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The Rheological and Proximate Properties of some Food thickeners ("Ukpo", "Achi" and "Ofo") as affected by processing

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ABSTRACT

Brachystegia eurycoma ("Achi"), *Mucuna solannie* ("Ukpo") and *Detarium Microcarpuim* ("Ofo") were subjected to different processing treatments which included blanching, Cooking and Roasting. One portion of the seeds of 'achi', 'ofo' and 'ukpo' were blanched for 2min, 4min, 6min and 8min respectively; Another portion was cooked for 20 min, 40min and 60min; and a third portion was roasted at 100°C, 120°C and 150°C for 20, 15, and 10 min respectively. The fourth portion is the raw sample which was used as the control sample. From the results obtained, it shows that the treatments given affected both the proximate and functional properties of these food thickeners. For protein content, raw 'achi' gave 10.52% but after treatment it was 4.32% when roasted. The result of the functional properties showed that the emulsion capacity of 'ofo' was 54.80%, which increased to 65.0% after 60min cooking but decreased to 46.00% after roasting. Also, it was observed that raw 'ukpo' had a viscosity of67.00Cp while it reduced to 42.00Cp after treatment although boiling increased the emulsification values. From these results, these products (Ukpo, Ofo and Achi) could be used in the food formulations that require emulsification and thickening (gelling) e.g. soups and sauces.

Keywords: Blanching, Emulsion Capacity, Roasting, Thickeners, Control sample.

INTRODUCTION

Brachystegia eurycoma ("Achi"), *Mucuna solannie* ("Ukpo") and *Detarium Microcarpuim* ("Ofo") were naturally found in tropical and sub-tropical areas. The common names of *Mucuna solannie* are Velvet bean and devil bead. *Brachystegia eurycoma* is locally known as 'achi' by the Ibos, 'akolodo' by Yorubas; 'okweri' by the Binis; 'eku' by the Isharis; 'ukung' by the Efiks; 'akpakpo' by Ijaws and 'oyam' by the Kwales. Also, *Detarium Microcarpuim* is locally called 'ofo' by the Ibos; 'ogbogbo' by the Yorubas and 'taura' by the Hausas. Equally, *Mucuna solannie* have its local names as 'ukpo' by the Ibos, 'yerepe' by the Yorubas and 'karasau' by the Hausas. (Ayozie, 2010).

'Ukpo', 'Achi' and 'Ofo' belongs to the same family leguminosae as well as the same sub-family caesalpiniacea. Some species of Mucuna (Ukpo) includes *Mucuna Urensi; Mucuna pruries; mucuna sloanei* and *Mucuna veracruz* while that of Detarium (Ofo) includes *Detarium microcarpium; Detarium senegalense* and *Detarium hendelotianium.* Also, some species of Brachystegia (Achi) includes *Brachystegia eurycoma; Brachystegia allenii, Brachystegia leonensis; Brachystegia kennedyi; Brachystegia kalongensis, Brachystegia bussei* and *Brachystegia monosperma* (Ezeoke, 2010).

Nutritionally, 'ofo', 'ukpo' and 'achi' are important and economic sources of protein, carbohydrate, calories as well as certain vitamins and minerals. These nutrients are essential to human nutrition but the composition of these nutrients in them differs. The protein of these foods are rich in lysine but deficient in sulfur containing amino acids particularly cysteine and methionine. Specifically, *Mucuna sloanei* (Ukpo) contains between 6-19% crude protein; 39.8- 61.49% carbohydrate; 1.84- 5.9% fat and 11.24-17.10% vitamins. 'Achi' contains between 10-32% crude protein and 18.67% carbohydrate; while 'ofo' contains 12.0- 15.6% protein; 0.79g/ml vitamins; 6.0% fat and 35.4- 68.2% carbohydrate (Ajayi *etal.,* 2006), (Ene – bong, 1992).

Flours from 'achi', 'ukpo' and 'ofo' have been found to be used in most states in Nigeria including Imo, Anambra,Akwa-Ibom and Ondo States. They are used as thickeners in traditional soups (for eating gari, pounded yam or cocoyam and fufu). They are equally used as emulsifiers and flavouring agents in traditional soups due to their gum content. These gums are called the seed gum and food gum (hydrocolliods). These are not true gums but are of simpler structures. These seeds gums are extracted from the seeds when crushed to flour and when in powder form have the ability to swell in water and thus are able to influence the viscosity of the liquid. Apart from this culinary use, it is possible for these gums when used as additives in other foods to impact desirable textural and functional properties to the finished food product particularly the "convenience foods" (Ajayi *et al*, 2006., Adebowale and Lawal, 1986).

