



Evaluation of the Nutritional Potentials of Fermented Oil Beans Seed *Pentaclethra macrophylla* Benth.

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Abstract

The seeds of fermented African oil bean (*Pentaclethra macrophylla* Benth) were analyzed for mineral elements, nutritional and anti-nutritional contents. The chemical analyses of the samples were carried out using standard methods. Data for each parameter were subjected to analysis of variance (ANOVA) while means of results were compared at 5% level of significance. The seeds of African oil bean were fermented for a duration of 4, 7 and 14 days at 30 °C respectively. The concentrations (mg/100g) of fermented African oil bean seed for 4days, 7days and 14days with regards to calcium, magnesium, potassium, sodium and phosphorus were 28.2mg/100g, 26.12mg/100g, 28.04mg/100g; 126.14mg/100g, 160.1mg/100g, 180.2mg/100g; 210.40mg/100g, 216.60mg/100g, 218.40mg/100g; 12.42mg/100g, 14.16mg/100g, 16.12mg/100g and 210.04mg/100g, 216.10mg/100g; 216.12mg/100g respectively. The percentage composition of protein, lipids, carbohydrates, Ash and fibre of the graded levels of fermented African oil bean seed (*P. macrophylla* Benth) after 4days, 7days and 14days duration of fermentation were 31.95%, 38.38%, 39.04%; 35.00%, 38.20%, 42.40%; 28.31%, 20.75%, 15.97%; 1.08%, 1.19%, 1.33% and 3.66%, 1.48%, 1.26% respectively. The concentration of fermented oil bean seed for 4days, 7days and 14days with regards to anti-nutritional factors, phytate, tannins, hydrocyanide (HCN) and oxalate were 0.04mg/100g, 0.02mg/100g, 0.01mg/100g; 0.042mg/100g, 0.004mg/100g, 0.002mg/100g; 0.02mg/100g, 0.04mg/100g, 0.008mg/100g and 0.12mg/100g, 0.11mg/100g, 0.10mg/100g respectively. The African oil bean seeds could serve as supplementary source of essential nutrients for man and his livestock provided the anti-nutrients inherent in the seeds are adequately detoxified to least significant levels at 14 days fermentation.

Keywords: Nutritional composition and anti-nutritional factors, fermented seeds, *Pentaclethra macrophylla* Benth.

Introduction

The African oil bean, *Pentaclethra macrophylla* Benth is a tropical tree crop which exists in abundance in the Southern and Middle belt zones of Nigeria and in other rain forest areas of West and Central Africa. It belongs to the Leguminosae family and the sub-family of Mimosoideae with no known varietal characterization (Keay, 1989; ICRAF, 2004). The tree is recognized by peasant farmers in these parts of the country for its soil improvement properties and as a component of an agro-forestry system

(Okafor and Fernandez, 1987). It is cultivated in forest areas (Ogbo, 2007). The African oil bean plant, *Pentaclethra macrophylla* Benth has been recognized as a food tree species for outlaying farms in the forest zone. According to Asoegwu *et al.* (2006) they grow either wild or semi-wild with no organized cultivation in plantations or orchards in Nigeria. Okafor *et al.* (1991) reported suitable techniques for the vegetative propagation of the plant with buds and stem cuttings resulting in drastically reduced fruiting age of 2-4 years and fruiting at breast height. The edible seeds of the African oil bean need rigorous but careful processing and fermentation prior to their consumption as food supplement (Asoegwu *et al.*, 2006; Ogbo, 2007; Enujiugha and Akanbi, 2008). Some parts of the plant have medicinal values, in Cameroon, the seeds are used to treat infertility while the pods are used to treat convulsion. In Nigeria comparative study of cancer risks and cancer levels have been carried out between the Easterners who ate fermented oil bean and those who did not. An improvement index was also measured between cancer patients who ate ugba as a meal supplement and those who did not, the result indicated that the fermented form of the African oil bean seed as a food supplement has greatly reduced the risks of cancer and some tobacco related diseases. It was discovered that cancer patients who regularly ate fermented oil bean seed as food supplement showed marked improvements in regaining quality health (Chidozie, 2006). In Ghana the smoke from burnt leaf is used to treat convulsion, the leaf/stem bark are used to treat diarrhea, the bark as ointment is used to treat itching, the bark decoction is used to treat lactogenicity, the bark as lotion is used in the treatment of wounds. The seed, when crushed and eaten with red ants, can induce abortion (Tico, 2005). The seed is also used to poison fish and arrows. Ashes of pods are used as cooking salt. The seeds are edible after roasting or boiling for at least 12hours. The seeds yield oil (30-36%) which is rich in protein and suitable for making candles and soap, flour from the seed can be used for bread making. The wood from the plant is used for fuel even though it makes good firewood, it gives unpleasant smell. It is also used for charcoal making.

