ISSN : 0974 - 7508 Volume 8 Issue 5

Trade Science Inc.

Natural Products

An Indian Journal

Full Paper

NPAIJ, 8(5), 2012 [175-181]

Characterization of three varieties of brown cowpeas (*Vigna unguiculata*) grown in Nigeria

Ijeoma Osuji[2], Florence O.Uruakpa*[,1], Uduak Ekot[2]

[1]Department of Applied Health Sciences, Indiana State University, Terre Haute, IN, (USA)

[2]Department of Food Science & Technology, Federal University of Technology, Owerri, (NIGERIA)

E-mail: Ojiugou@yahoo.com

Received: 22nd January, 2012 ; Accepted: 22nd February, 2012

ABSTRACT

Protein-rich cowpea grain is widely consumed in Nigeria where it is commonly known as "beans" with different varietal names. Composition of seed variety and the identification of its functional properties are essential in determining uses for cowpea flours in food formulation. This study characterized three lesser known varieties of brown cowpea grain grown in different regions in Nigeria based on their physical and functional properties. Three brown cowpea (white-eyed, firmly attached testa) varieties namely Akidi, Akidi Elu and Nkoti Iwang (26.02%, 25.46% and 24.90% protein, respectively) were assessed using standard methods. Swelling index of the flour was obtained as a ratio of volume occupied by sample after and before swelling. Water and oil absorption capacities of the flour were measured and result was expressed as g oil or water absorbed/g sample. Results show that average seed weight of Akidi Elu (0.12g) was higher than that of Akidi (0.10g) and Nkoti Iwang (0.11g). Bulk density, water absorption, oil absorption, swelling index and viscosity of the three cowpea flour fractions were significantly affected by their location ($P<0.05$). Bulk density ranged from 0.63 to 0.80 g/mL with Akidi Elu and Nkoti Iwang having higher values than Akidi. Water absorption of Akidi Elu (1.95 g H_20/g) and Akidi (2.00 g H_20/g) were statistically different from that of Nkoti Iwang (1.42 g H_20/g) flour. Brown cowpea flour can find application in food supplementation and as functional ingredient in various formulated foods.

KEYWORDS

Brown cowpea;
Functional and physical properties;
Varietal influence.

INTRODUCTION

Cowpeas (*Vigna unguiculata*) are one of the staple foods in the diets of most Africans and can serve as an important source of proteins, calories and income[3]. Its high protein content makes it an important ingredient in the diet of population groups of many tropical and sub-tropical countries[13,20]. Its proteins make good complement for grain proteins such as rice and starchy foods like cassava and plantain[11]; and could be substituted or blended with wheat flour to produce bread, leavened dough and cookies that are of acceptable qualities[30]. Cowpea varieties namely Akidi, Akidi Elu and Nkoti Iwang among others are common in Nigeria. Akidi and Akidi Elu are mostly consumed by people from eastern Nigeria while Nkoti Iwang is predominant in southern Nigeria.

Planting of Akidi and Akidi Elu seeds is between April and June while Nkoti Iwang seeds are planted between February and March; and harvesting starts about 5-6 months after planting. The seeds are removed from the pods after allowing it to dry in field or may be eaten when they are still green. These cowpea varieties (Akidi, Akidi Elu, Nkoti Iwang) are consumed by removing its seeds from the pods and eaten as pottage, used as a delicacy with sliced African oil bean seeds (called "ugba") or with boiled cassava (termed "edita iwa") and eaten with other starchy foods like plantains. Furthermore, they can be eaten with fresh corns or sliced cassava called "Abacha". Therefore the objective of this study was to investigate the physical and functional properties of the lesser known varieties of brown cowpeas grown in eastern Nigeria.

MATERIALS AND METHODS

Materials and sample preparation

Three varieties (Akidi, Akidi Elu, Nkoti Iwang) of cowpeas used in this study were obtained from local markets in Southeastern Nigeria. The seeds were cleaned and soaked separately in tap water (Akidi Elu and Akidi for 16hrs; Nkoti Iwang for 18hrs) to facilitate the removal of hulls from seeds. After dehulling; the seeds were sun-dried, ground, sieved through a double layer Muslim cloth to obtain flour and stored in a dry, air tight plastic container for further analysis.

