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ORIGINAL RESEARCH ARTICLE

EMPIRICAL ANALYSIS OF TRADITIONAL AKARA FRYING PROCESS

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ABSTRACT

Akara results from frying of fermented batter which after frying gives a dome –like shape, it has a brown crust and burnt material at the edges. Information on the existence of a mechanical device with capability for frying akara and carrying out turning operations appears to be very scarce. An empirical analysis of the traditional akara frying process was carried out in order to solve the above problem. The effect of different batter concentration (11g/ml, 13g/ml and 17g/ml) and spoon diameter-depth ratio (3.4.4.0,4.2) on the physical characteristics, frying time and frying rate of akara was investigated. The physical characteristics which include crust thickness, level of shrinkage, oil consumption, akara weight, density, surface area and extent of burnt material formation. Data obtained were subjected to statistical analysis using Excel and SPSS. The results showed that crust thickness, level of shrinkage, oil consumption, and burnt material increased with increase in concentration, frying time, weight, density and surface area also increased with increase in concentration. The result also indicates that crust thickness, level of shrinkage, oil consumption, weight, density, surface area, burnt material, frying time, decreases with increase in spoon diameter-depth ratio. Statistical analysis of variance (ANOVA) showed that all the processing variation and their interaction had significant effects on the physical characteristics of akara at 1% of significance. The model yielded coefficients that enabled the akara physical characteristics to be predicted with high coefficient of determination.

1.0 Introduction

Akara (fried bean cake) is a popular food in Nigeria and other West African Countries (Ngoddy *et al*., 1986; Henshaw and Lawal, 1993; Ekariko, 2005), and form part of diet for most ethnic groups in

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Nigeria. Nigerians usually eat it as breakfast with ogi, or lunch with gari or even dinner with eko. Akara is a traditional African food made by deep frying cowpea paste that has been whipped and seasoning with salt, pepper, onions and other optional ingredients. The outer crust of akara is crisp and the interior is spongy like bread. It is considered to be the most commonly consumed cowpea based food in West Africa (Henshaw & Lawal, 1993;Asare *et al*., 2013). Akara is made mainly from cowpea and other sources like maize ―Monsa‖.It can be fried with vegetable oil, palm oil, and other edible oils. It is a staple food which mostly consumed in Nigeria and other West African countries including Ghana, Togo, Benin, Mali and Gambia. Akara is prepared mainly for sale and consumption for breakfast and snacks. Akara is a popular recipe in Nigeria but its production depends on the different effects on the physical characteristics of Akara such as its sphericity, thickness, diameters in terms oflength, volume and volumetric index as well as its weight (Steinkraus, 1994); Akara is a deep-fat fried ball prepared from whipped cowpea paste, flavoured with pepper, onion and salt (McWatters, 1983; Olapade *et al*., 2004). Whipping of the paste is usually done prior to the addition of other ingredients to incorporate air and enhance the formation of stable foam (Ngoddy, *et al*., 1986; Hung and McWatters 1990). The paste obtained through milling dehulled and cleaned cowpea seeds can be processed into moin moin and akara by steaming or deep-fat frying of the paste respectively (McWatters, 1983). Akara is the most common cowpea-based product in West Africa (Reber, 1983), which makes it contribution to diet particularly significant.

Blending and whipping are important steps in processing of cowpea into akara. Blending clearly aids in reducing the particle size of paste to a more acceptable level and thus aiding in better distribution of moisture. Whipping incorporates air into paste, thus making it foam and giving it good dispensing properties and frying qualities (Mbofung *et al*., 2002). Cowpea is a good source of protein in the tropics with the seed containing appreciable amounts of lysine and tryptophan but is deficient in methionine and cystiene when compared to animal protein. The crop therefore plays a critical role in the lives of millions of people in Africa and other parts of the developing world, where it is a major source of dietary protein that nutritionally complements staple low-protein cereal and tuber crops. It is also a valuable and dependable commodity that produces income for farmers and traders (Singh *et al*., 2002; Langyintuo *et al*., 2003).A lot of researches has been conducted on other products such as turkey, chicken, and doughnut but not much has been carried out on Akara processing and production, hence the study aimed at studying the empirical analysis of traditional akara frying process.