According to Tico (2005) the anthelmintic bark when pounded is used for treatment of leprosy sores. In the Agro-forestry industry they supply wood and farming materials (stakes and mulch). Its trunk provides timber used for structural work. The oil bean seed tree yields forest products for making wooden household utensils (Okafor, 1987). The persistent flat glossy brownish flattened pod explodes at maturity and disperses the seeds. The number of seeds in the pod depends on the length of the pod and size of the seeds, the pods normally contain about 8 flat glossy brown seeds up to 7cm long. The mature dispersed seeds are harvested by gathering them manually from around the tree. The kernel (a dicotyledon), which is gray in colour, is embedded in a glossy brownish seed coat. The seeds may be said to be irregular and oval and lies flat in its natural position.

Pentaclethra macrophylla Benth was identified as a minor food supplement by Okafor (1987), while other workers have investigated and found that this oil seed contains 23-28% protein. It also contains the twenty (20) essential amino acids and essential fatty acids that make up over 10% of the fatty acids in the oil (Enujiugha and Agbede, 2000; Ogbo, 2007). The oil content and carbohydrate contained in raw African oil bean seeds are $53.98 \pm 0.99\%$ and $19.16 \pm 0.76\%$ dry wt, respectively (Enujiugha and Ayodele-Oni, 2003; Enujiugha and Akanbi, 2005). The seed when boiled, processed and fermented for about 3-4 days (72 hours) is called *Ugba ukpkala* in Igbo language of Eastern Nigeria, in Fulani language of Northern Nigeria, it is called Ataa or Atawa, in Zaire it is known as Twa Bobala, in Wolof language of Senegal, Gambia and Mauritania, it is called Ataa or Atawa, in the Fula language of West Africa (Mauritania, Senegal, Mali, Guinea, Burkina Faso, Niger, Nigeria, Cameroon, Gambia, Chad, Sierra Leone, Benin, Guinea-Bissau, Sudan, Central African Republic, Ivory Coast, Ghana, Togo, Liberia and Gabon), it is also known as Ataa or Atawa. The fermented seeds are used traditionally as condiments and seasonings to add flavour to food (Enujiugha and Akanbi, 2002; Ogbo, 2007; Enujiugha and Akanbi, 2008) and used for the preparation of many delicious African delicacies and snacks including, African salad, soups and sausages for eating with different staples. It is rich in vitamins and mineral and in high demand for both local consumption and for export. It is a low acid food which could be prepared into flour and explored in food fortification and confectionaries. The seed is a source of edible oil and used for candle making, cooking and soap. The seed shells are decorative and are often used to make beads which are worn as necklace, rosaries and sometimes as local dancing apparels. The seeds of African oil bean which are rich in nutrients (protein, fatty acids and minerals) have been found to be a highly nutritive animal feed when fortified (Egonu and Njoku, 2006).

The incidence of protein deficiency in Nigeria is high because many people cannot afford meat, fish and other proteinous animal products due to their astronomic costs (Balogun, 2011). African oil bean seed is consumed by many people especially the Igbos. Thus this study was conducted with the aim of creating awareness on the best level of fermentation that would be useful for human consumption. The result of this study will therefore, serve as a guide to those who cannot afford conventional sources of animal protein like meat, fish, eggs and so on to go for the cheaper alternative plant source of protein (oil bean seed) using the best identified level of fermentation for maximum utilization and benefit.



