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EFFECT OF PROCESSING ON THE PROXIMATE AND FUNCTIONAL PROPERTIES OF "AKPARATA" (*AFZELIA AFRICANA*) FLOUR.

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ABSTRACT: *The Mahogany bean also known as "Akparata" (Afzelia africana) seeds were divided into three portions. The first sample coded with R_{10}, R_{20} and R_{30} was processed by roasting at 100^0C (for 10, 20 and 30 minutes) respectively and second sample of the seeds coded C_{40}, C_{50} and C_{60} were cooked at 100^0C (for 40, 50 and 60 minutes) respectively while the raw unprocessed (third sample) served as the control. The proximate compositions showed significant difference at ($P< 0.05$) in some nutrients evaluated. In terms of moisture content, all the cooked samples (C_{40}, C_{50} and C_{60}) were higher (28 – 33.5%) than the Control (10.5%) and roasted (4.5 – 6.5%) samples. Also the ash content for the roasted and cooked samples were significantly higher at ($P< 0.05$) than the control sample (4.0%). The protein content of the raw sample (38.4%) was significantly higher at ($P< 0.05$) than all the samples treated by roasting and cooking. In terms of fat content, all the roasted samples had higher values (28.0 – 35.5%) than the raw (9.5%) and cooked (7.0- 8.0%) samples which were significantly different at ($P< 0.05$). The functional properties of the "Akparata" (Afzelia africana) flour with respect to bulk density showed that the roasted samples were higher (0.62 - 0.68g/ml) than the cooked (0.47 -0.54g/ml) and raw (0.60g/ml) samples . In water absorption capacity, all the values obtained in roasted and cooked samples were higher than the control (2.83%). This trend is also similar to oil absorption capacity. With respect to the foaming capacity, the control sample had higher value of (5.66%) when compared to the roasted (0.91 -3.23%) and cooked (1.12 -1.14%) samples. For the viscosity, the raw sample gave the highest value (16cp) when compared to roasted (6 – 10cp) and cooked (5 – 8cp) samples.*

KEYWORDS: Akparata seeds, cooking, flour, functional, roasting.

INTRODUCTION

Mahogany bean (*Afzelia africana)* also known as "Akparata" in the Igbo speaking south east area of Nigeria is an underutilized legume plant in the family of *Fabaceae* sub family *Caesalpinaceae*. It is a deciduous tree and is known as Counter wood tree or African Oak. It is known by different names in Nigeria. It is called "Yiase", among the Tivs; "Akparata" among the Ibos and "Apa", "Ukpo", "Kawo" among the Yoruba, Idomas and the Hausa people of Nigeria respectively. It is widely distributed and consumed by many African countries including Senegal, Sudan, Uganda, Tanzania, Sierra leone, Ghana and Nigeria (Keay *et al.*, 1964).

"Akparata" (*Afzelia africana)* is an excellent source of protein as well as soluble dietary fiber, it has relatively high quantities of Iron, Zinc, Phosphorus and exceptional high Calcium (Ene-Obong and Carnovale, 1992). It is a good source of dietary protein and mineral that compare with animal protein from meat, egg and fish. It has high percentage of oil and it is composed of palmitic acid and oleic acid (Ikwuagwu *et al.*, 2000). "Akparata" cotyledons are used as

Soup thickeners and its leaves are fermented and used for preparing yam potage. Vegetable oil can be extracted from "Akparata" and the vegetable oil can be processed into other industrial products for the benefits of mankind (Acland, 1980).

Nigeria is presently passing through a developmental stage in which there is strong emphasis on local sourcing of raw materials and so there is a growing commercial interest in processing Nigerian foods. In the processing of "Akparata", the seeds are cracked before boiling in water followed by dehulling and grinding into flour in large quantities before it can be preserved for future consumption. This helps to reduce the seasonal glut of the product and scarcity of the local thickening agents experienced each year (Ikwuagwu, *et al.*, 2000).

The aim of this work therefore is to evaluate the proximate composition and functional properties of "Akparata" as affected by processing such as; cooking and roasting.