As a result of the growing need of the Nigerian Populace, the functionality of these local foods needs to be investigated to increase their utilization. Therefore this study is intended to investigate the effects of processing (blanching, cooking and roasting) on the proximate and rheological properties of these

three food thickeners. It is hoped that a good result from this research will help increase their utilization and also reduce post-harvest losses.

MATERIALS AND METHODS

MATERIALS COLLECTION: The raw materials ('Achi', 'Ofo' and 'Ukpo') used for this work were obtained from Ekeominwa market in Owerri municipal, Imo State.

The chemicals and equipment/facilities used for the generation of samples and their analyses were obtained from the department of Food Science and Technology and Crop Science and Technology of Federal University of Technology, Owerri. The chemicals were of analytical grade.

PREPARATION OF SAMPLES: The seeds of 'Ukpo', 'Achi' and 'Ofo' were cleaned to remove dirt. The seeds were further divided into four batches. 'Achi' was roasted at 150^{o}C for 10min; 120^{o}C for 20min and 100^{o}C for 30min; 'Ukpo' was roasted for 30min at 150^{o}C; 40min at 120^{o}C and 50min at 100^{o}C. Equally, 'Ofo' was roasted at 100^{o}C for 40min; 120^{o}C for 30min and 150^{o}C for 20min respectively. The second batch of each sample ('achi', 'ukpo' and 'ofo') waqs blanched for 2min, 4min, 6min, and 8min while the third batch of each sample was cooked for 20min, 40min and 60min respectively. All these pretreatments were carried out before dehulling. The fourth batch is the control sample which was soaked for six (6)h and dehulled. They were all dried at 60^{o}C for about 3hr in a Gallenkamp moisture extraction oven and milled into flour using a disc attrition mill. They were then packaged in airtight containers and laabelled for analyses of both the proximate and rheological properties.

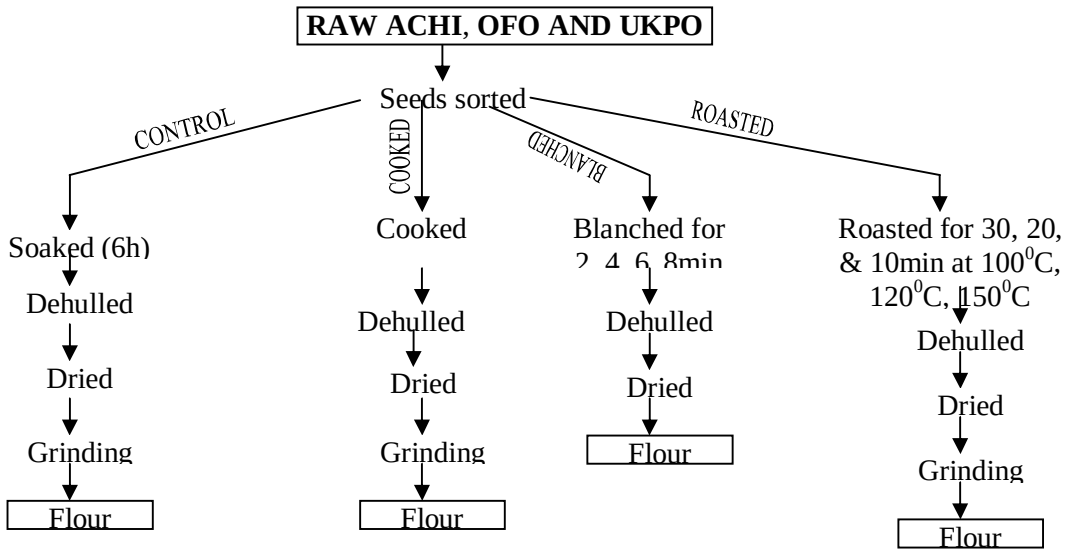

Fig. 1: Flow diagram of the processing treatments (soaking, blanching, cooking and roasting) of Achi (*Brachystegia eurycoma***), Ofo((***Detarium microcarpium),* **and Ukpo***(Mucuna sloanei)*

ANALYSIS OF THE SAMPLES

Proximate Composition Determinations

This was carried out according to the method of AOAC (1990).