Physical property analysis

Seed characteristics

The seed characteristics were determined following the procedure of Fashakin and Fasanga[15]. The raw seeds were randomly selected from each variety and examined by subjective methods for shape, testa texture, seed color, eye color and testa attachment to the cotyledon. The degree of attachment was described as loose or firm depending on the resistance of the testa to peeling using fingers after soaking. The texture was described as smooth or wrinkle depending on how the seed appears to the eye.

Seed size and weight

The size of seed was dimensionally characterized by measuring each of ten randomly picked seeds for their length (L), width (W) and thickness (T) in mm using a vernier caliper of about 0.001mm precision[42]. The average seed size was calculated.

Weight of 100 seeds randomly selected was determined by weighing[5]. The average seed weight was calculated.

Determination of proximate composition of the brown cowpea varieties

Moisture content of the samples was determined by drying at 105^{o}C for 3hrs using[6]. Ash content was determined using Gallenkamp muffle furnace, England[6]. Fat was determined in the soxhlet apparatus[6] using petroleum ether as the solvent of extraction. The macro Kjeldahl procedure based on the AOAC method was used for nitrogen and the protein content g samples was calculated using 6.25 as the conversion factor. Crude fibre was by AOAC[6] and carbohydrate was by difference.

Evaluation of the functional properties of cowpea flour samples

Water and oil absorption capacity

The oil and water absorption capacities of cowpea seeds were determined as described by Carcea Benecini[8]. One gram cowpea flour sample was stirred in 10ml of distilled water/oil for 1min by manual shaking. The mixture was then allowed to stand at room temperature for 30min and centrifuged at 1,500rpm for 30min. The supernatant was decanted and the volume in the measuring cylinder was noted and converted to weight (in grams) by multiplying by the density of oil (0.902g/ml) or water (1g/ml). The oil/water absorption capacities were expressed as grams of oil/water absorbed per gram of flour sample.

Emulsion and foaming capacity

The procedure of Beuchat et al. (1975) as modified by Eke (2002) was used. Two grams of flour sample and 75ml of distilled water were blended for 30s using a magnetic stirrer. After complete dispersion, deodorized vegetable oil was added continuously through a burette until emulsion breakpoint, separation into two layers was reached. The emulsion capacity was expressed as mL of oil emulsified per g of flour.

Emulsion capacity = Vol. (mL) of oil ÷ g of sample

The foaming capacity of flour samples was determined according to Onwuka[32]. Two grams of samples was blended with 100 mL distilled water in an electric blender for 30min. The mixture was transferred into a 250 mL measuring cylinder and the volume after 30s was recorded. The foam capacity was expressed as percent increase in volume using the formula of Abbey and Ibeh[1] as reported by Onwuka[32].

Foam capacity = (Vol. after whipping – Vol. before whipping) ÷ Vol. before whipping x 100

Swelling index and bulk density

The method of Abbey and Ibeh[1] was employed. One gram of the flour samples were weighed into 10ml graduation measuring cylinder. Exactly 5 mL distilled water was carefully added and the volume occupied by the sample recorded. The sample was allowed to stand and disperse in water for 1hr and the volume was again recorded. The swelling index was calculated as ratio of volume occupied after swelling.

Swelling Index = Vol. occupied by sample after swelling ÷ Vol. occupied by sample before swelling

The method of Onwuka[32] was followed. A 10ml graduated measuring cylinder was weighed and filled gently with the flour samples. The bottom of the cylinder was tapped gently on laboratory bench several times until there was no further diminution of the sample level after filling to the 10ml mark. The bulk density was calculated as:

Bulk Density (g/ml) = Weight of samples (g) ÷ Volume of sample (mL)

Gelling capacity and viscosity

The gelation capacity of cowpea flour was determined according to the method of Onwuka[32]. Sample suspensions 2-20% (w/v) were prepared in 5ml distilled water in test tubes. The test tubes containing these suspensions were heated for 1hr in a boiling water bath, followed by rapid cooling under running cold tap water and the test tubes were further cooled for 2hrs at 4°C. The gelation capacity was determine as the least gelation concentration determined as the concentration when the sample from the inverted test tubes did not fall or slip.