2.0 Materials and Methods

2.1 Preparation of Akara

Cowpea was sourced locally at Bodija market in Ibadan, Oyo State. 650 g weight of cowpea was soaked inside a container for five minutes, then the soaked cowpea was dehulled traditionally using hands by rubbing it between two palms. It was then cleaned by separating the coat from the grains. 320 g weight of onions and peppers were mixed with cleaned cowpea and the mixture was then milled. After milling, the viscosity of batter was taken at 11g/ml, 13g/ml and 17g/ml by adding different quantity of water. 1250 ml volume of oil was poured inside a frying pan and placed on fire. The frying was conducted at three different spoon diameters–depths. The frying time were obtained by the addition of time of first turning of akara ball with the time of second turning. The oil temperature before frying was noted as well as oil consumed by akara ball was determined. The experiment was repeated five times.

Figure 1: Frying of akara ball

Figure 2: Akara ball inside the net after frying for cooling

2.2 Determination of physical characteristics

2.2.1 Viscosity

Three different sizes of spoon were used with three levels of viscosity at 11g/ml, 13g/ml, and 17g/ml of butter viscosity respectively.

Viscosity or concentration were expressed as

$$c = \frac{m}{v} \tag{1}$$

Where, m = mass of batter (g)

v = volume of batter (ml)

c = viscosity or concentration (g/ml) of batter

2.2.2 Frying time (F_t)

The time of frying with size was calculated by adding the time of first turning with the time of second turning

$$\mathbf{F_t} = \mathbf{F_{t1}} + \mathbf{F_{t2}} \tag{2}$$

Where, F_t= Frying time (seconds)

Ft_1 = Time of first turning (seconds)

Ft_2 = Time of second turning (seconds)

2.2.3 Diameter-depth ratio

This is the ratio of the diameter of spoon (in mm) to the depth of spoon (in mm)

$$D_d = \frac{S_D}{S_d} \tag{3}$$

Where, D_d = diameter – depth ratio

S_D = diameter of spoon (mm)

S_d = depth of spoon (mm)

2.2.4 Crust thickness

The crust thickness of akara ball was obtained by the use of vernier caliper. It is measured in mm

2.2.5 Level of shrinkage

The levels of shrinkage were calculated using the expression.

$$\mathbf{s_n} = \mathbf{P_v} - \mathbf{M_w} \tag{4}$$

where, s_n= Level of shrinkage (mm)

P_v = volume of spoon (ml)

$\mathbf{M_w}$ = weight of akara(g)

Weight of akara ball Each weight of akara ball was obtained by weighing each akara ball on an electric weighing balance.

2.2.6 Density of akara ball

The density of akara ball were expressed as

$$D = \frac{M_w}{V_p} \tag{5}$$

Where, D = density of akara ball (g/ml)

M_W = Weight of akara ball (g)

V_p = Volume of akara ball (ml)

2.2.7 Surface area of akara (cm^2)

The surface area of each akara ball was obtained using the method of coating. This method of cooking was wrapping of akara ball with foil paper and cut off the excess paper. Then, the foil paper was removed from akara ball and spread on a graph sheet. The shape of the foil paper on the graph sheet was traced and the surface area of akarawas obtained by counting the numbers of square occupied by foil paper.

2.2.8 The extent of burnt material formation

The extent of burnt material formation was obtained by the use of vernier caliper. It is measured in mm.

2.2.9 Oil Consumption (ml)

The volume of oil consumed by akara ball were obtained by measuring the initial volume of oil before frying and final volume of oil after frying

$$\mathbf{O_c = V_i - V_f} \tag{6}$$

Where, O_c = Oil consumption (ml)

V_i = Initial volume of oil before frying (ml)

V_f = final volume of oil after frying (ml)

Note – Neglect the volume of oil evaporated or sublimed by heat.

2.3 Data Analysis

The results obtained were analysed and evaluated using Turkey and Duncan Multiple Analysis of Variance, as well as multiple regression models.Data analysis were used to determine the variation of physical characteristics of akara ball and frying parameters such as frying time, frying rate, density, oil consumption, level of shrinkage, crust thickness, weight, extent of burnt material and surface area at three different levels of batter viscosity and three spoon diameter-depth respectively.

3.0 Results and Discussion

The result of frying parameters and physical characteristics determined for each batter concentration at different spoon sizes are presented in Tables 1, 2, and 3 respectively.