Plate 1: *Pentaclethra macrophylla* Benth seed pod with leaves

<http://www.prota4u.org/plantphotos/Pentaclethra%20macrophylla%202.JPG>



Plate 2: *Pentaclethra macrophylla* Benth pod with seeds

<http://database.prota.org/PROTAhtml/Photfile%20Images%5CPentaclethra%20macrophylla%20ofruit%20and%20seed.JPG>

Materials and Methods

Sample Collection/Identification

The seeds of *Pentaclethra macrophylla* Benth were bought from a local market in Sabon Gari, Zaria, Kaduna State, Nigeria. The samples were deposited at the Herbarium of the Department of Biological Sciences, Ahmadu Bello University, Zaria for identification.

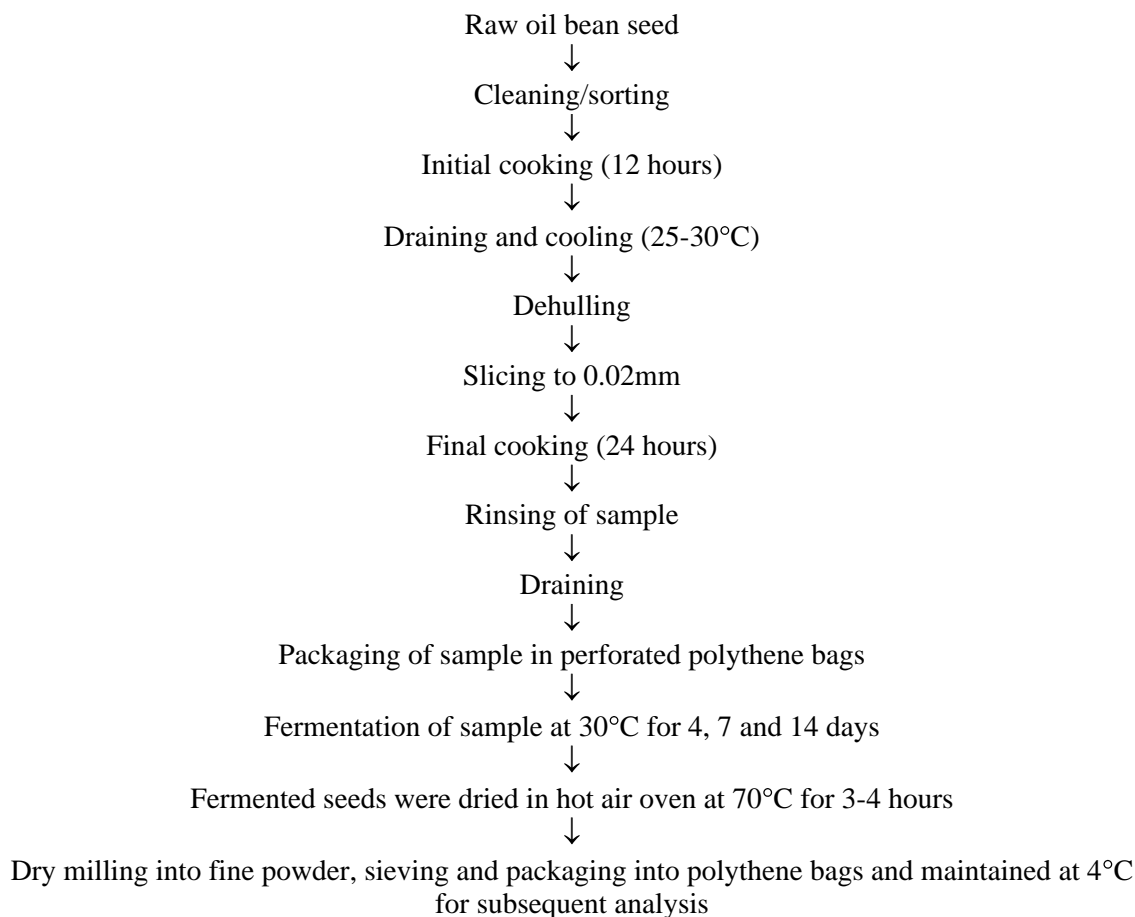
Sample Preparation

The seeds were sorted out to remove dirt, stones and other forms of impurities. Two hundred grams (200g) of the seeds were weighed and then the following procedures were carried out:

- Initial cooking: Whole oil bean seeds, *Pentaclethra macrophylla* (Benth) were cooked for 12hours (when the seeds were cooked, they normally split open when pressed manually). After opening, it is only the decorticated/dehulled seeds that were used.
- Slicing: The whole seed samples were sliced into smaller pieces (0.02mm) systematically to aid in fast fermentation.
- Final cooking: After slicing into smaller pieces the seeds were then cooked for the second time (24 hours).
- Washing of the sample: After the second cooking the seed samples were thoroughly washed to remove the bitter taste. Subsequently the water was drained off using a sieve and the seeds were packed into polythene bags for fermentation. The fermentation process was monitored on daily basis.
- Duration of fermentation: The seeds were fermented at a temperature of 30°C. The fermentation lasted for 14days. The first phase of the experiment lasted for 4days, the second phase (7days) and the last phase (14days). Fermented samples were oven dried at 70°C for 3-4 hours, milled to fine powder and thereafter packed in polythene bags.

It was established during this study that the shelf-life of fermented Ugba product did not extend beyond 14 days due to high rate of deterioration as a result of extensive moldiness of the product which implies high susceptibility to microbial spoilage.

Flow chart for the production of fermented oil bean seed based on the methods of Enujiugha (2000) with modifications



Biochemical Analyses

The samples were taken to the Central laboratory of the National Research Institute for Chemical Technology (NARICT), Basawa, Zaria, Nigeria, for analyses which included proximate, anti-nutritional factors and mineral analyses.

Determination of Nutritional Content

The samples were analyzed for proximate composition (crude protein, lipids, soluble carbohydrate, ash and crude fibre). The protein was determined by micro Kjeldahl

method (AOAC, 1980), the crude protein = $6.25 \times \%N$; the oil was also extracted by adoption of AOAC (1980) method using petroleum ether 40-60°C by means of soxhlet extractor in a continuous extraction process whereby non polar components of the sample were easily extracted into the organic ether. The soluble carbohydrate as Nitrogen Free Extract (NFE) was calculated by difference as: $NFE = 100 - (\% \text{ crude-protein} + \% \text{ crude lipid} + \% \text{ Ash} + \% \text{ moisture} + \% \text{ crude fibre})$. The Ash content of the sample which was determined by AOAC (1980) was determined from the loss in weight that occurs during igniting the sample at 55°C in muffle furnace which was enough to permit all the organic matter to burn off without allowing any appreciable decomposition of the ash constituents.

The AOAC (1980) method was adopted to determine the crude fibre content of the sample, this involved sequential digestion of the sample with dilute acid and alkali solutions. The insoluble residue obtained was ignited at 550°C in a muffle furnace for 2hours, cooled in a desicator and weighed to obtain crude fibre.

Determination of Anti-Nutritional Factors

Hydrogen Cyanide Determination

Hydrogen cyanide was determined by the alkaline titration procedure (AOAC, 1995). Ten gram (10g) of ground sample was soaked in a mixture of 200cm³ of the distilled water and 10cm³ of orthophosphoric acid. The mixture was left overnight to release all bounded hydrocyanic acid. The mixture was then distilled until 150cm³ of the distillate was collected, 20cm³ of distillate was taken into a conical flask containing 40cm³ of distilled water then 8cm³ of 6mol dm⁻³ aqueous ammonia and 2cm³ of 5% potassium iodide solutions were added. The mixture was titrated with 0.02 mol dm⁻³ silver nitrate to a faint end point with permanent turbidity.

$$1\text{ml } 0.02\text{N AgNO}_3 = 1.08\text{mg HCN}$$

Determination of Tannin

Tannin was determined using the standard method described by AOAC (1980). The method was however, slightly modified. About 2g of the ground sample was defatted for 2 hours using soxhlet extraction apparatus. The residue was dried in an oven for 12 hours at 100°C, boiled with 300ml of distilled water, diluted to 500ml in standard volumetric flask and filtered through non-absorbent cotton wool.

