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Sensory evaluation of African catfish (*Clarias gariepinus*) smoked with melon shell briquettes and firewood

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Abstract
Agricultural Biomass can play a significant role in alternative energy generation. Briquetting of melon shell residues can alleviate some of the problems of energy shortage being encountered world-wide. This study was conducted to determine and compare the suitability and efficiency of melon shell briquettes as an alternative energy sources to fuel wood in fish smoking with a view to mitigate the measures in firewood utilization. Briquettes were made using a hydraulic press machine. A metal rectangular die of dimension 12.3cmx9. 2cmx7.3cm length, Width and height respectively, Fish samples collected were smoked using fuel wood and melon shell briquettes in a modified drum smoking kiln. Sensory (organoleptic) parameters of the samples were determined and the results subjected to statistical analysis using One-way Analysis of variance (ANOVA). Except their color, the samples were not significantly different ($p>0.05$) in the (taste, odor and texture) sensory attributes. However, the densification characteristics of briquettes were 0.12, 0.09 and 0.20 lengths, breadth and mass, respectively and 1.94 and 0.52 relaxation and density ratio respectively. The Specific Fuel Consumption (SFC) recorded was 4.10 and 3.82 kg/kg of fresh fish, smoked with fuel wood and melon shell briquettes at the costs of ₦41. 73 and ₦29. 10, respectively. The burning rate (BR) recorded was 0.023 and 0.022kg/min, for firewood and melon shell briquettes respectively. It was, therefore, concluded that melon shell briquettes should be efficiently used as an alternative to fuel wood in fish smoking. Since Both Firewood and melon shell briquettes yielded best-smoked fish products. Then 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. Constant turning of fish and regulating of the smoke density and temperature should be adequately taken care of during smoking.

Keywords: Brequettes, melon shell, fish, sensory evaluation

1. Introduction
Fish once caught is fully and efficiently utilized to avoid deterioration. To prolong the shelf life of fish, it is preserved by many processes, including sun drying, solar drying, canning and smoking among others. Fish smoking is the commonest preservation method in Nigeria because of the simplicity of the process which makes it acceptable in remote fishing villages where the technology for other preservation methods is not readily available (Oyero, 1999) [20].

Dried fish is a major component of harvested fisheries in many countries including Nigeria. About 25 to 30% of the world fish catch is consumed in the dried, salted, smoked form or combination of these processes (Aliya *et al*., 2012) [2]. Three processes cooking, drying and smoking is involved in hot smoking, resulting in a longer product shelf life of 6-9 months when stored properly.

Ogali (1994) [14] reported that 15% of the total catch in Kainji Lake is lost due to spoilage and breakage between the source of supply and consumers and that the use of chilling, freezing and canning are not common in the tropics due to high cost, therefore, smoking is a type of preservation that readily comes to mind after a large catch, hence unsold catches were usually preserved by smoking. Losses arising from bacteria and breakdown of tissue by enzymes (catalytic spoilage) are enormous hence the need to preserve fish (Ndakatu, *et al.*, 2011) [13].

Some of these processes, though important for preservation have various effects on the physical and nutritional quality of fish because it has been observed that different processing and drying methods have different effects on the nutritional compositions of fish (Oparaku and Mgbenka, 2012) [21].

Fish smoking and its effect have been of interest to several researchers (Aminullah-Bhugan *et al*., 2006 [3]; Ahmed *et al*., 2011[1]; Olayemi *et al*., 2011 [17]; Aliya *et al*., 2012; Omodara and Olaniyan, 2012) [19]. 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) [5]. 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) [8]. 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) [6].

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) [12]. This research was conducted to determine and compare the efficiency of a melon (*Citrullus vulgaris*) shell briquettes in fish smoking as a mitigation measures to firewood utilization.