Moisture Content Determination

Two grams of each of the sample was weighed into dried weighed crucible. The samples was put into a moisture extraction oven at 105^0C and heated for 3h. The dried samples was put into desiccators, allowed to cool and reweighed. The process was reported until constant weight was obtained. The difference in weight was calculated as a percentage of the original sample

$$\text{Percentage moisture} = \frac{W_2 - W_1}{W_2 - W_3} \times \frac{100}{1}$$

Where

W_1 = Initial weight of empty dish
W_2 = Weight of dish + undried sample
W_3 = Weight of dish + dried sample

Ash Content Determination

Two grams of each of the samples was weighted into crucible, heated in a moisture extraction oven for 3h at 100^0C before being transferred into a muffle furnace at 550^0C until it turned white and free of carbon. The sample was then removed from the furnace, cooled in a desiccator to a room temperature and reweighed immediately. The weight of the residual ash was then calculated as

$$\text{Ash Content Percentage} = \frac{\text{Weight of Ash}}{\text{Weight of original of sample}} \times \frac{100}{1}$$

Crude Protein Determination

The micro kjeldahl method described by A.O.A.C (1990) was used. Two grams of each of the samples was mixed with 10ml of concentrated H_2SO_4 in a heating tube. One tablet of selenium catalyst was added to the tube and mixture heated inside a fume cupboard. The digest was transferred into distilled water. Ten millimeter portion of the digest mixed with equal volume of 45% NaOH solution and poured into a kjeldahl distillation apparatus. The mixture was distilled and the distillate collected into 4% boric acid solution containing 3 drops of methyl red indicator. A total of 50ml distillate was collected and titrated as well. The sample was duplicated and the average value taken. The Nitrogen content was calculated and multiplied with 6.25 to obtain the crude protein content.

This is given as percentage Nitrogen

$$= \frac{(100 \times N \times 14 \times VF)\, T}{100 \times Va}$$

Where

N= Normality of the titrate (0.1N)
VF= Total volume of the digest= 100ml
T= Titre Value
Va= Aliquot Volume distilled

2.2.4 Fat Content Determination

Two grams of the sample was loosely wrapped with a filter paper and put into the thimble which was fitted to a clean round bottom flask, which has been cleaned, dried and weighed. The flask contained 120ml of petroleum ether. The sample was heated with a heating mantle and allowed to reflux for 5h. The heating was then stopped and the thimbles with the spent samples kept and later weighed. The difference in weight was received as mass of fat and is expressed in percentage of the sample.

The percentage oil content is percentage fat

$$= \frac{W_2 - W_1}{W_3} \times \frac{100}{1}$$

Where

W_1 = weight of the empty extraction flask
W_2 = weight of the flask and oil extracted
W_3 = weight of the sample

2.2.5 Crude Fibre Determination

Two grams (2g) sample and 1g asbestos were put into 200ml of 1.25% of H_2S0_4 and boiled for 30 minutes. The solution and content then poured into buchner funnel equipped with muslin cloth and secured with elastic band. This was allowed to filter and residue was then put into 200ml boiled NaOH and boiling continued for 30 minutes, then transferred to the buchner funnel and filtered. It was then washed twice with alcohol, the material obtained washed thrice with petroleum ether. The residue obtained was put in a clean dry crucible and dried in the moisture extraction oven to a constant weight. The dried crucible was removed, cooled and weighed. Then, difference of weight (i.e. loss in ignition) is recorded as

Crucible fibre and expressed in percentage crude fibre

$$= \frac{W_1 - W_2}{Wt} \times \frac{100}{1} \qquad W3 \qquad 1$$

Where

W_1 = weight of sample before incineration
W_2 = weight of sample after incineration
W_t = weight of original sample

Carbohydrate Content Determination

The nitrogen free method described by A.O.A.C (1990) was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameters as

Nitrogen free Extract (NFE) percentage carbohydrate

$$(NFE) = 100 - (m + p + F_1 + A + F_2)$$

Where
m = moisture
p = protein
F_1 = Fat
A = ash
F_2 = Crude fibre

ANALYSIS OF THE RHEOLOGICAL PROPERTIES;

Foaming capacity and stability

Foaming capacity and stability of the flour samples were studied according to the methods described by Desphande *et al* (1982). For stability, the flour sample (0.5g) was blended for 30 min in distilled water (40 ml) at top speed in a blender. The whipped mixture was transferred into 100 ml graduated cylinder. The blender was rinsed with 10 ml distilled water and then gently added to the graduated cylinder. Foam volume in the cylinder was recorded per sample after 30min standing. Triplicate measurements were taken for each sample and mean values recorded.