A volume of 25ml of the infusion was measured into 2 litre porcelindish and titrated with 0.1N potassium permanganate (0.1N potassium permanganate was standardized

against 0.1N oxalic acid) until the blue solution changed green, then few drops of 0.1N potassium permanganate was added. The difference between the two titration was multiplied by 0.006235 to obtain the amount of tannin in the sample since 0.1N oxalic acid = 0.006235g tannin.

Determination of Percentage Phytate (Reddy *et al.*, 1982)

A known weight of each ground sample was soaked into 100ml of 2% HCl for 5 hours and filtered. Twenty-five cubic centimetres (25cm³) of the filtrate was taken into a conical flask and five cubic centimetres (5cm³) of 0.3% ammonium thiocyanate solution was added. The mixture was titrated with a standard solution of FeCl₃ until a brownish – yellow colour persisted for 5 minutes.

The concentration of the FeCl₃ was 1.04% W/V

Calculation mole ratio of Fe to phytate = 1:1

Concentration of phytate phosphorous

$$= \frac{\text{Titre value} \times 0.064}{1000 \times \text{Weight of sample}}$$

Phytic acid content was calculated on assumption that it contains 28.20% phosphorus by weight.

Determination of Total Oxalate

The total oxalic acid of the powdered samples was determined by the modified method of Abeza *et al.* (1968). About 2g aliquot of the plant materials was weighed into a 250ml flask, 190ml, distilled water and 10ml of 6M hydrochloric acid were added. The mixture was digested for 1 hour on boiling water bath, cooled, transferred into a 250ml volumetric flask, diluted to volume and filtered. Four drops of methyl red indicator were added followed by concentrated ammonia until the solution turned faint yellow. It was then heated to 100⁰C, allowed to cool and filtered to remove precipitate containing ferrous ions. The filtrate was boiled, 10ml of 5% calcium chloride added with constant stirring and was allowed to stand overnight. The mixture was filtered through Whatman No. 40 filter paper. The precipitate was washed several times with distilled water. The precipitate was transferred quantitatively to a beaker and 5ml of 25% sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 80⁰C and titrated against 0.5% potassium permanganate until the pink colour persisted for

approximately one minute. A blank was also run for the test sample. From the amount of potassium permanganate used the oxalate content of the unknown sample was calculated thus

1ml of potassium permanganate = 2.24mg oxalate

Elemental Analysis

The ground sample was ashed and pellets of 0.2983g and 19mm diameter were made by applying a pressure of 10 tons (204081.60Nm²) on a hydraulic press using three drops of an organic binder (10% solution of styopore in toluene) (Anhwange *et al.*, 2005). The pellets were introduced into the X-ray fluorescence (SRF) generator (model SL12170) and analyzed (Funtua, 1999). Measurements were taken using an annular 25 mCi ¹⁰⁹Cd as the excitation source, that emit Ag-K X-rays (22.1 keV) and ⁵⁵Fe that emits Mn-K X-rays (5.89 keV), in which case all elements with lower characteristic excitation energies were accessible for detection in the samples. The spectra for the samples were collected for 3000s with the ¹⁰⁹Cd source and the spectra were then evaluated using the AXIL-QXAS program (Bernasconi, 1996). Sodium and magnesium were analyzed by Atomic Absorption Spectrometer (Unicam 969 AAS), while sulphur and phosphorus were analyzed by standard colorimetric procedures (Allen *et al.*, 1974).

Results and Discussions

The proximate analysis of fermented oil bean seed in table 1 shows that protein increased from 31.95% in 4days to 38.38% (7days) and 39.04% (14days) while the lipid content increased from 35.00% in 4days to 38.20% (7days) and 42.40% (14days). Therefore, this result proved that the longer the duration of fermentation the higher the percentage protein and lipid content. This finding is in concordance with the findings of Olaniyi *et al.* (2009) and Tamburawa (2010) who worked on Parkia (Locust bean seed). Fermentation is associated with microbial activities which stimulates better nutrient availability (particularly protein) and digestibility with significant softening of the cotyledons (Enujiugha and Akanbi, 2002). Fermented African oil bean seed has been established to produce better nutritional quality products compared to the raw seeds (Enujiugha and Agbede, 2005). The microbial enzymes from the fermenting organism aid in hydrolysis of the seed macromolecules (Enujiugba, 2003). The result of this finding is also in concordance with the findings of Ogbo (2007) which reported that due to the successive processing steps during the fermentation process there was progressive softening of the cotyledons with increased palatability of fermented African oil bean (*Pentaclethra macrophylla* Benth) seeds. The crude fibre content did not however follow the same pattern as the protein and fat in this study, it reduced with increased