Apparent viscosity of the flour sample was determined by blending 10g of flour sample in 300ml of distilled water using a mixer. The viscosity was determined by method of comparison at a constant temperature (25°C) using an Ostwald viscometer and the viscosity reading recorded in centipoises as the average of three readings[33].

Statistical analysis

All analyses were carried out in triplicate. Values from proximate composition and functional properties were statistically analysed using analysis of variance (ANOVA) procedure to determine the significance of the factor means according to Steel and Torrie[38]. In the tests where the variance ratios (F values) proved significant, Fisher's least significant difference (LSD) procedure[37] was used to separate the factor means.

RESULTS AND DISCUSSIONS

Physical characteristics

The physical properties data for cowpea flour varieties are presented in TABLE 1. All the three seed varieties are brown in color with white eye. The seeds were slightly different in testa texture; Akidi Elu and Nkoti Iwang had wrinkled testa while Akidi had smooth testa but all were firmly attached to the cotyledon. The average seed weight of the three varieties was 0.10 - 0.12g and the values were low when compared to the weight 0.13 - 0.22g reported by Marconi et al.[26]. Also, the dimension of the seeds varied among varieties; the seed length ranged from 8.9 to 9.7 mm, width from 5.4 to 6.3 mm and thickness was from 3.9 to 4.3mm. These results were similar to the reports of Purseglove[35] who found that cowpea seeds vary in size, color, length (2 - 12 mm), testa texture (smooth or wrinkled) and hilum white eye surrounded by brown seed coat; and Maia et al.[25] who reported length of 6.7 - 11.2 mm and width of 5.3 - 8.2 mm for cowpea seed varieties.

TABLE 1 : Physical characteristics of three cowpea seed varieties grown in Nigeria

Cowpea seed varieties	Akidi	Akidi Elu	Nkoti Iwang
Seed color	Brown	Brown	brown
Eye color	White	White	White
Testa texture	Smooth	Wrinkle	Wrinkle
Testa attachment to cotyledon	Firm	Firm	Firm
Seed size (L×W×T); mm	9.7×6.3×4.1	8.9×5.4×4.3	9.4×6.1×3.9
Mean seed weight (g)	0.10 ± 0.01	0.12 ± 0.01	0.11 ± 0.01

Full Paper

Proximate composition

The proximate composition of flour fractions from the three cowpea varieties are presented in TABLE 2. The three varieties had nutrient composition values that varied in moisture 12.7-13.2%, protein 24.9- 26.0%, ether extract 1.9-2.2%, ash 2.5-2.6%, fiber 2.6-2.8% and carbohydrate 53.9-54.7%. The moisture content of Akidi Elu (13.1%) and Nkoti Iwang (13.2%) flour was higher (P<0.5) than that of Akidi (12.7%). However, the finding supported the result of Fisher and Bender (1985) who reported values of 10-13% moisture for cowpea species. The moisture content of flour fractions in this study was desirable because flour with moisture content higher than 14% are susceptible for bacterial activity and mold growth which will result in spoilage and development of hydrolytic rancidity[19].

The protein content varied (p<0.05) among the three varieties with highest value obtained for Akidi (26.0%) while Nkoti Iwang had the lowest value (24.9%). This was in agreement with the report of Chavan et al.[9] who stated protein content of 18.3-35.0% for cowpeas. The three varieties had good protein content but not as high as the protein content of soybean which is about 40%[40]. The ether extract content of the varieties ranged from 1.93 to 2.18% which corroborates the report of Davidson et al.[10] who stated ether extract values of 1.9-2.5% on dry matter basis. Akidi had the least fat content which compared well with the values reported by Enwere[14] and Holland et al.[18]. The values of this study are very acceptable because cowpeas are known for its low fat content.