2. Materials and Methods

2.1 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 Gidan kwano Campus on longitude 09^0 32.69'N latitude 006^0 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 Gidan kwano campus on longitud**e** 09^0 31.02'N latitude 006^0 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.the experimentation was commences 24, June, 2017 and terminated in November, 2017. It has an annual rainfall of 1,200mm, with the highest mean monthly in September. The temperature ranges between 22 – 37 ^{0}C. The peaks are 40^0C in February to March and 35 ^{0}C in November to December. While laboratory analysis was conducted at waft laboratory located in gidan kwano campus of the federal university of technology, Minna Niger state, Nigeria. On longitud**e** 09^0 31.96'N latitude 006^0 27.20'E at 249.6m high, situated.

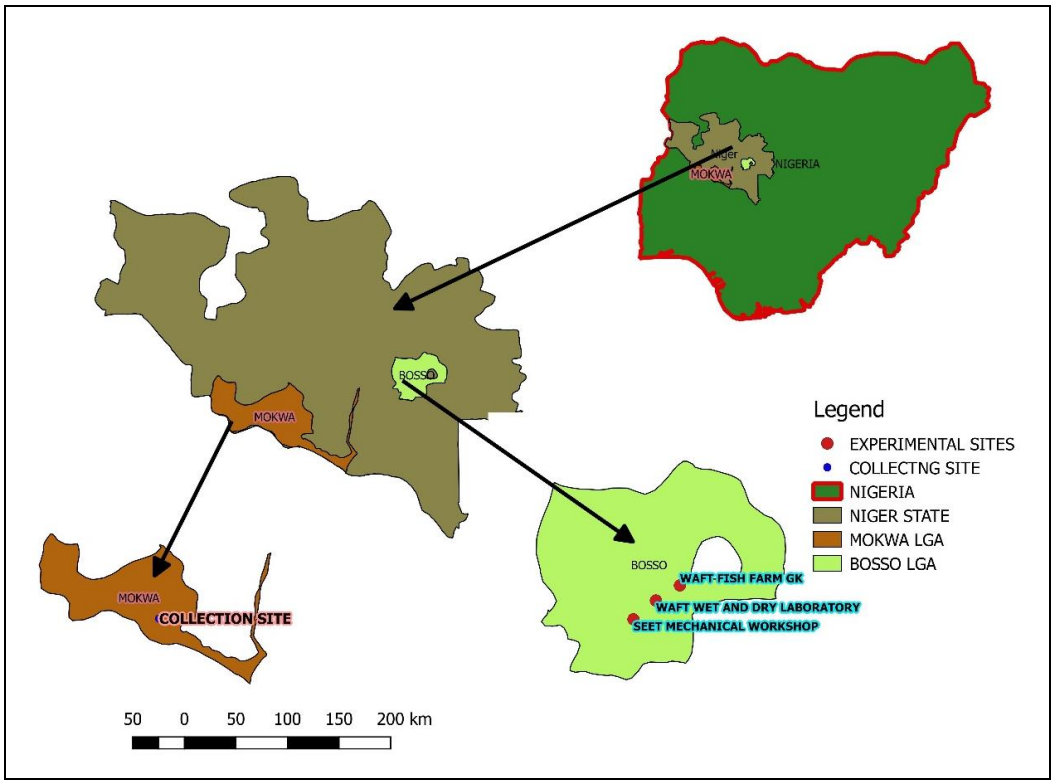

Fig 1: Nigeria shows the location of Niger State and two of the experimental sites. Source NPC 2006 and researchers' modification 2016.

2.2 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. From 14-28, July, 2017.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.

2.3 Energy sources

2.3.1 Collection of Melon shell

The Mellon shell, was collected from Mokkwa town of 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.