duration of fermentation. It reduced from 3.66% in 4days to 1.48% (7days) and 1.26% (14days) respectively. This result agrees with the findings of Tamburawa (2010) which revealed that crude fibre values decreased in soaked and fermented locust bean seed with increased duration of soaking and fermentation due to breaking/softening of the fibre. The NFE followed the same trend as the CF content.

The anti-nutritional factors of oil bean seed which includes phytate, cyanide, and oxalate reduced with increased duration of fermentation as indicated in table 2. Therefore, the longer the duration of fermentation the lesser the quantity of anti-nutritional factors in the fermented seed. This finding is in accord with the findings of Tamburawa (2010) which indicated that increased duration of fermentation progressively reduced levels of anti-nutrients in Parkia seed. Anti-nutrients have been established to interfere with digestive processes by binding with nutrients and making them unavailable for efficient body utilization. (Makkar and Becker, 1997; Francis *et al*, 2001; Francis, 2002). The presence of anti-nutrients like Tannin interferes with digestive processes by binding the feed proteins, vitamins, minerals and digestive enzymes. The presence of cyanide and oxalate could lead to poisoning. Phytate reduces the availability of dietary phosphorus, it also forms complexes with dietary protein and reduces their availability.

The result of this finding agrees with that of Ogbo (2007) which reported a slight increase in Ash contents of fermented African oil bean (*Pentaclethra macrophylla* Benth). Results in Table 3 further shows that the mineral elements of oil bean seed which includes calcium, magnesium, potassium, sodium and phosphorus increased with longer duration of fermentation.

The results of this study indicated that the longer the duration of fermentation the higher the protein, lipid, and mineral element contents in the oil bean seeds. Fermentation at longer periods has also been shown to reduce the level of the anti-nutritional composition of the seeds.

Table 1: Proximate composition of fermented African oil bean seed (*Pentaclethra macrophylla* Benth) at different day intervals

Proximate composition	Fermentation period		
	4 days	7 days	14 days
Dry matter	95.00	97.13	97.12
Ash	1.08	1.19	1.33
Crude protein	31.95	38.38	39.04
Crude lipid	35.00	38.20	42.40
Crude fibre	3.66	1.48	1.26
Nitrogen free extract	28.31	20.75	15.97

Table 2: Anti-nutritional composition (mg/100g) of fermented African oil bean seed (*Pentaclethra macrophylla* Benth) at different day intervals

Anti-nutritional composition	Fermentation period		
	4 days	7 days	14 days
Phytate	0.04 mg/100g	0.02 mg/100g	0.01 mg/100g
Tannins	0.042 mg/100g	0.004 mg/100g	0.002 mg/100g
Hydrogen cyanide	0.02 mg/100g	0.04 mg/100g	0.008 mg/100g
Oxalate	0.12 mg/100g	0.11 mg/100g	0.10 mg/100g

Table 3: The mineral composition of fermented African oil bean seed (*Pentaclethra macrophylla* Benth) at different day intervals

Mineral composition (mg/100g)	Fermentation period		
	4 days	7 days	14 days
Calcium	28.20	26.12	28.04
Magnesium	126.14	160.10	180.20
Potassium	210.40	216.60	218.40
Sodium	12.42	14.16	16.12
Phosphorus	210.04	216.10	216.12

Conclusion

Based on the results of this study, it has been discovered that graded levels of fermented oil bean seed (*Pentaclethra macrophylla* Benth) in terms of nutrients is best at 14days level of fermentation which has highest amount of protein 53.12% and lipids 42.40% (source of energy) along with minimum anti-nutrient levels. With this protein level it will go a long way to alleviating protein deficiency among the poor and less privileged people in the study area and Nigeria at large particularly with the aim of meeting up with the FAO protein requirement recommended levels for man. However, efforts should be made to ensure that fermented *Ugba* product should not extend beyond 2 weeks (14 days) because it has been established to have a high rate of deterioration and high susceptibility to microbial spoilage within 2 weeks of production.