The fiber content of the flour fractions was in agreement with that of Enwere[14] who reported that cowpeas contain 1.5 to 4% crude fiber. Fiber is known to have beneficial effect on metabolism in the gastrointestinal tract (e.g., lowers fecal transit time, eliminates toxicants by binding them). The ash content did not vary among varieties but the data was similar to the value 2.5-4.9% reported by Chavan et al.[9]. The carbohydrate (CHO) content of the varieties was not affected by locations but the values were low and compared well with the report of Edeogu et al.[12] which reported CHO content of 51.0-63.5%. These values of this study were desirable because CHOs are good sources of calories.

TABLE 2 : Mean values for proximate composition of cowpea seed varieties

Component (%)	Cowpea seed varieties		
	Akidi	Akidi Elu	Nkoti Iwang
Moisture content	12.65±0.05^{c}	13.06±0.02^{b}	13.20±0.10^{a}
Protein	26.02±0.45^{a}	25.46±0.15^{b}	24.90±0.10^{c}
Ether extract	1.93±0.03^{c}	2.18±0.03^{a}	2.12±0.03^{b}
Fiber	2.75±0.05^{a}	2.80±0.018^{a}	2.55±0.05^{a}
Ash content	2.56±0.01^{a}	2.60±0.29^{a}	2.51±0.01^{a}
Carbohydrate*	54.09±0.49^{a}	53.90±0.85^{a}	54.72± 0.26^{a}

***By difference; $^{a\text{-}c}$Mean values with the same superscript between rows are statistically equal at p = 0.05**

Functional properties of flours from three cowpea seed varieties

Water and oil absorption capacity

The functional characteristics data of flours from cowpea seed varieties are reported in TABLE 3. Result showed that Akidi (2.0 g/g) and Akidi Elu (2.0 g/g) flour fractions had higher (p<0.05) water absorption capacity (WAC) than Nkoti Iwang (1.4 g/g). WAC represents the ability of the flour to associate with water, an important characteristic in baked products such as dough and pastes. Lin and Zayas[22] reported similar WAC of 1.9-2.2 mL/g for cowpeas. It is possible that the high protein content of Akidi and Akidi Elu contributed to the higher WAC values obtained for these varieties. The higher protein content enables these flour fractions to bind more water due to their ability to form hydrogen bonds with water molecules and polar groups on the polypeptide chains[16]. Earlier study by Wolf[41] showed that this property enabled bakers to add more water to dough to improve handling characteristics and maintain freshness in the bread and other baked products. The findings of this study suggest that Akidi, Akidi Elu and Nkoti Iwang flours would be useful functional ingredient in baked products.

The data presented in TABLE 3 indicated that there was significant difference (p<0.05) in oil absorption capacity (OAC) of flour fractions from the three varieties (Akidi: 0.9 g/g; Akidi Elu: 0.9 g/g; Nkoti Iwang: 1.5 g/g). These OAC values were lower than those reported by Suliman et al.[39] on lentil cultivars (1.9-2.0g/g). The ability of proteins to bind fat is important since fat acts as flavor retainer and increases the mouthfeel of foods[16]. Nkoti Iwang flour fraction had the highest OAC which would be useful in ground meat formulations such as sausages. Atuobi et al.[7] reported variations in functional properties of starches from four cowpea varieties

TABLE 3 : Mean values for functional properties of cowpea seed varieties

Cowpea seed varieties	Akidi	Akidi Elu	Nkoti Iwang
Water absorption capacity ($g\ H_2O/g$ flour)	2.00 ± 0.05^a	1.95 ± 0.23^a	1.42 ± 0.10^b
Oil absorption capacity (g oil/g flour)	0.90 ± 0.01^a	0.89 ± 0.15^b	1.47 ± 0.29^c
Swelling index (mL/g)	2.02 ± 0.07^a	2.30 ± 0.02^b	1.85 ± 0.06^c
Emulsion capacity (mL/g)	3.53 ± 0.08^a	3.50 ± 0.16^a	3.30 ± 0.05^a
Bulk density (%)	0.63 ± 0.01^a	0.80 ± 0.01^b	0.67 ± 0.02^c
Gelation capacity (%)	6.00^a	6.00^a	5.00^a
Foaming capacity (%)	39.00^a	38.00^a	41.00^a
Viscosity (cps)	3.09 ± 0.15^a	3.20 ± 0.02^b	3.14 ± 0.15^c