EMULSION CAPACITY

Emulsion capacity was determined according to A.O.A.C (1990). A flour sample (2g) and distilled water (100 ml) were blended for 30 sec at high speed of 100 rpm. After complete dispersion, peanut oil was added from a burette in streams of about 5ml. blending continued until there appeared separation into two distinct layers (emulsion breakpoint). Emulsion capacity was expressed as grams of oil emulsified by 1g flour. Triplicate measurements was made and average results taken.

BULK DENSITY

Bulk density of flour samples were determined by weighing the sample (50g) into 100ml graduated cylinder, then tapping the bottom ten times against the palm of the hand and expressing the final volume as g/ml.

WETTABILITY

The method of Onwuka (2005) was used. Into a 25 ml graduated cylinder with a diameter of 1 cm,1g of sample was added. A finger was placed over the open end of the cylinder which was invested and clamped at a height of 10cm from the surface of a 600 ml beaker containing 500 ml of distilled water. The finger was removed and the rest material allowed to be dumped. The wettability is the time required for the sample to become completely wet.

VISCOSITY

The method of Onwuka (2005) was adopted. Ten (10) percent of the flour was suspended in distilled water and mechanically stirred for 2h at room temperature. Oswald type Viscometer was used to measure the viscosity.

WATER ABSORPTION CAPACITY DETERMINATION

The method of Abbey and Ibeh (1998) was adopted for determination of water absorption capacity. Flour sample (1g) of each treatment was weighed separately (and also together with a clean, dry centrifuge tube, into which it was placed). Distilled water was mixed with the flour to make up to 10ml of dispersion. It was then centrifuged at 3500 rpm for 15min . The supernatant was discarded and the tube with its contents reweighed as gram water absorbed per g of sample. The gain in mass was the water absorption capacity of the flour sample.

OIL ABSORPTION CAPACITY

Two (2g) of sample was mixed with 20ml of oil in a blender at high speed for 30sec. Samples were then allowed to stand at 30^0C for 30 minutes then centrifuged at 1,000rpm for 30 minutes. The volume of supernatant in a graduated cylinder was noted. Density of water was taken to be 1g/ml and that of oil determined to be 0.93g/ml. Means of triplicate determinations were reported.

SWELLING INDEX DETERMINATION

The swelling index of the samples were determined using the method of Ukpabi and Ndimele (1990). Three grams (3g) of each flour sample was dispersed in 30 ml of cold distilled water in a graduated 50ml cylinder. The suspension was left at room temperature for 60min to absorb water, while the change in volume (swelling) was recorded every 15min. The swelling power of each flour sample was calculated as a multiple of the original volume.

SOLUBILITY DETERMINATION

The cold water extraction method, as described by Udensi and Onuora (1992), was adopted. Flour dispersion (10% w/v, db) was prepared with each of the flour samples by dispersing 1g (dry basis) of flour in 5 ml distilled water and making it up to 10ml. It was left for 60 minutes while it was stirred every 10 minutes. Then it was allowed to settle for 15 minutes after which 2ml of the supernatant were weighed in a dry Petri dish, evaporated to dryness and re-weighed. The difference in mass is the total soluble solids. Solubility was calculated as follows:

$$\text{Solubility} = \frac{\text{TSS (\%) } ((V_s M_e - M_d) \times 100}{2M_s \qquad 1}$$

Where

V_s = Total supernatant/ filtrate

M_d = Mass of empty, dry Petri dish

M_e = Mass of Petri dish plus residual solid after evaporative drying

M_s = mass of flour sample used in the preparation of the dispersion.

GELATION CAPACITY

The method of Onwuka (2005) was adopted in the determination of gelation capacity. A sample suspension of 2.20% (w/v) in 5ml of distilled water was prepared in test tubes. The samples were heated for 1h in a boiling water bath followed by rapid cooling under running cold tap water. The test tubes were then cooled further for 2h at 4^0C. The gelation capacity is the least gelation concentration determined as the concentration when the sample from the inverted test tube will not fall or slip.

RESULTS AND DISCUSSIONS

The effect of processing on the proximate composition of 'achi', 'ofo' and 'ukpo'.