The knowledge of functional properties as influenced by these methods of processing will help the food Engineer in the design, choice of appropriate handling equipments and processing system to be adopted. Also it will help to know the areas it can be applied in food formulation and prevent the crop from getting into extinction.

MATERIALS AND METHODS

The three kilogram (3kg) seeds of "Akparata" (*Afzelia africana*) used for this project were purchased from Orie Market in Akaeze, Ivo Local Government Area of Ebonyi State, South Eastern Nigeria.

Material Preparation

The three kilogram (3kg) of the seeds were divided into two equal parts, each of the parts were further divided into three equal parts respectively, 1.5kg were roasted at 100^{o}C for 10, 20, and 30 minutes and the remaining 1.5kg were also cooked at 100^{o}C for 40, 50 and 60 minutes respectively while the uncooked served as the control. The first sample after cracking the red orange aril of the seed were roasted at 100^{0}C for 10, 20 and 30 minutes respectively followed by dehulling and grinding into flour prior to analysis. The second sample were cooked at 100^{0}C for 40,50 and 60 minutes respectively followed by dehulling before drying in an oven at 100^{0}C for 1 hour and grinding into flour prior to analysis. The dehulled sample that was neither cooked nor roasted served as the control.

Proximate Analysis.

The percentage moisture content and the percentage fat content were carried out by the method of A.O.A.C (1990). The crude protein and crude fibre were carried out by the method described by Pearson (1976). The Ash content was done by the method described by James (1995) while the carbohydrate was calculated by difference.

Determination of the Functional Properties of "Akparata" flour samples.

Bulk density

This was done according to Onimawo and Akubor (2005). 10ml capacity graduated measuring cylinder was filled with the sample and the initial volume was recorded. The cylinder was tapped continuously to displace air and vacuum until the volume becomes constant. The final

volume was noted after it is levelled, and bulk density of the samples were calculated as follows:

The bulk density (g/ml) = weight of samples / volume of sample

Water absorption capacity

The method as described by Abbey and Ibeh (1988) was adopted. 1g of each sample were weighed separately and also together with a clean dry centrifuge tube into which it was placed. Distilled water was mixed with the samples to make up to 10ml dispersion. The sample and 10ml distilled water were mixed thoroughly for 30 seconds, then the sample was allowed to stand for 5minutes at room temperature and then centrifuged at 1000 rpm for 5minutes, then the volume of free water (supernatant) was read directly from the graduated centrifuge tube and calculated as follows:

Water Absorption Capacity =

W2 = Weight of tube + sample before water addition

W3 = Weight of tube + sample after water absorption

Oil absorption capacity

The method as described by Abbey and Ibeh (1988) was adopted. One gram of each of the flour samples were weighed separately and also together with a clean dry centrifuge tube into which it was placed. Oil was mixed with the sample to make up to 10ml dispersion. The sample and oil were mixed thoroughly for 30 seconds, then the sample was allowed to stand for 5minutes at room temperature and then centrifuged at 1000 rpm for 5minutes. The volume of free oil was read directly from the graduated centrifuge tube and calculated as follows:

Oil absorption Capacity = x

W2 = Weight of tube + sample before oil addition

W3 = Weight of tube + sample after oil absorption

Wettability

The method of Onimawo and Akubor (2005) was adopted. Wettability was estimated by measuring the wetting time (seconds) of 1g of flour sample droped from a height of 15mm of the surface of 200cm^3 distilled water contained in 250cm^3 beakers at room temperature. One gram of the sample was weighed into a clean, dry test tube and was covered. The tube was clamped in-vertically on a retort stand 15cm over 200cm^3 distilled water container in 250cm^3 beaker at room temperature. Gently the paper covering the tube was removed and the sample was allowed to fall under gravity into the beaker. The wetting time was recorded as the time (seconds) required for all the powder to be wetted and penetrate the surface of the still water.

