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Research Article

Comparative Nutritional Composition of African Catfish (*Clarias gariepinus*) smoked with melon shell briquettes and firewood

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ABSTRACT

The effects of two different energy sources on the quality of smoked *C. gariepinus*; proximate and mineral compositions were studied. Fish samples collected were smoked using fuel wood and melon shell briquettes in a modified drum smoking kiln. The proximate composition of the samples was determined and the results subjected to statistical analysis using One-way Analysis of variance (ANOVA). There was no significance difference ($p>0.05$) in their moisture, ash and crude fiber contents. The Significant difference ($p<0.05$) was recorded in their crude protein, fat and carbohydrate (NFE) content. The total volatile base nitrogen (TVB-N) and Minerals showed no significant difference ($p>0.05$) except in phosphorus. There was a significant difference ($p<0.05$) in the mineral composition (sodium, potassium, calcium and magnesium) among the smoked fish samples. The recommendation focused on the need for both firewood and melon shell briquettes yielded the best-smoked fish products. Smoking of fish can be done using melon shell briquettes as an alternative source of fuel to reduce energy scarcity and promote environmentally friendly practice in waste management.

INTRODUCTION

Fish smoking and its effect have been of interest to several researchers (Aminullah-Bhugan *et al*., 2006; Ahmed *et al*., 2011; Olayemi*et al*., 2011; Aliya*et al*., 2012; Omodara and Olaniyan, 2012). Many of these authors have reported that smoking of fish accelerates drying (that is, lowers the moisture content or water activity) and prevents microbial activities on the fish. Fish smoking is an age long method of processing fish in Nigeria. However, the process is laborious with associated drudgeries. In order to remove these drudgeries and to conserve wood fuel energy, efforts must be put in place towards research and improve on alternative sources of energy in fish processing.

However, World wood resources are depleting at a rapid rate and the food and Agricultural organization (FAO) of the United Nations during the United Nations conference on New and Renewable sources of energy held in Nairobi in 1981, estimates, that nearly one billion are living in regions with either acute scarcity or deficit wood supply situation (Danshehu, 1995). Wood is a predominant source of fuel in many developing countries like Nigeria. About 200 million people in developing countries depend on wood biomass for their daily domestic energy needs (FAO, 1990).

One third of the world's population of six billion lives in developing countries lack access to modern energy services for economic, social development and some of their present energy systems are unsustainable (Brien *et al*., 2007). Researchers have reported that about 80-90% of wood consumed in Nigeria are in the form of fuel wood (Fuwape and sobanke 1998). Beside of these limitations, modern energy is usually very expensive and beyond the reach for most fish processors. This has encouraged the use and preference for fuel wood as a major source for domestic activities (Adedire, 2002). The alternative source of fuel wood in fish smoking is by Briquetting the Agricultural waste product, which is the transformation of a powdery or granular product into a larger more convenient solid size.

This is accomplished by compacting the mashed product with the help of a compressor or hydraulic pressure. The major agricultural residues are Mellon shell, sugar cane trash, Sawdust; a milling residue is also available in huge quantity. Apart from the problems of transportation, storage, and handling, the direct burning of loose biomass in conventional grates is associated with very low thermal efficiency and widespread air pollution. The conversion efficiencies are as low as 40% with particulate emissions in the fuel gases in excess of 3000 mg/ Nm^2 (Maninder, and Sonia 2012).

Many waste materials, from sawdust to Melon shell, can be turned into clean-burning, easy-to-handle fuels that cut waste and carbon emissions. With increasing pressure on the earth's resources, turning different types of organic waste into clean-burning fuel helps save forests and cut greenhouse gas emissions by replacing wood, charcoal and fossil fuels for fish smoking and other industrial processes. Aside from being cleaner and easier to handle, biomass briquettes are also less polluting (David and Anne; 2014). Catfish (*Clarias gariepinus*) is a very important freshwater fish species in Nigeria; it has enjoyed wide acceptability in most part of the country because of its unique taste, flavor and good texture. It is widely distributed, extensively cultivated in ponds, but underpriced (Kumolu *et al.*, 2009).

