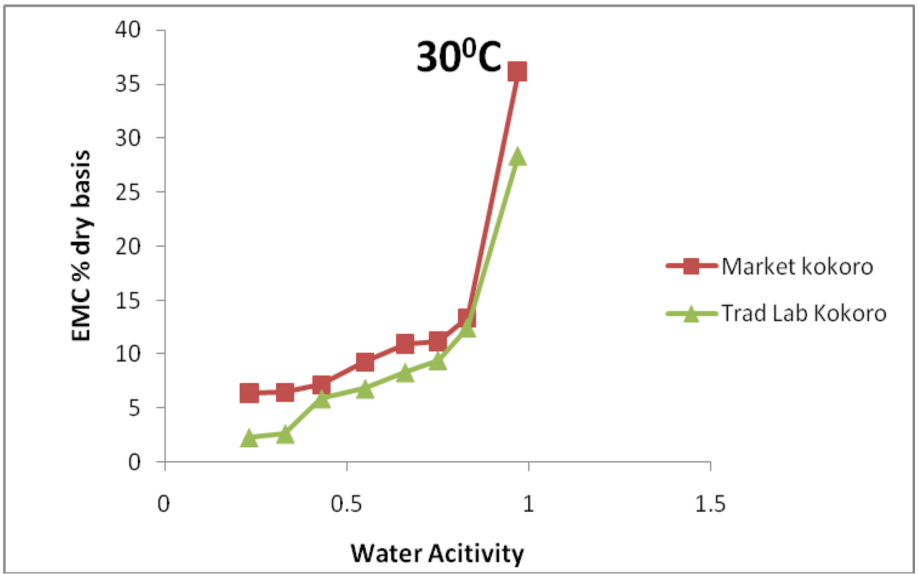

Figure 3: Graph of EMC versus Water Activity at 30^{0}C

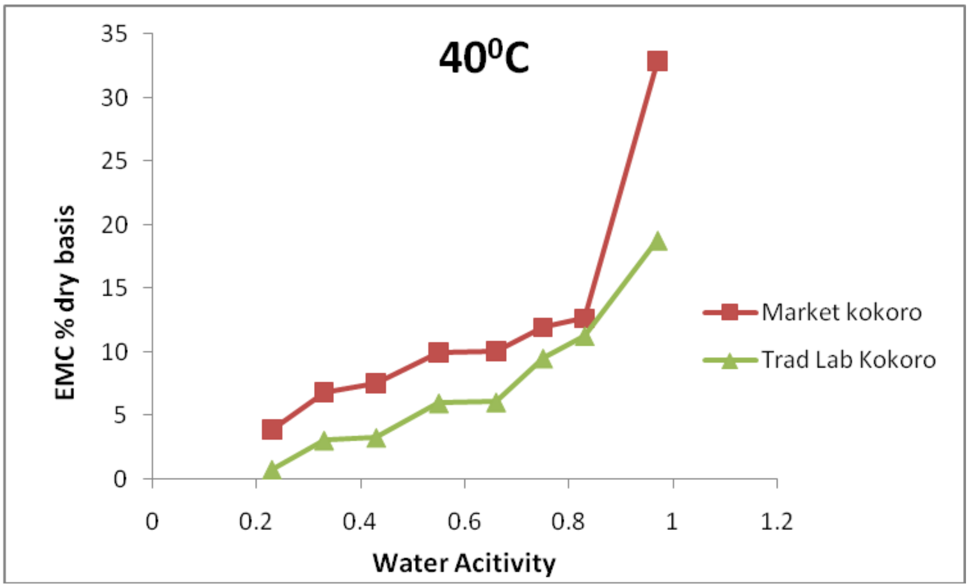

Figure 4: Graph of EMC versus Water Activity at 40^{0}C

Table 5: Model and Statistical Parameters of Experimental Sorption Data for LaboratoryTraditional and Open Market *Kokoro* Samples*

Samples	Models	A	B	C	D	R^2	RMSQ	%E	F-Cal	F-Tab (0.05)
Open market	Peleg	40.23	17.18	11.68	0.53	0.99	0.00	0.00	364.68	6.39
	GAB	3.46	1.23E+8	0.93		0.96	1.03	0.38	111.99	5.41
	Oswin	7.11	0.46			0.97	0.55	0.20	247.26	5.14
	Langmuir	5.75	6.20			0.37	2.17	0.81	10.04	5.14
Laboratory-Produced using traditional method	Peleg	26.31	17.79	9.90	0.71	1.00	0.02	0.01	963.57	6.39
	GAB	2.77	1.02E+8	0.92		0.98	0.42	0.20	390.66	5.41
	Oswin	5.53	0.43			0.98	0.18	0.09	974.62	5.14
	Langmuir	3.87	6.81			0.43	1.66	0.87	12.37	5.14

* Where R^2= Coefficient of determination, %E= Mean relative error, RMSQ=Root mean square,

Table 6: GAB Monolayer moisture content *Kokoro* at different temperatures

Samples	T (^{o}C)	M_o	F-Cal	F-Tab (0.05)
Open market	40	3.02	113.96	5.41
	30	3.45	129.54	5.41
	20	3.92	92.47	5.41

Laboratory-Produced following traditional method	40	1.82	833.93	5.41
	30	2.75	121.64	5.41
	20	3.73	216.41	5.41

V. Conclusions

The sorption isotherm studies revealed that the monolayer value which is indicative of the safest water activity (a_w) for an acceptable and good keeping quality *Kokoro* was found to be 1.8 to 4.28 kg-solid/kg-water (dwb) and therefore *Kokoro* obtained from this study was shelf stable.