Recommendations

- Food nutritionist should endeavour to explore avenues of extending the shelf life of fermented *Pentaclethra macrophylla* Benth (*Ugba*) without impairing its nutritional quality, freshness (flavour, colour and appearance) and consumer acceptance.
- Processing techniques like hydro-thermal boiling and roasting could be evaluated to ensure that anti-nutrient inherent in the seeds are reduced to the bearest minimum for better efficient utilization of nutrients.

References

- Abeza, R.H.; Blake, J.T. and Fisher, E.J. (1968). Oxalate Determination: Analytical Problems Encountered with certain lant species. *Journal of the Association of Official Agricultural Chemists* 51:963-965.
- Allen, E.S., Grimshaw H.M., Parkinson, Y.A. and Quamby, (1974). Chemical Analysis of Ecological materials; Blackwell Scientific Publications Oxford London pp: 67-89.
- Anhwange, B.A., Ajibola, B.O. and Oniye, S.J. (2005) Nutritional Potential of the Seeds of *Bauhinia monandra* (Linn). *Journal of Food Technology* 3(2): 2004-208, 2005.
- AOAC (1980) *Official Method of Analysis of Association of Official Analytical Chemists* 13th Edition, Washington DC. pp 291 – 858.
- AOAC (1995) *Official Methods of Analysis*, 13th edition Association of official Analytical Chemist, Washington, D.C.
- Asoegwu, S. Ohanyere, S. Kanu, S. and Iwueke, C. (2006). “Physical Properties of African Oil Bean Seed (*Pentaclethra macrophylla*)” *Agricultural Engineering International: the CIGR Ejournal*. Manuscript FP 05 006. Vol. VIII. August, 2006.
- Balogun, B.I. (2011) Growth Performance And Feed Utilization Of *Clarias Gariepinus* (Teugels) Fed Different Dietary Levels Of Soaked *Bauhinia Monandra* (Linn) Seed Meal And Sun-Dried Locust Meal (*Schistocerca Gregaria*) Unpublished Ph.D. Thesis Ahmadu Bello University, Zaria.
- Bernasconi, G.B. (1996) AXIL-QXAS, Instruction manual, IAEA, Vienna.
- Chidozie, J.I. (2006). African Oil Bean Seed as an Essential Food Supplement in the Control of Cancer and Tobacco related diseases. UICC World Cancer Congress, July 8-12, 2006, Washington DC, USA.
- Egonu, E.C. and Njoku, H.O. (2006) Production and Shelf-life Studies of African Oil Bean Peanut Butter; *Nigerian Journal of Microbiology* 20(2): 987-993.
- Enujiugha, V.N. (2000) Development of a New Food Paste for *Pentaclethra* species. *Appl. Trop. Agri.*, 5:89-94.
- Enujiugha, V.N. (2003) Nutrient Changes during the Fermentation of African Oil Bean (*Pentaclethra macrophylla* Benth) Seeds. *Pakistan Journal of Nutrition* 2(5): 320-323.
- Enujiugha, V.N. and Agbade, J.O. (2005) Nutritional and Anti-nutritional characteristics of African Oil Bean Seeds (*Pentaclethra macrophylla* Benth). *Appl Trop Agric*. 5:11-14.
- Enujiugha V.N. and Akanbi C.T. (2002). Adaptable techniques for the postharvest processing and preservation of African oil bean seeds. Proceedings, Regional