MATERIALS AND METHODS

Experimental sites

The experiment was conducted at the Federal University of Technology, Minna, Briquetting at Mechanical Central workshop of the School of Engineering and Engineering Technology Gidankwano Campus on longitude 09^0 32.69'Nlatitude006^0 27.60'E at 243.3m high, situated in Bosso Local Government Area of Niger state, Nigeria with an area of 1,592 km² and a population of 147,359 (Census 2006).

The fish smoking experimentation was carried out in the Fishery unit of the Teaching and Research Farm of the School of Agriculture and Agricultural Technology Gidankwano campus onlongitud**e** 09^0 31.02'Nlatitude006^0 26.42'E at 200m high, situated, Federal University of Technology, Minna, Niger State, Nigeria; it is located in the Northern guinea savannah with distinct dry and wet seasons. It has an annual rainfall of 1,200mm, with the highest mean monthly in September. The temperature ranges between 22 - 37^0C. The peaks are 40^0C in February to March and 35^0C in November to December. While laboratory analysis was conducted at waft laboratory located in Gidankwano campus of the federal university of technology, Minna Niger state, Nigeria. Onlongitud**e** 9^0 31.96'N latitude 6^0 27.20'E at 249.6m high, situated.

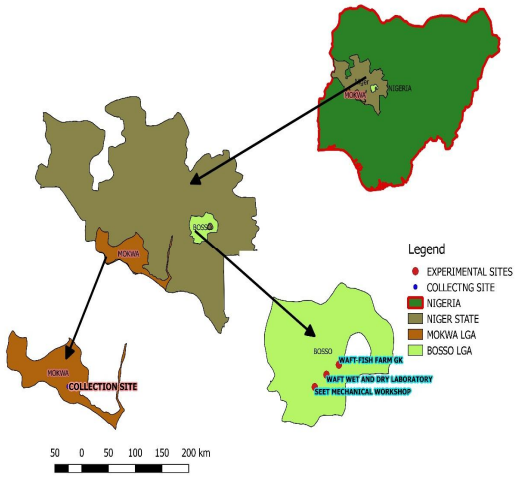

Fig. 1: Nigeria shows the location of Niger State and two of the experimental sites. Source NPC 2006 and researchers' modification 2016.

Fish Samples

The fish species used for this experiment were catfish *Clarias spp.* Thirty (30) fresh Catfish *C. gariepinus* of Average weight ranges of 500 - 800g each, were purchased from the Mobil fish market in Minna, Niger State, Nigeria. They were degutted and then washed thoroughly with clean tap water to remove blood and slime. Thereafter fish Samples was divided into two groups of 15 each and bent into horseshoe shapes, for smoking with firewood and melon shell Briquettes respectively. Using the Improved modified drum Smoking Kiln, The initial mean weight of the fish was recorded in kg. The fish was then brined in 25% salt solution for 1 Hour to improve their flavor and enhance their shelf life. They were then drained for about 30 minutes before smoke drying in an improved smoking kiln. The fish were arranged on top of wire gauze placed in a smoking kiln for each of the treatments (firewood and Mellon shell briquettes). The fish were turned regularly to prevent charring for 24 hours until dried to a constant weight. Samples of the smoked fish were taken for the proximate, sensory and other biochemical Analysis.

Energy sources

Collection of Melon shell

The Mellon shell was collected from Mokkwa town in Niger state, the Local Government Area, with an area of 4,338 km² and a population of 244,937 (Census, 2006). It is counted as one of the major processors of Mellon seed (*C. vulgaris*) (Egusi) in Nigeria. A total of about 25 Kg was collected and then ground into small granules or fine particles and soaked in water for Briquetting.

Compaction tests on the slurry samples were carried out using a hydraulic press machine. A metal rectangular die of dimension 12.3cm x 9.2cm x 7.3cm length, width and height respectively, were used for this study. The dye was freely filled with known amount of weight for each sample mixture and be positioned in the hydraulic powered press machine for compression into briquettes. The piston was actuated through hydraulic pump at the speed of 30mm/min of piston movement to compress the sample. Compacted pressure was 9.0MPa.A known pressure was applied at a time to the material in the die and was allowed to stay for 4 minutes (dwell time) before ejection and the briquette formed was then being aired/sun dried. Stop watch was used for timing purpose.