The results of the proximate compositions of 'achi', 'ofo' and ' ukpo' are shown in the Tables 1, 2, and 3 below**.** From Table

1, the result of the proximate composition of 'achi' showed that raw 'achi' had the highest protein content of 10.52% which decreased as the sample were subjected to different process of treatments. The cooked samples had less protein with the sample cooked for 60min having a protein content of 9.50%; while the samole blanched for 8min had a protein content of 10.20%. the roasted samples encountered the least protein resulting from the heat of roasting. The sample roasted at 150^{o}C for 10min had a protein content of 4.32%. these decreases could be attributed to the leaching of water-soluble proteins into the blanching and cooking water and also to the denaturation of proteins by heat of processing and increased exposure time of heating (Abbey and Ibeh, 1988; Nwamekezi *et al*, 1994). From the result of the Analysis of Varience (ANOVA), there was no significant difference (P≥0.05) between raw 'achi' and all the blanched and cooked samples although significant difference (P≤0.05) occurred between them and the roasted samples; and even with that roasted at 100^{o}C (8.32%) and that roasted at 150^{o}C (4.32%). The protein content of 'ofo' (Table 2) followed the same trend with the same treatments given. On the protein composition of 'ukpo', there was a significant difference (P≤0.05) between the raw 'ukpo' (19.80%) and the blanched samples of 11.22% at 8min blanching; but there was no significant difference (P≥0.05) between the cooked and blanched samples and between 60min cooking and roasted samples. This result shows that the increase in temperature of both cooking and roasting affected the protein content of 'ukpo'.

For the Ash content of these thickeners, there was a significant decrease (P≤0.05) as heating increased. From blanching, to cooking and roasting except for the 2min blanched 'achi' which gave a higher percentage (3.00%) compared to the raw 'achi' with 2.50%. this could be a result of the mineral contents being exposed with heat denaturation. There was a significant difference (P≤0.05) between the raw and blanched; cooked and roasted and also between the blanched, cooked and roasted samples. Roasted samples at 150^{o}C showed the least ash contents of 1.50%, 1.60% and 2.0% for 'achi', 'ofo' and 'ukpo' respectively. This reductions could have been due to high heat and exposure time or as a result of leaching out of the water soluble minerals into the cooking water (Fox and Cameron, 1982; Iwuoha and Kalu, 1995).

For the moisture content; the results in Tables 1,2 and 3 showed that there was a significant increase (P≤0.05) on the moisture contents of 'achi', 'ofo' and 'ukpo' from raw to blanched and to the cooked samples. This may be due to increased contact time with water used for blanching and cooking operations. From Table 2, there was a significant decrease (P≤0.05 on the moisture content of raw and roasted for 20min at 150^{o}C against the raw which had a moisture content of 5.05%. this reduction could be attributed to the increased temperature of roasting. The same trend followed in the moisture content of 'achi' and 'ukpo' under the same pretreatments as shown in Tables 1 and 3 respectively.

From table 1, it was observed that the crude fibre of 'achi' increased significantly (P≤0.05) as the heat of processing increased. There was no significant difference (P≤0.05) between the raw and blanched samples, and also between the blanched and cooked and roasted samples. This could be as a result of conversion of some of their food ingredient to food fibres. The increase was higher on the roasted samples, although the raw still had higher levels in each case. 'Achi' had the highest crude fibre content, (Table 1); followed by 'ukpo' (Table 3) while 'ofo' had the least (Table 2) of 8.70%, 7.30% and 7.00% respectively. Since fibre plays an important role in diet, certain physiological responses have been associated with the consumption of dietary fibre lowering the plasma cholesterol and lowering the faecal bulk. This high fibre content of 'achi' probably explains the bulky ash content in it; and so can be recommended for easy bowel movement.

The fat and carbohydrate contents of 'achi', 'ofo and 'ukpo' showed a similar result to that of protein content of 'achi' as shown in Tables 1, 2 and 3 under the same treatments. This trend is that the fat contents of the raw samples were highest which decreased with the processing treatments. This could be as a result of leaching into the processing water which slightly rose during roasting as a result of fat exposure. There was a significant difference (P≤0.05) between the fat contents under the different processing treatments. For the carbohydrate, the differences that occurred was as a result of the differences in the other proximate composition parameters.

Table 1: Proximate composition of achi produced by processing methods '

Samples	% Protein	% Ash	% Crude fibre	% Moisture content	% Fat	% Carbohydrate
Raw	10.52^{a}	2.50^{b}	8.70^{a}	8.50^{a}	8.48^{a}	61.30^{d}
2min blanching	10.33^{a}	3.00^{a}	8.50^{a}	11.50^{d}	7.99^{b}	58.68^{d}
4min blanching	10.30^{a}	2.95^{ab}	8.40^{b}	13.50^{d}	7.80^{b}	57.05^{de}
6min blanching	10.28^{a}	2.90^{ab}	8.20^{b}	15.00^{cd}	7.20^{c}	56.42^{de}
8min blanching	10.20^{a}	2.75^{b}	8.20^{b}	17.30^{c}	7.20^{c}	54.35^{de}
20min cooking	9.80^{ab}	2.50^{c}	7.50^{c}	23.40^{b}	6.93^{d}	49.87^{f}
40min cooking	9.58^{ab}	2.30^{c}	7.10^{d}	26.30^{a}	6.90^{d}	47.82^{f}
60min cooking	9.50^{ab}	2.05^{d}	7.11^{d}	27.25^{a}	6.90^{d}	47.19^{f}