- Workshop on Promotion of Appropriate Agroprocessing Technologies in West Africa, Ile-Ife, Nigeria (23rd-26th October, 2002). pp. 164-169.
- Enujiugha, V. N. and Akanbi, C. T. (2005). Compositional changes of African oil bean (*Pentaclethra macrophylla* Benth) seeds during thermal processing. *Pakistan Journal of Nutrition*. 4 (1): 27 – 31.
- Enujiugha, V.N. and Akanbi, C.T. (2008). Quality Evaluation of Canned Fermented oil bean seed Sliced during ambient storage. *African Journal of Food Science*. Vol. (2) pp 54-59.
- Enujiugha, V.N. and J.O. Agbede,. (2000). Nutritional and anti-nutritional characteristics of African oil bean (*Pentaclethra macrophylla* Benth) seeds. *Applied Tropical Agriculture*, 5:11– 14.
- Enujiugha V.N. and Ayodele-Oni, O. (2003). Evaluation of nutrients and some anti-nutrients in lesser-known, underutilized oilseeds. *Int. J. Food Sci. Technol*. 38(5): 525-528.
- Francis, G. (2002). *Feed Ingredients: Antinutrients in Plant-derived Fish Feed Ingredients*. The Advocate, April, 2002. p. 37-38
- Francis, G.; Makkar, H.P.S. and Becker, K. (2001). Antinutritional factors present in plant-derived alternative fish feed ingredients and their effects in fish. *Aquaculture* 199:197-227.
- Funtua, I.I. (1999) Application of the Transmission method in EDXRF for the determination of trace elements in Geological and Biological material. *Journal of trace Microprobe Tech.*, 17:293-297.
- ICRAF (International. Centre for Research In Agroforestry), 2004. *Pentaclethra macrophylla*. Agroforestry Database. World Agroforestry Centre. <http://www.worldagroforestrycentre.org/Sites/TreeDBS/Aft/speciesinfo.cfm>
- Keay, R.W.J. (1989). *Nigerian Trees*. Claredon Press, UK. 281 pp.
- Makkar, H.P.S. and Becker, K. (1997). Nutrient and anti-quality factors in different morphological parts of the *M. oleifera* tree. *Jour. of Agric. Sci. (Cambridge)*, 128:311-322.
- Ogbo, A.I. (2007). Fermented African oil bean (*Pentaclethra macrophylla* Benth) seeds, In: Clean Kitchen; Healthy Eating Issue No. 15, 2007. Pp 37 and 38.
- Okafor J.C., Okolonkwo U.C. and Ejiofor M.A.N. (1991). Evaluation of oils from fermented and unfermented seeds of the African oil bean tree *Pentaclethra macrophylla*. *Int. Tree Crops J*. 7(1,2): 95-101.
- Okafor, J. C. and Fernandez, E. C. (1987). Compound farms of southeast Nigeria. A predominant agroforestry homegarden system with crops and small livestock. *Agroforestry Systems*. 5(2): 153 – 168.
- Okafor, J.C. (1987). Diversification of the Nigerian food basket through increased use of indigenous fruits and vegetables. *Paper presented at the Training Workshop*

on Massive Cultivation of Fruits and Vegetables in Anambra State. July 21 –22, 1987 at Enugu Municipal Hall, Enugu.

- Olaniyi, C.O.; Aderinola, O.A.; Rafiu, T.A.; Akande, T.O. and Okunola, D.O. (2009). Proceedings of 14th Annual Conference of Animal Science Association of Nigeria (ASAN) September 14th -17th held at LAUTECH, Ogbmoso, Nigeria. (Eds) Akinlade, J.A.; Olayeni, T.B; Rafiu, T.A.; Akinwumi, A.O; Aderinola, O.A; Ojebiyi, O.O. and Odunsi, A.A. Pp 550-552.
- Reddy, N.R.; Sathe, S.K.; Salunkhe, D.K. (1982). Phytate in Legumes and Cereals *Advances in food Res.*, 28:1-92.
- Tamburawa, M.S. (2010). *Effect of Locust bean Seed Meal Diets on the Performance and Carcass Charactersitics of Broiler Chickens* A Ph.D Research Proposal, Presented at the Postgraduate Seminar Series of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University (A.B.U.) Zaria.
- Tico Etnobotanical Dictionary (2005) *Pentaclethra macrophylla* (Benth) <http://www.ars-grin.gov/duke/dictionary/tico/p.html>.

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