$^{a\text{-}c}$Means with different superscript between columns are significantly different (P<0.05)

Emulsion and foaming capacity

The result presented in TABLE 3 showed no varietal effect on the emulsion capacity of the three cowpea varieties (3.3-3.5 mL/g). Similar data (2.2-10.6 mL oil/g sample) for cowpea flours was reported by Nwoji[29]. The emulsion capacity of these flours would be attributed to the protein in the flour. The value of Akidi flour suggests that more protein molecules moved to the interface and absorb more water/oil due to its high protein content than other varieties.

The foam capacity of the flours 38-41% showed no difference among the cowpea varieties (Akidi, Akidi Elu, Nkoti Iwang). This data compared well with foam capacity values (28-110%) reported for processed groundnut flours[2]. Good foam capacity values measured for Akidi, Akidi Elu and Nkoti Iwang flour fractions make them useful ingredient as aerating agents in food systems such as whipped toppings, ice cream mixes and favorite cowpea products (called 'akara' and 'moi-moi' in Nigeria). These products require the production stable high foam volumes when whipped[16].

Gelling capacity and viscosity

The gelation concentration of Akidi Elu and Akidi flours was 6% (w/v) while that of Nkoti Iwang flour was 5% (w/v). This was similar to the value (6%) reported for processed groundnut[2]. The low gelling concentration obtained in this study indicated that gelation is not only dependent on the quantity of protein in the flour but may be related to the 1) type of protein, 2) non-protein components, and 3) protein solubility. A similar conclusion was reached by Sathe and Salunkhe (1981) in their study on great northern bean. Therefore, cowpea flours could be used as a thickener in food formulations.

Gel formation of cowpea macromolecules (e.g., carbohydrates, proteins) occurs by the formation of a three-dimensional network of macromolecules, interactions through attractive forces between molecules and mainly through hydrogen bonding with water molecules[34]. During heat treatment (e.g., cooking, baking) there is a withdrawal of moisture from surrounding matrix which hydrates the carbohydrate or protein molecules. Expansion of macromolecules (via molecular interaction) causes a firmer gel to form during cooking[23]. The gel structure contributes to the texture and acts as a matrix for holding water as well as fat and other components[17]. The gelation capacity of 2% each was reported for starch from four cowpea varieties, indicating their purity[7]. The gelation capacity obtained in this study was 5-6%, an indication of mixture of macromolecules such as carbohydrates and proteins.

Flours from the three cowpea varieties had viscosity values of 3.09-3.20 cps at 25°C. The result compared well with the report of Ragab et al.[36]. Cowpea flour fractions of this study could serve as protein supplement in human diet and as functional ingredient in various food formulations.

Swelling index and bulk density

The swelling index (1.85-2.30 mL/g) of the three cowpea flour fractions supported the values 1.1-3.0 mL/g reported by Nwoji[29] for cowpea flours. Swelling ability provides evidence of non-covalent bonding between protein and water molecules. It is possible that higher swelling index values indicate better flour performance/handling and yield in baked products.

Akidi Elu, Akidi and Nkoti Iwang flour fractions had bulk density values of 0.80 g/mL, 0.63 g/mL and 0.67 g/mL, respectively. Akidi Elu flour had higher ($p<0.05$) values than Akidi and Nkoti Iwang (TABLE 3). The values were low compared to bulk density (1.4

g/mL) of varieties reported by Suliman et al.[39].