Gelling and boiling point

This was determined according to the method of Narayana and Narasinga (1982). Five grams of each sample were poured into a beaker (250ml pyrex beaker). Each flour sample was dispersed to make 50ml suspension using distilled water. A thermometer was clamped on a retort stand with its bulb submerged in the suspension with a magnetic stirrer and the system

was heated. The heating and stirring continued until the suspension began to gel, the corresponding temperature was recorded. The temperature at boiling point was also recorded.

Emulsification capacity

The Method of Palmashted (1987) was adopted. Emulsification capacity was estimated by blending 2g of flour sample with 25ml distilled water at room temperature for 30seconds in a warring blender. After complete dispersion, 25ml of vegetable oil (groundnut Oil) was added and the blending was continued for another 30seconds, then it was put into a centrifuge tube and centrifuged at 1000rpm for 5minutes. The volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsion capacity is expressed as the amount of oil emulsified and held per gram of sample.

Emulsion capacity = Height of emulsified layer/ Height of whole solution in the centrifuge tube x

pH Measurement.

The pH was estimated by preparing a 10% suspension of the sample in distilled water. The suspension was mixed thoroughly in a warring micro- blender, then the pH was measured with a good pH meter.

Foam capacity

The method of Abbey and Ibeh (1988) was adopted. Foam capacity was estimated by blending 2g of flour sample with 100ml distilled water in a warring blender (the suspension was whipped at 1000rpm for 5 minutes). The mixture was poured into a 250ml measuring cylinder and the volume was recorded after 30 seconds. Foam capacity was expressed as percent increase in volume using the formula below:

Foam Capacity = x

The foam volume was recorded at 15, 30, 60 and 120 minutes.

The foam stability was determined after whipping.

Foam stability = x

Viscosity

Viscosity was determined by suspending 20% flour in distilled water and mechanically stirred for 2hours at room temperature. Then Oswald type viscometer was used to measure the viscosity.