The moisture content of the ground material before and after compaction were determined using ASAE S269.4 (2003) involving the use of oven drying methods. The initial weight of the sample was determined (W1), and placed in an oven set at 105ºC for 24hours.The samples was removed and cooled in a desiccator, reweighed (W2). The moisture content of the sample was calculated from the following expression,

$$\text{Moisture Content} = \frac{w1-w2}{w1} x100$$

Collection of firewood

The wood materials were purchased from *local* wood seller at gurara junction along gidankwano road, which is a hardwood known to be preferable for smoke concentration than soft wood and may give products with lower pH and

more bacteriological stability the choice of this type of wood is that due to it, higher content of some phenolic compounds, particularly guaiacoland syringol than phenol and cresol, it is also one of the most common woods used in fish smoking in the savanna zone of Nigeria.(Eyo 2001)

Smoking process

The modified drum kiln was used for the smoke-drying process. It was made from a 400 L drum with 90 cm length and 58cm diameter. The drum was cut open midway. The base was used as the combustion chamber with a firebox of 22 × 22 cm^2 and internally built damper made of perforated metal plate were installed above the firebox. The smoking chamber was separated into three compartments using "chicken" wire mesh 10 cm above the damper. The briquette fire was set up in the combustion chamber and then lighted. The temperature of the smoke generated was monitored in the smoking chamber until the required temperature (60^oc-110^oc) is obtained using a mercury-in-glass thermometer. The fish samples were then is placed on the mesh in the kiln after weighing. The burning briquettes were then being adjusted continuously to maintain the required temperature of 60^oc in the chamber during the smoking period.

The fish samples were divided into two batches both in weight and number, one batch was smoked-dried using melon shell briquettes, while the other batch was equally smoked using firewood. The smoking was done using an improved smoking kiln. Smoked fish products were packed in low-density polyethylene (LDPE) zip lock bags and stored at ambient room temperature of 25-30°C.

Biochemical evaluation

Proximate

The Proximate analysis of the fish samples smoked with melon shell briquettes and firewood for moisture, ash and carbohydrate contents were determined as described by AOAC (2005). Crude protein, fiber and fat contents were determined using the methods described by (Pearson 1976).

Procedure for analysis of Total Volatile based-Nitrogen (TVB-N) in smoked fish

The TVB-N was determined by dissolving 100 g of the Smoked Catfish sample extract with 200 ml 7.5% aqueous trichloroacetic acid in a metal beaker and homogenized in Waring blender. Filtering the mixture through a Whatman no 3 filter paper. 25 ml of the filtrate was pipetted into a distillation flask with 6 ml 10% NaOH. Steam distillation was then being carried out using the Kjeldahl-type distillate (Struer TVN) and the TVB-N collected in 10 ml 4% boric acid (con 0.04 ml of methyl red and bromocresol green) indicator which turned green when alkalinized by the TVB-N (Malle and Poumeyro, 1989). The solution was then titrated with 0.0372 N sulfuric acid until there was a complete neutralization of the base which was indicated by a color change to pink.

The equation for calculating TVB – N

$$\text{TVB} - \text{N} = (\text{A}) \times \text{Strength of acid} \times 0.2 \times \frac{\text{volume of extract}}{\text{Volume of extract taken}} \times \frac{100}{\text{wt of sample taken}}$$

(*Mg/100grams)*

A = (titration reading - blank reading).

Mineral

Mineral contents of all the samples were also determined by atomic absorption spectrometry (AAS), flame photometry and spectrophotometer according to the methods of AOAC (2003).

Equations for calculating Mineral Element of Smoked fish samples:

$$\text{Phosphorus (mg/kg)} = \frac{\text{Abs} \times 0.61 \times \text{DF} \times \text{DF}}{\text{Atomic weight of P (30.97)}}$$

Statistical Analysis

The data collected was subjected to statistical analysis using one way Analysis of variance (ANOVA) and Duncan Multiple Range Test was used for mean separation. The statistical analysis was conducted by using IBM SPSS version 20 software.