CONCLUSION AND SIGNIFICANCE

Cowpea varieties grown in eastern Nigeria (Akidi; Akidi Elu) were higher in protein content (26.0%; 25.5%) than the protein content (24.9%) of the variety grown in southern Nigeria (NKI). This finding makes it probable that planting location affects the nutrient composition of beans. Akidi Elu had higher functional properties such as water absorption capacity, swelling index, bulk density and viscosity while Nkoti Iwang had the highest oil absorption capacity value. The three brown cowpea flour fractions have good functional attributes and can be used as functional ingredients in composite flour and baked products.

ACKNOWLEDGEMENT

Authors thank Department of Food Science and Technology, Federal University of Technology Owerri, Nigeria for help offered during the course of the study.

REFERENCES

[1] B.W.Abbey, G.O.Ibeh; Journal of Food Science, **53**, 1775-1777 **(1998)**.

[2] O.Abulude, L.L.Olawale, M.F.Olaleye; Journal of Environmental Agriculture & Food Chemistry, **5**, 1487-1491 **(2006)**.

[3] E.O.Afoakwa, P.R.Aidoo, R.Adjonu; International Journal of Food Science & Nutrition, **61**, 256-271 **(2010)**.

[4] S.A.Agboola; An Agricultural Atlas of Nigeria, Oxford University Press, Britain, 95-97 **(1979)**.

[5] AOAC; Official Methods of Analysis. Association of Official Analytical Chemists, 13th Edition, Washington, D.C., U.S.A, **(1980)**.

[6] AOAC; Official Methods of Analysis. Association of Official Analytical Chemists, 15th Edition, Washington, D.C., U.S.A., **(1990)**.

[7] C.Atuobi, E.Sakyi-Dawson, S.Sefa-Dedeh, E.O.Afoakwa, A.S.Budu; Journal of Nutrition & Food Science, **1**, 104 **(2011)**.

[8] M.Carcea Bencini; J.Food Sci., **51**, 1518-1526 **(1986)**.

[9] J.K.Chavan, S.S.Kadam, D.K.Salunkhe; Cowpea. In 'Handbook of World Food Legumes', Nutritional Chemistry, Processing Technology and Utilization, Salunkhe, Kadam, (Eds); CRC Press, Florida, **2**, **(1989)**.

[10] S.Davidson, R.Passmore, J.F.Brocks, A.S.Truswell; 'Human Nutrition and Dietitics', 6th Edition, New York: The English Language Book Society and Churuchill Livingstone, 110-115 **(1975)**.

[11] J.Doughty, A.Walker; Legumes in Human Nutrition, 2nd Edition, Food and Agriculture Organization of the United Nations FAO, Food and Nutrition Paper No. 20, Rome, **(1982)**.

[12] C.O.Edeogu, F.C.Ezeonu, A.N.C.Okaka, C.E.Ekuma, S.O.Elom; International J.Biotech. Biochem., **3(1)**, 57-67 **(2007)**.

[13] T.E.Ekpenyong, R.L.Brochers; J.Food Sci.Agric, **25**, 919-922 **(1980)**.

[14] N.J.Enwere; Foods of Plant Prigin., Afro- Orbis Publ. Nsukka, 24-46 **(1998)**.

[15] K.B.Fashakin, J.I.Fasanya; J.Tropical Sc., **28**, 111-118 **(1988)**.

[16] S.Y.Giami, D.A.Bekebain, N.J.T.Emelike; Nig.J. Nutri.Sci., 13-38 **(1992)**.

[17] A.M.Hermansson, M.Lucissano; J.Food Sci., **47**, 1955-1956 **(1982)**.

[18] B.Holland, I.O.D.Unirin, D.H.Burs; Vegetable, Herbs AND Spices. The Fifth Supplement to McCance Mddonson's, The Composition of Foods, 4th Edition, Cambridge UK: The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food, **(1991)**.

[19] A.I.Ihekoronye, P.O.Ngoddy; Intergrated Food Science and Technology for the Tropics, Macmillan Publishers, London, 283-285 **(1985)**.

[20] S.Kon; J.Food Sci., **44**, 1329-1330 **(1979)**.

[21] J.B.Lasekan, M.L.Harden, H.C.Brittin; J.Food Sci., **52(5)**, 1436-1437 **(1987)**.