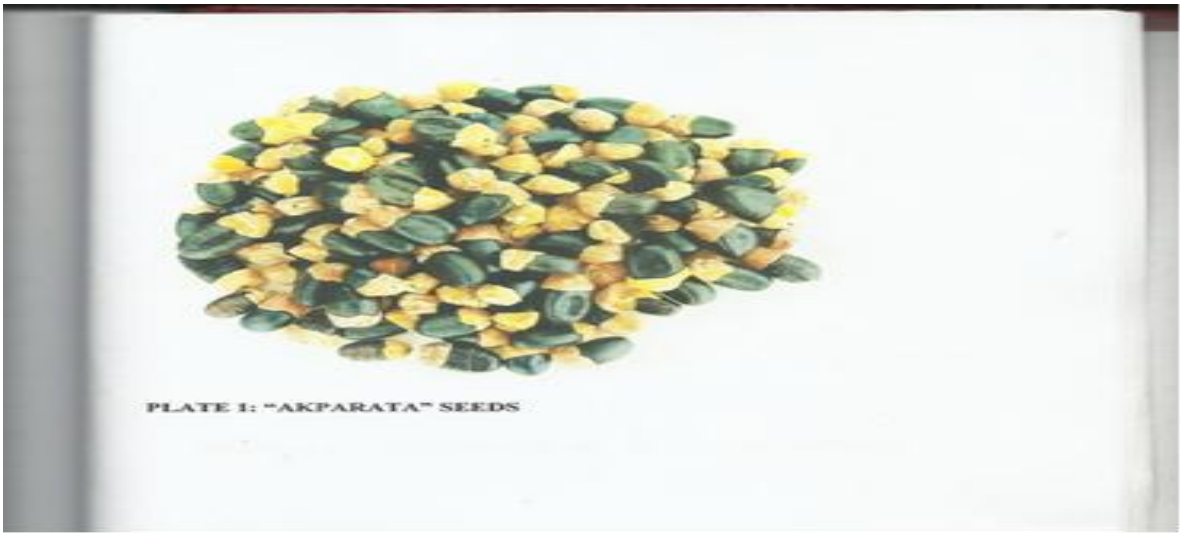

PLATE 1: "AKPARATA" SEEDS

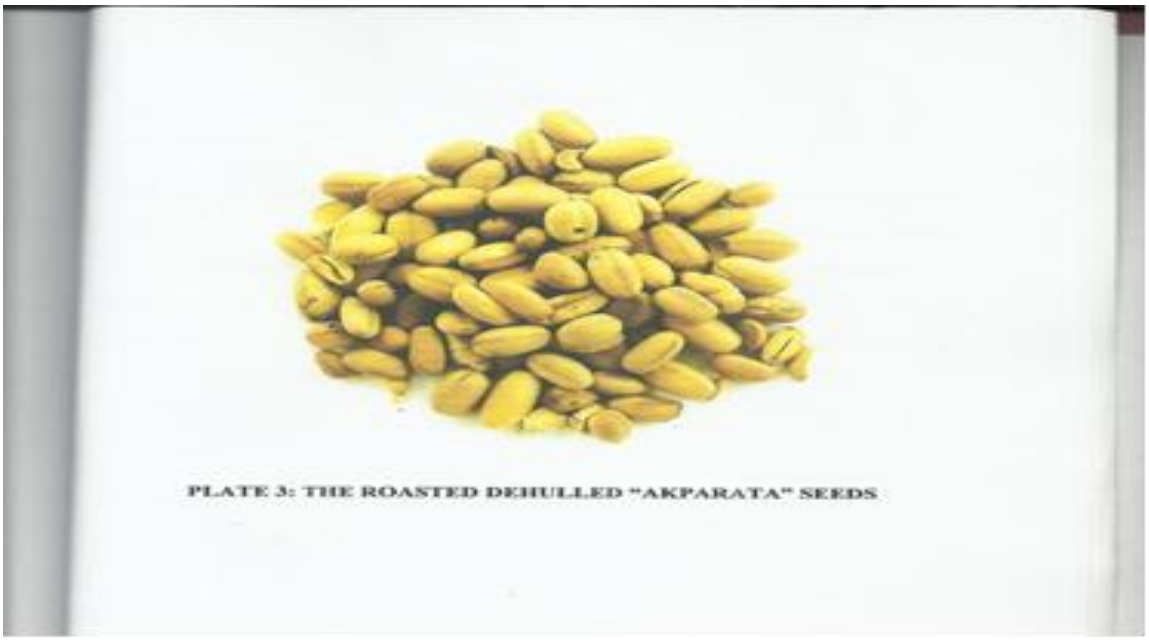

PLATE 3: THE ROASTED DEHULLED "AKPARATA" SEEDS

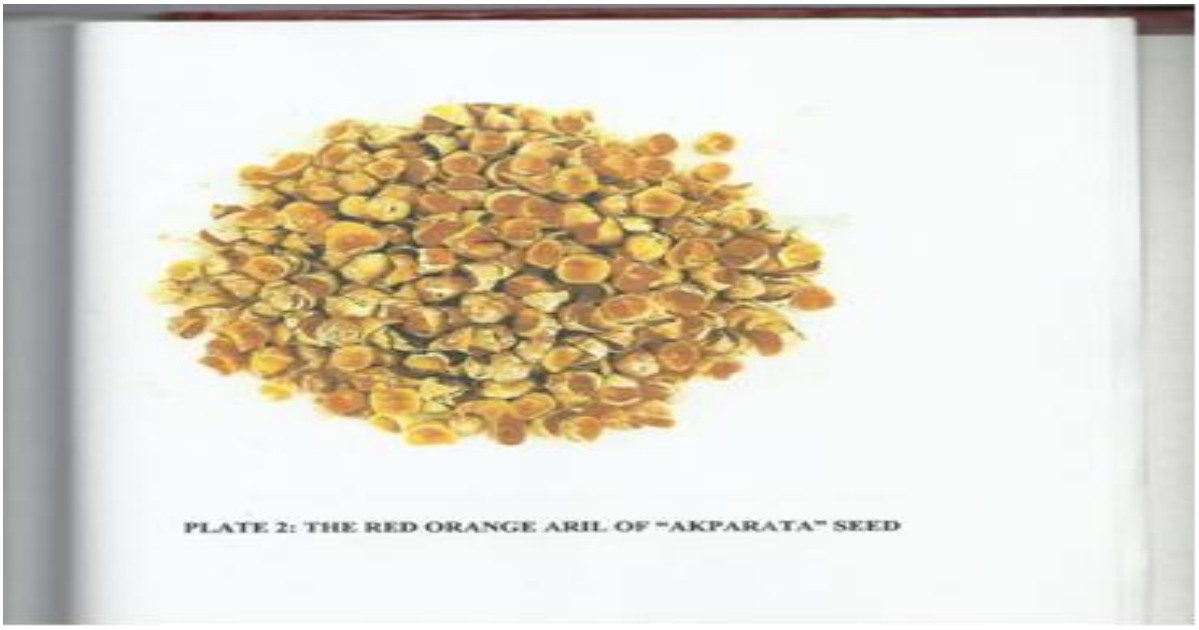

PLATE 2: THE RED ORANGE ARIL OF "AKPARATA" SEED

RESULTS

Table 1: Proximate Composition of "Akparata" As Affected by roasting and cooking.

Samples	Crude protein	Crude fat	Crude fibre	Moisture content	Ash content	Carbohydrate
R_{10}	24.0^{a}	30.5^{a}	13.3^{a}	6.5^{b}	15.6^{a}	10.1^{a}
R_{20}	21.0^{a}	35.0^{a}	8.05^{ba}	5.5^{b}	15.8^{b}	14.7^{a}
R_{30}	17.0^{a}	28.0^{a}	$7.8b^{a}$	4.5^{b}	16.6^{a}	26.1^{a}
C_{40}	19.0^{a}	8.0^{b}	13.6^{a}	28.0^{a}	16.8^{a}	14.6^{a}
C_{50}	18.0^{a}	7.0^{b}	10.8^{ab}	30.0^{a}	14.6^{a}	19.6^{b}
C_{60}	15.0^{a}	7.0^{b}	10.0^{a}	33.5^{a}	13.6^{a}	20.9^{b}
C_{A}	38.4^{b}	9.5^{b}	15.0^{abc}	10.5^{a}	4.0^{b}	22.6^{b}

Samples in the sample column with same superscript were not significantly different at (P> 0.05).

KEYS:

$_{10}$: Samples roasted at 100^0C for 10 minutes

R_{20}: Samples roasted at 100^0C for 20 minutes

R_{30}: Samples roasted at 100^0C for 30 minutes