From Table 1, it can be seen that the shortest frying time for concentration of 11 g/ml was obtained at spoon size A having pan diameter-depth ratio of 4:2 and the longest frying time was obtained at spoon size C having light spoon diameter-depth ratio of 3.4. Similar observations were obtained for the frying time when batter concentrations were 13 g/ml and 17 g/ml respectively (Table 2 and 3).

Table 1: Akara physical characteristics, frying time and frying rate for different spoon size at batter concentration of 11g/ml.

S/N	Measured Parameters	Spoon size A	Spoon size B	Spoon size C
1	Spoon depth (mm)	13	15	20
2	Spoon diameter (mm)	55	60	68
3	Spoon diameter depth ratio	4.2	4.0	3.4
4	Crust thickness (mm)	1.9	2.0	2.1
5	Extent of burnt material formation(mm)	1.8	1.6	1.7
6	Level of shrinkage	4.6	4.8	5.0
7	Oil consumption (ml)	6.9	7.6	8.0
8	Oil temperature (^{0}C)	205	198	204
9	Time of 1st turning (sec)	240	245	253
10	Time from 1st turning to 2nd turning (sec)	231	241	238
11	Frying time (sec)	471	486	491
12	Spoon volume (ml)	35	40	42
13	Variation of akara weight (kg)	0.056	0.051	0.065
14	Density (kg/ml)	0.00054	0.00057	0.00061
15	Frying rate (no/hr)	180	156	120
16	Surface area (cm^2)	36	43	45

3.1 Observable phenomena that occur during frying of akara

The first observed phenomenon after pouring the batter into the frying pan is rapid evaporation of water from the surface of the batter because of the high temperature of the frying oil and there was little reduction in temperature. There was a puffing (bubble like) at the top of akara because of loss of moisture. After that, due to the loss of moisture from the batter by hot oil and oil uptake by batter due to high temperature, crust was started to develop at the edges of akara. After the first turning of akara (1st turning) akara was swelled up and then gradually shrunk down due to loss of moisture and gradual increase in frying temperature. Burnt material started to develop at the ring of akara which indicates that akara is ready. Sequences of events that take place during the frying of mass:

(a) Rapid evaporation of water from the batter by hot oil and oil uptake by batter due to high temperature
(b) Formation of crust
(c) Swelling
(d) Shrinkage
(e) Burnt material formation.

Table 2: Akara physical characteristics, frying time and frying rate for different spoon size at batter concentration of 13g/ml

S/N	Measured Parameters	Spoon size A	Spoon size B	Spoon size C
1	Spoon depth (mm)	13	15	20
2	Spoon diameter (mm)	55	60	68
3	Spoon diameter depth ratio	4.2	4.0	3.4
4	Crust thickness (mm)	1.8	2.1	2.3
5	Extent of burnt material formation (mm)	1.7	1.5	1.8
6	Level of shrinkage	4.4	4.6	4.9
7	Oil consumption (ml)	6.5	7.3	8.1
8	Oil temperature (^{0}C)	202	200	204
9	Time of 1st turning (sec)	241	243	249
10	Time from 1st turning to 2nd turning (sec)	232	246	261
11	Frying time (sec)	473	489	510
12	Spoon volume (ml)	35	40	42
13	Variation of akara weight (kg)	0.054	0.053	0.068
14	Density (kg/ml)	0.00055	0.00058	0.00064
15	Frying rate (no/hr)	178	161	130
16	Surface area (cm^2)	34	40	42

Table 3: Akara physical characteristics, frying time and frying rate for different spoon size at batter concentration of 17g/ml

S/N	Measured Parameters	Spoon size A	Spoon size B	Spoon size C
1	Spoon depth (mm)	13	15	20
2	Spoon diameter (mm)	55	60	68
3	Spoon diameter depth ratio	4.2	4.0	3.4
4	Crust thickness (mm)	1.7	2.0	2.1
5	Extent of burnt material formation (mm)	1.6	1.5	1.7
6	Level of shrinkage	4.2	4.3	4.5
7	Oil consumption (ml)	6.6	7.4	8.2
8	Oil temperature (^{0}C)	201	210	215
9	Time of 1st turning (sec)	240	245	259
10	Time from 1st turning to 2nd turning (sec)	230	241	260
11	Frying time (sec)	470	486	519
12	Spoon volume (ml)	35	40	42
13	Variation of akara weight (kg)	0.053	0.056	0.064
14	Density (kg/ml)	0.00049	0.00056	0.00063
15	Frying rate (no/hr)	172	164	136
16	Surface area (cm^2)	35	42	44