RESULTS AND DISCUSSION

The results of statistical analysis of the proximate composition of the smoked fish products in Table 1 showed that the samples were not significantly different ($p>0.05$) in their moisture, ash and crude fiber contents. Statistically Significant difference ($p<0.05$) was recorded in their crude protein, fat and carbohydrate (NFE) content of the two samples. And it was observed that spoilage of fish flesh resulted from the action of enzymes and bacteria; this can be slowed down through the application of salt and removal of moisture to increase the shelf life of fish. Total Volatile base Nitrogen (TVB-N) is widely used as an indicator of the degree of lipid oxidation (Daramola; *et. al, 2013*). It helps to measure the level of fish spoilage and to explore the shelf life of fish. Total volatile base nitrogen (TVB-N) values of the two samples are also given in Table 1

Table 1: Proximate composition of smoked *C. gariepinus* using firewood and melon shell briquettes

Parameters	Firewood SFP	Melon shell briquettes SFP
Moisture (%)	14.97±0.55	15.84±0.61
Fat (%)	14.76±0.13	13.78±0.18
C P (%)	45.76±0.41	43.51±0.84
Ash (%)	3.15±0.05	3.19±0.05
C F (%)	1.16±0.04	1.14±0.04
NFE (%)	20.28±0.21	22.54±0.53
TVB-N(mg /100g)	30.22±1.81	28.82±0.80

mean±SE, FW SFP (firewood smoked fish product), MSB SFP (melon shell briquettes smoked fish product)

The result of the mineral content in Table 3: Showed that There was significant difference ($p<0.05$) in the mineral composition (sodium, potassium, calcium and magnesium) among the smoked Fish samples.no significant difference ($p>0.05$) in phosphorus concentration.

Table 2: mineral composition of smoked *C. gariepinus* using firewood and melon shell briquettes

Taste samp	Na	K	Ca	Mg	P
FW SFP	109.79±4 .82	157.50±1 5.30	600.51± 13.84	6.73± 0.08	2.71± 0.07
MSB SFP	86.04±3. 10	91.46±11 .10	512.82± 33.72	6.50± 0.02	2.59± 0.07

mean±SE (standard error of mean), FW SFP (firewood smoked fish product), MSB SFP (melon shell smoked fish product).

The crude protein, fat and carbohydrate (NFE) content of the two samples was significantly difference ($p<0.05$).with crude protein and fat had the higher percentage means values of 45.76±0.41 and 14.76±0.13 respectively in firewood smoked fish product and this could be as a result of higher differential temperature (DT): 48-79°C, because Fuel wood generate greater amount of heat within the Smoking Chamber with less smoke, hence, drying of the samples was achieved with low moisture content. The results of the proximate compositions in this study for moisture, fat and ash content in (table 1) disagree with the finding of Adebowale *et al.* (2008) who reported the range of moisture, fat and ash content of Nigerian smoked catfish to be 7.16 - 10.71, 1.58 - 6.09 and 9.21 - 12.16%, respectively but protein values are still within the range. The low crude fiber value recorded in the samples is due to the fact that the energy content in smoked *C. gariepinus* is high because crude fiber is considered as indigestible. The crude fiber content indicates the amount of cell walls in the feed. The fat levels in the two samples were below the range (15-33%) reported by Plahar *et al*. (1991) to cause rancidity problems in storage. In this study, the crude protein has the higher quantity of the dry matter in all the fish samples. This is in-line with the report that protein forms the largest quantity of dry matter in fish (Pannevis, 1993) and Kumolu-Johnson et.al (2009) and thus, smoked *C. gariepinus* is a good source of pure protein and would be more than enough to prevent malnutrition in children and adult who defends solely on this fish as a main source of protein. Smoking decreases the water activity in fish tissue. The studies on the proximate composition and elemental composition of the freshwater fishes have not really caught the attention of researches in fisheries; hence the consumer and fishery workers are left with limited or paucity of information on the importance of a particular fish species in their daily diets Adewoye and Omotosho (1998).