C_{40}: Samples Cooked at 100^0C for 40 minutes

C_{50}: Samples Cooked at 100^0C for 50 minutes

C_{60}: Samples Cooked at 100^0C for 60 minutes

C_A : Control

Table 2: Functional Properties of "*Akparata*" as affected by Processing

Samples	Bulk Density g/ml	Emulsion %	Foam capacity %	Foam stability %	Gelation Temp ^{0}C	Oil Absorb. Capacity	pH	Viscosity (cP)	Swelling Index	Water Abs. capacity	Wett. ability
R_{10}	0.68^a	40.0^a	3.23^a	8.00^a	76.00^a	1.89^a	6.59^a	10.00^a	1.80^a	3.73	28.00^a
R_{20}	0.62^a	32.0^a	2.12^a	6.00^a	70.00^a	1.98^a	6.69^b	9.00^a	1.80^a	3.43^a	20.00^a
R_{30}	0.68^a	14.80^a	0.91^a	5.67^a	60.00^{ab}	2.26^a	6.58^a	6.00^a	2.00^{ab}	3.76^a	14.00^a
C_{40}	0.52 ^{b}	28.00^a	1.45^{ab}	6.87^a	73.00^a	2.29^a	6.55^a	8.00^a	2.20^{ab}	3.96^a	28.00^a
C_{50}	0.54 ^{b}	18.00^a	1.14^a	5.80^a	63.00^b	2.55^a	6.71^b	8.00^a	2.40^b	5.64^b	12.00^a
C_{60}	0.47^b	6.00^a	1.12^a	4.50^a	60.00^b	2.89^{ab}	6.46^{ab}	5.00^a	2.80^a	5.35^{ab}	12.00^a
C_A	0.60^{ab}	87.20^b	5.66^b	11.32^b	60.00^b	1.13^b	5.87^{ba}	16.00^b	1.50^a	2.83^a	35.00^b

Samples in the same column with same superscript were not significantly different at P<0.05.