Table 4: Result of ANOVA on the crust thickness of akara

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	13.260[a]	8	1.658	23.47	0.000
Intercept	145.622	1	145.622	1642.52	0.002
Dp	8.330	3	2.777	72.154	0.000
C	.110	2	.055	9.462	0.000
Dp * C	.050	3	.017	2.341	0.025
Error	.031	18	.000		
Total	151.980	27			
Corrected Total	13.260	26			

R Squared = 0.894 (Adjusted R Squared = 0.850)

3.2 Crust thickness

The relationship between crust thicknesses, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$\mathrm{CT} = 0.952 - 2.447\mathrm{D_p} - 0.062\mathrm{C} + 0.173\mathrm{DPC} - 0.474\mathrm{D_p}^2 + 0.011\mathrm{C}^2, \mathrm{R}^2 = 0.994 \qquad (7)$$

Where:
CT = crust thickness in mm,
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 terms made 99.4% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show thatDp, C and DPC had statistical significant effect on crust thickness at 99.4% (Table 4). This implies that the crust thickness obtained at different diameter-depth ratio and concentrations are significantly different.

3.3 Level of shrinkage

The relationship between level of shrinkage, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$SH = 6.316 – 0.514Dp - 0.226C + 0.047DPC – 0.019DP^2 + 0.003C^2, R^2 = 0.968 \qquad (8)$$

Where:
SH = level of shrinkage in mm,
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, and Dp^2 term made 96.8% significant contributions to the predictive capacity of the equation. Similarly, the result of ANOVA shows that Dp, C and DPC had statistical significant effect on SH (level of shrinkage) at 99.4% (Table 5). This implies that the level of shrinkage obtained at different diameter-depth ratio and concentrations are significantly different.

Table 5: Result of ANOVA on the level of shrinkage of akara

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1.767[a]	8	.221	12.58	0.000
Intercept	524.273	1	524.273	28953.61	0.000
Dp	9.740	3	3.247	51.642	0.000
C	1.420	2	.510	2.306	0.011
Dp * C	.020	3	.007	1.432	0.000
Error	.000	18	.000		
Total	570.330	27			
Corrected Total	1.767	26			

R Squared = 0.968 (Adjusted R Squared = 0.961)

3.4 Frying time

The relationship between frying times, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$TF = 478.315 - 113.270Dp + 1.624C + 9.111DPC - 17.406DP^2 + 1.079C^2, R^2 = 0.950 \quad (9)$$

Where:
TF = frying time (sec),
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 term made 95.0% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show that Dp, C and DPC had statistical significant effect on frying times at 95.0% (Table 6). This implies that the frying time obtained at different diameter-depth ratio and concentrations are significantly different.

Table 6: Result of ANOVA on the frying times of akara

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6900.000[a]	8	862.500	751.23	0.000
Intercept	5955029.894	1	5955029.894	216421.24	0.000
Dp	5645.000	3	1881.667	263.82	0.007
C	428.500	2	214.250	126.19	0.000
Dp * C	817.000	3	272.333	78.32	0.018
Error	238.06	18	.196		
Total	6445575.000	27			
Corrected Total	6900.000	26			

R Squared = 0.950 (Adjusted R Squared = 0.938)

3.5 Oil consumption

The relationship between oil consumption, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$OC = 10.498 - 3.743Dp - 0.097C + 0.344DPC - 0.755DP^2 + 0.017C^2, R^2 = 0.985 \quad (10)$$

Where:
OC = oil consumption in ml,
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 term made 98.5% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show that Dp, C and DPC had statistical significant effect on oil consumption at 98.5% (Table 7). This implies that the oil consumption obtained at different diameter-depth ratio and concentrations are significantly different.Results show that the diameter-depth ratio of 3.4 is statistically higher that diameter-depth ratio of 4.0 and significantly lower than diameter depth ratio of 4.8.