100^0C roasting (30min)	8.32^{b}	1.90^{de}	8.60^{d}	5.50^{f}	7.83^{b}	67.85^{c}
120^0C roasting (20min)	8.09^{b}	1.70^{e}	8.50^{a}	3.50^{f}	7.24^{c}	70.97^{b}
150^0C roasting (10min)	4.32^{c}	1.50^{e}	8.40^{b}	3.10^{f}	6.83^{d}	75.85^{a}

a-f: means with the same superscript on the same column are not significantly different at (P≥0.05)

Table 2: Proximate composition as affected by processing methods of 'ofo' samples

Samples	**% Protein**	**% Ash**	**% Crude fibre**	**% Moisture content**	**% Fat**	**% Carbohydrates**
Raw	13.36^{a}	3.50^{a}	7.00^{a}	5.05^{e}	5.60^{a}	65.49^{c}
2min blanching	12.90^{a}	3.20^{a}	5.90^{cd}	8.55^{d}	5.40^{a}	64.05^{c}
4min blanching	11.80^{ab}	3.00^{ab}	5.70^{d}	15.10^{c}	5.10^{b}	59.30^{d}
6min blanching	10.90^{b}	2.95^{c}	5.60^{d}	22.25^{b}	4.92^{b}	53.38^{e}
8min blanching	10.80^{b}	2.75^{c}	5.50^{d}	25.05^{a}	4.18^{de}	51.72^{f}
20min cooking	10.00^{bc}	2.5^{d}	5.00^{e}	26.45^{a}	4.00^{de}	52.05^{fe}
40min cooking	9.80^{bc}	2.2^{e}	4.45^{f}	22.25^{b}	3.89^{e}	42.59^{g}
60min cooking	9.79^{bc}	2.05^{e}	4.45^{f}	25.00^{a}	3.78^{e}	54.93^{e}
100^0C roasting (40min)	8.80^{c}	1.80^{f}	6.50^{b}	4.35^{e}	4.81^{c}	73.74^{b}
120^0C roasting (30min)	8.00^{cd}	1.75^{f}	6.30^{b}	2.40^{e}	4.32^{d}	77.23^{a}
150^0C roasting (20min)	6..48^{d}	1.60^{f}	6.00^{c}	2.39^{e}	3.92^{d}	79.61^{a}

a-f means with the same superscript on the same column are not significantly different at (P≥0.05)

Table 3: Proximate composition as affected by processing methods of "ukpo" samples

Samples	% Protein	% Ash	% Crude fibre	% Moisture content	% Fat	% Carbohydrates
Raw	19.80^{a}	4.25^{a}	7.30^{a}	12.75^{g}	5.20^{a}	50.6^{cd}
2min blanching	15.57^{b}	4.0^{b}	5.70^{cd}	15.95^{f}	5.20^{a}	53.58^{c}
4min blanching	15.00^{b}	3.8^{bc}	5.50^{cd}	22.75^{e}	5.13^{a}	47.82^{de}
6min blanching	12.23^{c}	3.7^{c}	5.20^{e}	25.00^{e}	5.00^{ab}	48.87^{d}
8min blanching	11.22^{c}	3.5^{c}	5.00^{e}	29.60^{d}	4.80^{b}	45.09^{e}
20min cooking	10.06^{cd}	3.0^{d}	4.39^{f}	32.80^{c}	4.72^{b}	44.49^{e}
40min cooking	10.00^{cd}	2.85^{d}	4.30^{f}	35.80^{b}	4.68^{b}	42.37^{e}
60min cooking	9.98^{d}	2.75^{de}	4.10^{fg}	43.85^{a}	4.66^{b}	34.66^{f}
100^0C roasting (50min)	9.91^{d}	2.50^{f}	6.50^{b}	10.250^{a}	5.00^{ab}	65.84^{b}
120^0C roasting (40min)	8.99^{d}	2.30^{f}	6.10^{c}	5.500^{h}	4.80^{b}	72.31^{a}
150^0C roasting (30min)	7.22^{e}	2.0^{g}	5.90^{c}	4.95^{h}	4.80^{b}	75.13^{a}

a-f means with the same superscript on the same column are not significantly different at (P≥0.05)