Keys:

R_{10}: Samples roasted at 100^{O}c for l0 minutes

R_{20}: Samples roasted at 100^{O}c for 20 minutes

R_{30}: Samples roasted at 100^{o}c for 30 minutes

C_{40}: Samples cooked at 100^{o}c for 40 minutes

C_{50}: Samples cooked at 100^{o}c for 50 minutes

C_{60}: Samples cooked at 100^{o}c for 60 minutes

C_A: Control

DISCUSSION

Proximate Composition of "Akparata" flour

The percentage protein content of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 24.0, 21.0, 17.0, 19.0, 18.0, 15.0, and 38.4 respectively. (R = roasted: C = cooked: C_A = control) Table 1.0.

The control sample (C_A) had the highest crude protein content while the lowest was recorded for sample C_{60}. This could be attributed to the heat of the processing. This is in line with the result of Ihekoronye and Ngoddy (1985) who observed that excessive heat of processing causes severe protein damage which leads to destruction of amino acids by complete decomposition or by racemisation and the formation of cross-linkages forming poly-amino acids.

Fat Content: The percentage fat content of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 30.5, 35.0, 28.0, 8.0, 7.0, 7.0, and 9.5 respectively. The fat content of all the roasted samples R_{10}, R_{20}, R_{30}, were higher than the (C_A) and the cooked samples. The higher fat content of roasted samples could be attributed to cells rupture.

Crude Fiber: The percentage crude fiber content of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 13.3, 8.05, 7.8, 13.6, 10.8, 10.0 and 15.0. The higher crude fiber content of the control sample could be attributed to the inner coating of the raw seed which were not removed during processing. The processing method brought about a decrease in crude fiber as reported by Asagbara *et al*., (2009) who also observed a decrease in crude fiber during his work on upgrading of local technology of ogiri production.

Moisture Content: The percentage moisture content of the samples, R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 6.5, 5.5, 4.5, 28.0, 30.0, 33.5, and 10.5 respectively. From the table 1.0, the cooked samples (C_{60}, C_{50} and C_{40}) had the highest moisture content than the control (C_A) and roasted samples. This could be attributed to water absorption during cooking of the sample.

This is in line with the result of Okafor and Agu (2014) who observed an increase in moisture content during his work on water Absorption capacity of plantain based flour. Also during roasting, there is loss of water resulting in the moisture content of raw "Akparata" seeds coming down from 10.5% (Control sample) to 6.5%, 5.5% and 4.5% from roasted samples (R_{10}, R_{20} and R_{30}) respectively.

Ash Content: The percentage ash content of the samples, R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 15.6, 15.8, 16.6, 16.8, 14.6, 13.6 and 4.0 respectively. Significant difference ($p < 0.05$) existed between the Ash contents of the control and the processed samples. This could be attributed to the presence of anti-nutritional factors that chelate the mineral present in the control which have not been inactivated by heat. This was in line with the result obtained by Ihekoronye and Ngoddy (1985) who observed the presence of anti-nutritional factors such as tannins in food product of vegetable origin.

Carbohydrate: The percentage carbohydrate content of the samples, R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 10.1, 14.7, 26.1, 14.6, 19.6, 20.9, and 22.6 respectively. Table 1.0, showed that sample R_{30} had the highest percentage of carbohydrate (26.1) followed by the control sample.

Functional Properties of "Akparata" flour

Bulk Density (g/ml): the values of bulk density of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 0.68, 0.62, 0.68, 0.52, 0.54, 0.47 and 0.60 respectively. The roasted samples had the highest bulk density than the control and cooked samples. This could be attributed to different particle sizes obtained during milling of the seeds. The roasted seeds may likely have coarse ground particles than the cooked samples which were conditioned by water used in cooking before milling. According to Okafor and Agu (2014), bulk density increases with increased particle size.