Ogbonnaya and Shaba (2009) reported no negative effect of the drying processes on the proximate and mineral values in catfish except losses in the energy value. The moisture content in both samples were within the recommended range of smoked fish product, with no significant difference ($P>0.05$). Ahmed *et al* (2011) and Effiong and Fakunle (2012) also reported similar result. The Total Volatile Nitrogen increased during storage. The ratio of Volatile Base Nitrogen to the Total Nitrogen has been recommended as a useful index of quality in fish (Huss 1988). Kirk and Sawyer (1991) suggested that a value of 30-40mg N per 100g as the upper limit. And the limit of acceptability of fish is reported to be 30mg N per 100g by Connell (1995). Beyond this level, white fish and prawns are regarded as unacceptable. However, result from this study both in firewood smoked fish product and melon shell briquettes smoked fish products shows that stored smoked fish products still have their final TVB-N values (26.37±1.63and29.87±1.00) within acceptable limits, since they all have values less than 30 mg N per 100g.

The Mineral composition of melon shell as stated by (Ogbe*et al.*, 2013). Calcium (%) 2.10±0.13, Magnesium (%) 0.42 ±0.10, Potassium (%) 1.30 ±0.04, Sodium (ppm) 259.85 ± 1.78 and Phosphorus (ppm) 30.11 ±0.20.this revealed that the low concentration of minerals element in melon shell briquettes smoked fish product of this study compered to firewood smoked fish products could be as result of the low concentration from the raw melon shell. Sodium chloride diffuses to muscles from the outside due to difference in osmotic pressure between the brine and fish muscle. This process does not continue indefinitely: sodium and chlorine ions form a water binding complex with protein, which it exerts an osmotic pressure and eventually equilibrium is reached (Horner, 1997). It also clear from the results of this study that smoked *Clarias gariepinus* is a good source of macro and micro mineral elements in spite of the two different source of fuel for smoking the fish samples and may contribute to health, growth and development of human beings. The high Calcium content (600.51±13.84 and 512.82±33.72)mg/100g observed in all the samples is of nutritional benefit, particularly for children and the aged who need higher intakes of calcium for bone formation and maintenance. Calcium and potassium play a vital role in regulating thyroid activity and the potassium content in this study is (157.50±15.30 and 91.46±11.10) for fire wood and melon shell briquettes smoked fish samples, which are expected to be within the ranges needed to maintain the regulation of thyroid activity in good balance (ARL,2012). The mineral composition (sodium, potassium and calcium) in this study had the highest values in all the smoked fish samples. This could be attributed to the rate at which they are available in the water body and the ability of the fish to absorb these organic elements from their diet and the environment. Onyia et al., (2010) reported similar findings and attributed this to the dominance of the element in the water body.

CONCLUSION

From the experiment carried out, it was generally found out that the characteristics of biomass briquettes produced from compaction of melon shell and waste paper were satisfactory and compatible with the other researches. Nevertheless, the results obtained from this study have met the objectives set at the early stage of the research. That is to develop a solid fuel from the mixing of melon shell and waste paper at 3:1 ratios has been achieved successfully. The briquettes were compatible with each other's and it is suitable as a new solid fuel sources that can be utilized in many applications. The Briquetting of melon shell with waste paper can improve its physical and mechanical properties. . In view of this, the utilization of melon shell in the production of briquettes can greatly provide alternative energy sources for fish smoking, domestic cooking and also serve as a measure in curbing the environmental hazard posed by poor methods of agricultural waste disposal in addition to reducing the popular use of firewood which has an adverse effect on our environment (deforestation).

RECOMMENDATION

Both Firewood and melon shell briquettes yielded the best-smoked fish products. Smoking of fish can be done using melon shell briquettes as an alternative source of fuel.

In order to obtain a high quality of smoked fish. Salt treatment (25%brine) should in addition be carried out before smoking. The role of salt has been enunciated in the discussion. Constant turning of fish and regulating of the smoke density and temperature should be adequately taken care of during smoking. This could ensure good quality of smoked fish.

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