PROXIMATE COMPOSITION

Effects of processing on the functional properties of 'achi', 'ofo' and 'ukpo'

The results of the effects of processing on the functional properties of 'achi', 'ofo' and 'ukpo' are given in Tables 4, 5 and 6 below. the swelling index of raw 'achi' was 1.34% while that of 'ofo' and 'ukpo' were 2.92% and 2.08% respectively. From Table 5, there was no significant difference (P≥0.05) between the raw, blanched and cooked 'ofo' samples except for the 40 and 60min samples. There was a significant decrease (P≤0.05) between the raw, cooked and roasted and also between the cooked and roasted 'ofo' samples. The swelling index of 'achi' followed the same trend under the same pretreatment as shown on Table 4. 'Ukpo' showed a significant difference (P≤0.05) from cooked to roasted samples. Thus, there was a reduction on the swelling index of 'achi', 'ukpo' and 'ofo' when heat was induced. Swelling which implies the ability to increase in volume is attributed to both protein and starch mixing with water, with protein playing a dominant role at low temperature and starch at high temperature (Safe-dedah and Stanley, 1979). Thus, 'ofo' which gave the highest swelling index could be recommended for use in preparing soups in large quantities e.g. parties and occasions; while 'achi' could be used for small servings.

The result of water absorption snd oil absorption capacities of raw 'achi' was statistically different from other pre-treatments (blanched, cooked and roasted). Tables 4, 5 and 6 showed that cooking and roasting increased the water absorption capacity of 'achi', 'ofo' and 'ukpo' respectively. From Table 4, there was a significant difference (P≤0.05) for raw and blanched

'achi' (6-8min) samples. 'ofo' and 'ukpo' followed this same trend but amongst 'achi', 'ofo' and 'ukpo', there was a significant difference ($P \leq 0.05$) between raw and cooked and also between cooked and roasted samples with roasted 'achi', 'ofo' and'ukpo' at 150^{o}C having the highest water absorption capacity (4.40, 4.26 and 5.42 respectively) and oil absorption capacity (4.99ml, 4.56ml and 5.42ml respectively). The water absorption capacity (WAC) and oil absorption capacity (OAC) of the seed flour is affected by heat treatment which causes dissociation of the native proteins into sub-units that had more water-binding sites than oligomeric proteins (Abbey and Ibeh, 1994). Raw 'achi' gave a WAC of 2.00ml while that of 'ofo' and 'ukpo' gave 1.80ml and 2.32ml respectively; thus making 'ukpo' the most preferred thickener in soups that need high binding capacity.

From Tables 4, 5 and 6, it was observed that the gelation temperature of raw 'achi', 'ofo' ans 'ukpo' gave 14.80^{o}C, 11.20^{o}C and 23.00^{o}C respectively. There was a significant difference ($P \leq 0.05$) between the raw 'achi', 'ofo' and 'ukpo' and the blanched samples. Also, significant difference ($P \leq 0.05$) was observed between blanched and cooked and with cooked and roasted samples of 'achi', 'ofo' and 'ukpo'. The samples cooked for 60minutes gave the highest gelation capacities of 26.60; 20.20; and 33.78 respectively. Thus, from the result obtained, 'ukpo' had the highest gelling capacity and thus could be recommended for use in large quantities e.g. in parties (occasions). The roasting of 'achi', 'ofo' and 'ukpo' gave the least gelation capacity, thus the roasted samples could be better used in cooked forms if gelling is the main property of interest. The gelation capacity of legumes is due to its protein content, thus have been attributed to the globular interaction of their different protein contents (Fleming *et al*).

The viscosity of these three thickeners followed a decreasing trend from raw sample to the roasted samples as observed in Tables 4, 5 and 6. If viscosity is the only parameter of interest, the raw samples which had the highest viscosity values of 17.30 (achi); 63.20 (ofo); and 67.00 (ukpo) would be recommended. It was also seen that 'ukpo' had the highest viscosity and as such could be of greater importance where bulk cooking is required. From the results; there was no significant difference between the raw and the blanched samples but significant differences ($P \leq 0.05$) occurred between the raw and the cooked and with the roasted samples.