Table 7: Result of ANOVA on the oil consumption of akara

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.720^a	8	1.215	7.154	0.021
Intercept	1337.859	1	1337.859	3251.72	0.000
Dp	9.290	3	3.097	1.843	0.001
C	.085	2	.043	.721	0.000
Dp * C	.250	3	.083	.284	0.000
Error	.000	18	.000		
Total	1488.240	27			
Corrected Total	9.720	26			

R Squared = 0.985 (Adjusted R Squared = 0.981)

3.5 Density

The relationship between variation of density, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$D = 0.001 + 0.000Dp - 1.476E\text{-}005C - 3.146E\text{-}005DPC - 6.533E\text{-}005DP^2 + 3.035E\text{-}006C^2, \quad R^2 = 0.993 \qquad (11)$$

Where:
D = Density kg/ml,
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 term made 99.3% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show that Dp, C and DPC had statistical significant effect on density of akara 99.3% (Table 8). This implies that the density obtained at different diameter-depth ration and concentrations are significantly different.

Table 8: Result of ANOVA on density and spoon diameter ratio on akara concentrations

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5.347E-008[a]	8	6.683E-009	124.896	.000
Intercept	8.142E-006	1	8.142E-006	42631.052	.000
Dp	4.567E-008	3	1.522E-008	326.289	.007
C	2.025E-009	2	1.012E-009	62.324	.000
Dp * C	3.725E-009	3	1.242E-009	1.231	.617
Error	.000	18	.000		
Total	8.963E-006	27			
Corrected Total	5.347E-008	26			

a. R Squared = 0.993 (Adjusted R Squared = 0.986)

3.6 Surface area

The relationship between variation of surface area, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$D = 107.675 - 33.638Dp - 0.413C + 3.674DPC - 9.723DP^2 - 0.033C^2,\ R^2 = 0.939 \tag{12}$$

Where:
SA = surface area in cm^2,
C = concentration in g/ml,
Dp = Diameter depth ratio

A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 term made 93.9% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show that Dp, C and DPC had statistical significant effect on surface area at 93.9% (Table 9). This implies that the surface area obtained at different diameter-depth ratio and concentrations are significantly different.

Table 9: Result of ANOVA on surface area in cm^2

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	404.667[a]	8	50.583	196.73	.000
Intercept	39042.300	1	39042.300	24518.68	.000
Dp	372.000	3	124.000	172.81	.000
C	29.500	2	14.750	10.065	.000
Dp * C	.000	3	.000	.004	.000
Error	.000	18	.000		
Total	43845.000	27			
Corrected Total	404.667	26			

R Squared = 0.993 (Adjusted R Squared = 0.986)

3.7 Burnt materials

The relationship between burnt materials, spoon diameter depth ratio and akara concentration could be adequately expressed using multiple regression models presented as:

$$D = 2.061+1.078Dp - 0.073C - 0.147DPC + 0458DP^2 + 0.009C^2,\ R^2 = 0.929. \quad (13)$$

Where:
BM = extent of burnt materials in mm,
C = concentration in g/ml,
Dp = Diameter depth ratio
A t-test of coefficient shows that the constants Dp, C, DPC, Dp^2 and C^2 term made 92.9% significant contributions to the predictive capacity of the equation. In a similar vein, the ANOVA results show that Dp, C and DPC had statistical significant effect on burnt materials at 92.9% (Table 10). This implies that the burnt materials obtained at different diameter-depth ration and concentrations are significantly different.

Table 10: Result of ANOVA on the variation of burnt materials on akara concentrations

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.307[a]	8	.038	15.921	.000
Intercept	69.713	1	69.713	2689.387	.000
Dp	.208	3	.069	48.696	.000
C	.047	2	.024	53.294	.000
Dp * C	.052	3	.017	2.82	.107
Error	.170	18	1.070		
Total	74.310	27			
Corrected Total	.307	26			

R Squared = 0.993 (Adjusted R Squared = 0.986)

4.0 Conclusion

The evaluation of frying parameters and physical characteristics using the traditional frying method for different pan diameter-depth ratio and batter concentration revealed the following:
Crust thickness, level of shrinkage, oil consumption and burnt material increased with increase in concentration. Frying time, weight, density and surface area also increases with increase in concentration. Crust thickness, frying time, weight, density, surface area and oil consumption decreased with increase in diameter-depth ratio.

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