Emulsion: The percentage emulsification capacity of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 40, 32, 14.8, 28, 18, 6 and 87.2 respectively. The percentage emulsion for the raw sample (87.2) was higher in value for both roasted and cooked samples. This could be attributed to high level of protein in the raw sample (control) and this was in line with the results of Onimawo and Egbekun (1998) who observed that the capacity of proteins aided the formulation and stabilization of emulsion for applications in cakes.

Foam Capacity / Foam Stability: The percentage foam capacity of samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 3.23, 2.12, 0.91, 1.45, 1.14, 1.12 and 5.66 respectively, and the foam stability of the above samples were 8, 6, 5.6, 6.8, 5.8, 4.5 and 11.32 respectively. The percentage foam capacity and foam stability were higher in value for both roasted and cooked samples. This could be attributed to protein dependent of foam capacity / foam stability of the samples. According to Onimawo and Egbekun (1998), foam capacity and stability can be influenced by number of factors which include temperature, protein type and method of preparation.

Gelation Temperature: The gelation temperature of samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 76, 70, 60, 73, 63, 60 and 60 respectively. The different gelation temperature

could be attributed to the level of the carbohydrate present in the samples. Sample R_{10} had the highest gelation temperature compared to the other samples because of its low carbohydrate value. According to Ihekoronye and Ngoddy (1985), the gelatinisation temperature of starch is distinctive for different amount of starches.

Oil Absorption Capacity: The percentage oil absorption capacity of samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60} and the control C_A were 1.89, 1.98, 2.26, 2.29, 2.55, 2.89 and 1.13 respectively. The percentage oil absorption capacity of the control sample was lower in value when compared with roasted and cooked samples. This could be attributed to the processing method adopted. According to Onimawo and Egbekun (1998), heat treatment improves the oil absorption capacity of flour proteins.

pH: The pH values of R_{10},R_{20}, R_{30}, C_{40}, C_{50}, C_{60}, and control were 6.59, 6.69, 6.58, 6.55, 6.71, 6.46 and 5.87 respectively. The pH of the raw sample (5.87) was lower compared with all the samples roasted and cooked. This could be attributed to acid nature of the raw sample. According to Onimawo and Egbekun (1998), the leaching out of the organic acid is based on the processing method adopted.

Swelling Index: The swelling index values of sample R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60}, and control were 1.8, 1.8, 2.0, 2.2, 2.4, 2.8, and 1.5. The swelling index of the control was lower compared with all the samples roasted and cooked. This could be attributed to the inertness of the starch particles in the raw samples. Swelling index is dependent of heat treatment. According to Ihekoronye and Ngoddy (1985), swelling of the granules is slight in cold water but on heating, some of the intermolecular hydrogen bonds are disrupted and swelling is noticeable. Further heating causes more loosening of the network, allowing additional water to enter and enlarge the granules.

Viscosity (cP): The values of viscosity of samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50}, C_{60}, and C_A were 10, 9, 6, 8, 8, 5 and 16 respectively. The viscosity of the control samples were the highest compared to the roasted and cooked samples. This could be attributed to the protein dependence on viscosity. According to Onimawo *and Egbekun* (1998), viscosity is defined as the internal friction acting within a liquid.

Water Absorption Capacity: The percentage water absorption capacity of samples R_{10}, R_{20}, R_{30}, C_{40}, C50, C_{60}, and C_A were 3.73, 3.43, 3.76, 3.96, 5.64, 5.35, and 2.83 respectively. The percentage water absorption capacities of the control were lower in value when compared with roasted and cooked samples. This could be attributed to processing method adopted. According to Onimawo *and Egbekun* (1998), heat of processing increases water absorption capacity.