The emulsion capacity for raw 'achi' (Table 4) was 48.20% while that of 'ofo' and 'ukpo' (Tables 4 and 5) gave 54.80% and 58.30% respectively. 'ukpo' had the highest emulsion capacity and as a result could be recommended for thickening soups that need high binding capacity while 'ofo' and 'achi' could be used where light soups are required e.g. white soup. There was a significant difference ($P \leq 0.05$) between the raw and blanched 'achi' (at 4min, 6min and 8min); also significant difference existed for cooked and roasted 'achi' compared to raw samples. 'ofo' and 'ukpo' showed a similar trend under the same given treatments. The emulsifying capacities increased with blanching and cooking but decreased with roasting. 'Achi', 'ofo' and 'ukpo' when roasted at 150^{o}C gave the least emulsifying capacities of 35.00, 46.00 and 52.39 respectively.

The foaming capacity followed the same trend with that of emulsification where the highest values were observed with the cooked samples. The foaming capacities of 2.30%, 1.80% and 3.40% was observed for raw 'achi', 'ofo' and 'ukpo' respectively. While the highest values of 4.80%, 3.90% and 6.80% was observed for samples cooked for 60minutes for 'achi', 'ofo' and 'ukpo' respectively. Foaming capacity is related to emulsion and also to the quantity of protein in the systems. For foods that require high levels of foam like in ice creams, the 'ukpo' can beused to substitute some of the foaming ingredients used, but for products that do not require foaming, 'ofo' could be recommended. The roasted samples had the least foaming capacities. This low value for roasted flour samples could be attributed to higher degree of protein denaturation as compared to the protein nature in the raw, blanched and cooked samples (Nwosu, 2010).

The bulk densities of the raw samples were higher than all the treated samples. This decreasing trend also showed significant difference among the different treatments given. The roasted samples had the lowest bulk density values thus would be more convenient for packaging and transportation.

For wettability, there were increases as blanching and cooking progressed which decreased during roasting. It took longer times to wet the cooked samples than the roasted samples.

The pH values of 'achi', 'ofo' and 'ukpo' showed a slight variation. Raw 'achi' had a pH value of 5.90; 'ofo', 5.80 and 'ukpo', a pH value of 5.82 which were almost the same as mildly acidic in nature. Their pH increased slightly as blanching and cooking commenced but decreased slightly after roasting. This slight variation could be as a result of possible generation of acids or alkali in the seeds of 'achi', 'ofo' and 'ukpo' during the given treatments.

The result obtained from the proximate composition is in agreement with the works of Ene – Obong (1992). The raw seeds had low protein values (10.52- 19.80) but high carbohydrates though this could be high in dietary fibre.

Also from the results of the functional properties, there was increases in emulsion capacity, foaming capacity and stability while these parameters decreased with roasting. This result have shown that the under utilized food sources could be used as supplements after processing to improve the nutritional needs of population. Also after the processed samples had high water and fat absorption properties after processing and hence may be useful as functional agents in fabricated foods

such as bakery products and ground meat formulations.(Giami and Nwachukwu 2010).

The high elemental composition, protein, lipid and carbohydrates contents of the seeds suggest that they could serve as supplementary sources of essential nutrients to man and livestock, provided the antinutritional content of the seeds are considerably reduced or eliminated.

The seeds also could be recommended for use in instant food formulae especially for heat processed ones since the viscosity values are low; while the blanched ones could be used as food thickeners e.g. In soup and sauces. (Amadi, 2004).

Since the emulsion capacities and viscosities of Ukpo and Ofo were higher than that of "Achi" (53.3 and 54.8%, 67.0 and 63.2%, and 48.2 and 17.3% respectively) from the findings, these products could be used where high emulsification and thickening is required.

These food thickeners can be packaged, stored and used for further processing since it has be shown that they can store up to twelve weeks without loosing most of their functional properties like viscosity, wettability, swelling index and solubility. These improvements are also an index of quality in various food formulations like soups and sauces. Consequent to these observation, it could be suggested that "Achi", "Ofo", and "Ukpo" be grown in large quantities, processed using the above methods and packaged for further use.

CONCLUSION

The results obtained from this work have given an insight of the nutritional and functional properties of the seeds of the three thickeners Achi (*Brachycarpium eurycoma*), Ofo (*Detarium microcarpium),* Ukpo (*Mucana sloenie*). The nutritional composition showed a high level of protein, carbohydrates (dietary fibre) and fat which are essential for man and livestock. Also the results of the studies on functional properties showed that these seed displayed diverse functional characteristics. From the studies it is believe that the seeds have both great nutritional and functional values which could be used to meet the nutritional needs of the populace.

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