References

[1]. Uzor-Peters P. I., Arisa, N. U., Lawrence, C. O., Osondu N. S. and. Adelaja A. 2008. Effect of partially defatted soybeans or groundnut cake flours on proximate and sensory characteristics of *Kokoro*. *African Journal of Food Science* 2: 098-101.

[2]. Otunola, E.T., Sunny-Roberts, E. O., Adejuyitan, J.A. and Famakinwa, A.O. 2012. Effects of addition of partially defatted groundnut paste on some Properties of '*Kokoro'* (a popular snack made from maize paste). *Journal of America Nutrition* 3(7): 280-286.

[3]. Omueti O. and Morton I. D. 1996. Development by Extrusion of Soybean Snack sticks a Nutritionally Improved Soya-maize Products based on the Nigeria Snack (*Kokoro*). *International Journal of Food Science and Nutrition* 47: 5-13.

[4]. Daramola, O. A., Idowu, M. A., Atanda, O. O. and Oguntona, C. R. B. 2010. Effects of packaging material on the quality of "pupuru" flour during storage. African Journal of Food Science 4(5): 258-263.

[5]. Association Official Analytical Chemists, 2000. Official methods of analysis of the Association of Official Analytical Chemists, Arlington, Virginia volume II, 15th ed. Sec. 985.29.

[6]. Osborne, D. R. and Voogt, P. (eds.) (1978). Calculation of calorific value in: The Analysis' of Nutrients in foods. Academic Press, New York.

[7]. Oyelade, O. J., Igbeka, J. C. and Aworh, O. C. 2001. Moisture isotherms of cowpea flour at 30 ^{o}C and 40 ^{o}C. *Journal of Applied Sciences* 4 (1): 1700–1711.

[8]. Famurewa, J. A. V., Oluwamukomi, M. O. and Alaba, J. O. 2012. Storage stability of pupuru flour (a cassava product) at room temperature. *British Journal of Applied Science and Technology* 2(2): 138-145.

[9]. Perry,R.H., Green, D. (1984): Chemical Engineers Handbook, Sixth Edition. McGraw Hill, New York.

[10]. Ajisegiri, E. S. A., Chukwu, O. and Sopade, P. A. 2007. Moisture-sorption study of locally parboiled rice. *Australian Journal of Technology* 11(2):86 -90.

[11]. Guzman, A. Q. 2012. Good Manufacturing Practices in the snack food industry in Latin America. Food Safety Magazine. April/ May.

[12]. Fasasi O. S. and Alokun O. A. 2013. Physicochemical properties, vitamins, antioxidant activities and amino acid composition of ginger spiced maize snack '*Kokoro*' enriched with soy flour (a Nigeria based snack). *Agricultural Sciences* 4(5): 73 – 77.

[13]. Aremu, M. O., Olaofe, O., Akintayo, E. T. 2006. A comparative study on the chemical and amino acid composition of some Nigerian underutilized legume flours. *Pakistan Journal of Nutrition* 5: 34-38.

[14]. Maliki, K. 1999. Investigation of storage stability of "*Kokoro*". *Nigeria Food Journal* 22: 58.

[15]. Connor, W. E. 2000. Importance of n-3 fatty acids in health and disease. *American Journal of Clinical Nutrition* 71: 171–175.

[16]. Sanni, L.O., Atere, C., and Kuye, A. 1997. Moisture sorption isotherms of fufu and tapioca at different temperatures. *Journal of Food Engineering* 34 (2): 203–212.

[17]. Falade, K. O. and Aworh, O. C. 2004. Adsorption isotherms of osmo oven dried African star apple (*Chrysophyllum albidum*) and African mango (*Irvingia gabonensis*) slices. *European Food Research and Technology* 218: 278–283.

[18]. Brunauer, S., Emmet, P. H. and Teller, E. 1938. Adsorption of gases in multimolecular layers. *Journal of American Chemical Society* 60: 309- 319.

[19]. Moreira, R., Chenlo, F., Torres, M. D. and Valejo, N. 2008. Thermodynamic analysis of experimental sorption isotherms of Ioquat and quince fruits. *Journal of Food Engineering* 88: 514-521.

[20]. Onayemi, O. and Oluwamukomi, M. O. 1987. Moisture equilibria of some dehydrated cassava and yam products. *Journal of Food Process Engineering* 9:191–200.

[21]. Simal, S., Femenia, A., Castell-Palou, A. and Rossello, C. 2007. Water desorption thermodynamic properties of pineapple. Journal of Food Engineering 80: 1293-1301.

[22]. Owuamanam, C.I., Iwouno, J.O., Ihediohanma, N.C. and Barber, L.I. 2010. Cyanide reduction, functional and sensory quality of *gari* as affected by pH, temperature and fermentation time. *Pakistan Journal of Nutrition* 9 (10): 980-986.

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