Wettability: The values of the wettability of the samples R_{10}, R_{20}, R_{30}, C_{40}, C_{50},C_{60} and C_A, were 28, 20, 14, 28, 12, 12 and 35 respectively. The value of wettability of the raw sample (control) were higher in value when compared with roasted and cooked samples. This could be attributed to high level of crude fiber in the raw sample (control), and this is in line with the result of Oluwole and Aderibigbe (2010), who observed an increase in wettability in a fibrous materials.

CONCLUSION

The results had shown that "Akparata" (*Afzelia africana)* had good functional and proximate properties and the flour can be used as a composite flour during baking to enrich or fortify the baked products due to high concentration of protein in it. Although there were some differences in the proximate and functional properties of the processed (roasted and cooked) samples from the Raw sample (Control), the difference were within the acceptable limits.

RECOMMENDATION

From the outcome of this work, it is recommended that:

The Federal Government through its agencies such as National Agency for Food and Drug Administration and Control (NAFDAC) should educate the food producers on the importance of using "Akparata" flour as soup thickner due to the good nutritional values of the seeds. The seeds help in softening bulky stools and have been associated with the protection against colon and rectal cancer

Production of baked products with "Akparata" flour will enhance the economic Importance of "Akparata" in Nigeria. This will hopefully translate to better standard of living for the local "Akparata" producers, processors and Marketers.

Production of Vegetable oil with "Akparata" seeds will offer good health benefit to mankind due to the presence of high level of unsaturated fatty acids that are present in it which can offer protection against Cardiovascular diseases.

REFERENCES

Abbey B.W and Ibeh G.O (1988). Functional properties of Raw and Heat Processed Cowpea. *Advance Journal 0f Food Science and Technology vol.* 2(1): 41-44 .

Acland J.O. (1980). East Africa Crops: An Introduction to the production of field and plantation crops in Kenya, Tanzania and Uganda, FAO/ Longman Group Limited, London. Pp 47-50.

A.O.A.C. (1990). Official methods of analysis 15th Edn Association of official Analytical chemists Washington, DC USA.

Asagbara A.E., Onawola O.O and Etoamaihe (2009).Upgrading of the Local Technology of Ogiri Production(a food condiment).A FIIRO Research Report Publication. Pp 1- 58.

Ene-Obong H.N and Carnovale, E. (1992). Food Chemistry. Pp 169-175.

Ihekoronye A. I. and Ngoddy P.O. (1985) Integrated Food Science and Technology for the Tropics. Macmillan Publishers, London.P 18

Ikwuagwu O.E, Ononogbu I.C and Njoku O.U (2000). Production of Biodiesel using Rubber Seed Oil Crop Products. *Nigeria Journal* 12:27-62.

James C.S (1995). Experimental Method of Analytical Chemistry of Food. Champman and Hall New York.

Keay R.W.J, Onochie C.E.A and Stanfield (1964). Forest Research. *Advance Journal of Nigeria Tree 1:* 51-54.

Narayana, K. And Narasinga, R.M.S (1982). Funtional Properties of Raw and Heat Processed Winged Beans *(Psophocorpus tetragondobus*) Seed Flour. *J. Food Science*. 47:1534-1538

Okafor, C.C. and Agu, C.). (2014). Effect of Particle Size and Fibre Type on Water Absorption Capacity of Plantain Based Flour. Proceedings: The 38th Nigerian Institute of Food Science and Technology Annual Conference and General Meeting, Lagos, Nigeria. Book of Abstracts. P 287.

Oluwole, D.M and Aderibigbe,Y.E (2010).Microbiology and Proximate Composition of Ogiri, A Pastry Produced from Different Melon Seeds. P 42

Onimawo, I.A. and Akubor, P.I. (2005). Functional properties of food. In: Food Chemistry. Integrated Approach with Biochemical Background. Ambik Press Limited, Benin City, Nigeria. Pp 208-221

Onimawo A, I and Egbekun,K M. (1998). Comprehensive Food Science and Nutrition. Published by Ambik press LTD. Benin City, Edo State.pp.200-208

Pearson D. (1976). The Chemical Analysis of Foods, 7th edition, Longman group Limited.