[22] C.S.Lin, J.F.Zayas; J.Food Sci., **53**, 1308-1311 **(1987)**.

[23] L.Ma, A.Grove, C.Barbosa; Journal of Food Science, **61**, 881-882 **(1996)**.

[24] R.Marcae, R.K.Robinson, M.J.Sadler; Legumes. In: Encyclopedia of Food Tech.Nutrition, Academic Press Inc., London, 2718-272 **(1993)**.

[25] F.M.M.Maia, J.T.A.Oliveira, M.R.T.Matos, R.A.Moreira, I.M.Vasconcelas; F.Sci.Food Agric., **80**, 453- 458 **(2000)**.

[26] E.Marconi, G.Lombardi-Bocca, E.Carnovale, N.Q.Ng; Nutritional Evaluation of Wild and Cultivated Species of Cowpea. In: Cowpea Genetic Resources, N.Q.Ng, L.M.Monti, (Eds); Amarin Printing Group, Thailand, 101-110 **(1990)**.

[27] L.B.Mokgope; Cowpea Seed Coat and Their Extracts: Phenolic Composition and use as Antioxidants in Sunflower Oil, M.Sc. Thesis, Department of Food Science, University of Pretoria, South Africa, **(2006)**.

[28] D.E.Nandanie; Processing and Utilization of Legumes, www.apo.tokyo.org; **(2003)**.

[29] V.V.Nwoji; Effect of Processing on the Storage Stability and Functional Properties of Cowpea (Vigna unguiculata) Flour in the Production of Cowpea Bean (Akara) and Paste (Moi-moi). In Proceedings of 29th Annual Conference of Nigeria Institute of Food Science and Technology, 11-13 October, 2005. E.C.Okoli, (Ed); 199-200 **(2005)**.

[30] H.N.Nzerogu; Journal of the Science of Food Agriculture, **41**, 123-14 **(1993)**.

[31] J.C.Okaka; Cereals and Legumes; Storage and Processing Technology, Date and Micro Systems Publ.: Enugu, 2-13 **(1997)**.

[32] G.I.Onwuka; Food Analysis and Instrumentation, Naphtali Prints: Lagos, 133-37 **(2005)**.

[33] I.A.Osuji; Effect of Different Media on Cooking Time of 'Akidi Elu' (Vigna unguiculata) Seeds and Functional Properties of the Flour, M.Sc. Thesis, Federal University of Technology, Owerri, Nigeria, **(2006)**.

[34] R.D.Phillips, K.Liu, K.H.McWatters; Journal of Agricultural Food Chemistry, **40**, 2483-2487 **(1990)**.

[35] J.W.Purseglove; Tropical Crops Dictyledobs, Longman Press: London, 321-326 **(1974)**.

[36] D.M.Ragab, E.E.Babiker, A.H.Eltinay; Journal of Food Chemistry, **84**, 207-212 **(2004)**.

[37] E.E.Roessler; Statistical Evalution of Experimental Data, Multiple Comparison. In Food Analysis, Principle and Techniques. D.W.Gruenwede, J.R.Whitaker, D.Marcel, (Eds); New York, 12-13 **(1984)**.

[38] R.C.D.Steel, J.H.Torrier; Analysis of Variance 111: Factorial Experiments. In: Principles of Procedures of Statistics, A Biometrical Approach. 2nd Edition, Mc Graw-Hill, London, 336-376 **(1980)**.

[39] M.A.Suliman, A.H.Eltinay, A.E.O.Elkhalifa, E.E.Babiker, E.I.Elkhalil; Pakistan Journal of Nutrition, **5**, 589-593 **(2006)**.

[40] J.O.Uzuegbu, O.S.Eke; Basic Food Technology, Principles and Practices. Osprey Publ.: Owerri, Nigeria, 85 **(2000)**.

[41] W.J.Wolf; Journal of Agricultural & Food Chemistry, **18**, 969-975 **(1970)**.

[42] D.S.Zibokere; Ife Journal of Technology, **2**, 67-70 **(1994)**.