2.3.2 Melon shell Briquettes Press

Generally, the briquettes were made through the following procedures:

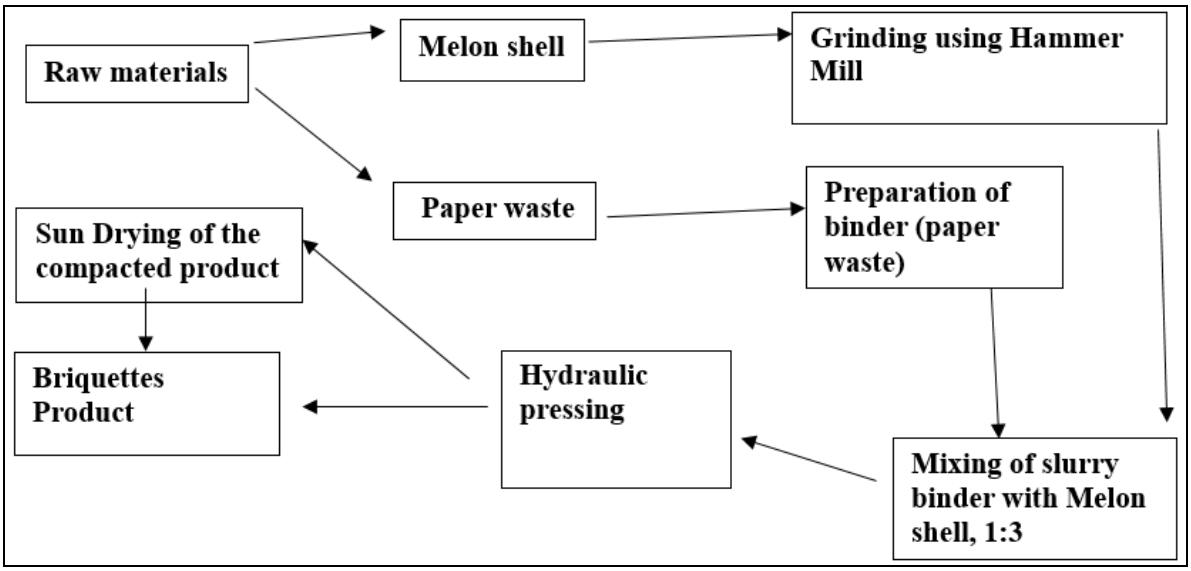

Fig 2: Flow diagram of briquette production process

Compaction tests on the slurry samples were carried out using a hydraulic press machine. A metallic 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) [4] 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,

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

2.3.3 Determination of Densification Characteristics of the Briquette

The densities of briquettes formed from the residue were determined immediately after ejection from the mold and this was calculated from the ratio of the mass to the volume of briquette. The mass was obtained by using a digital weighing scale, while the volume was calculated by measuring the length, breadth and thickness of the briquettes by means of a Vermeer caliper (Oladeji, 2012) [16]. The relaxed densities of the briquettes from the melon shell residues were determined after the stable moisture contents of briquettes produced were obtained. The relaxed density, which is also known as a spring back density can be defined as the density of the briquette obtained after the briquette has remained stable and was calculated simply as the ratio of the briquette's mass to the new volume. Equilibrium moisture contents of the briquettes formed were determined in line with ASAE S269.4 (2003). The compressive strengths of the briquettes were also investigated by using a universal testing machine at civil engineering. Compressive strength was determined in accordance with ASTM Standard D1037-93.

The following densities and related ratios were determined:

$$(1)\ \text{Density Ratio} = \frac{\text{relaxed density}}{\text{maximum density}}$$

$$(2)\ \text{Relaxation Ratio} = \frac{\text{maximum density}}{\text{relaxed density}}$$

$$(3)\ \text{Compaction Ratio} = \frac{\text{maximum density}}{\text{initial density}}$$

$$\text{Burning rate} = \frac{\text{Total weight of the burnt briquette}}{\text{Total time taken}}$$

2.3.4 Collection of firewood

The wood materials were purchased from *local* wood seller at gurara junction along gidan kwano 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 guaiacol and 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) [7]

Consumption of the various wood materials were measured by weighing a load of each wood material at the beginning of the smoking process and weighing all the remaining and partial burnt at the completion of smoking. SFC was computed as:

$$\text{Specific fuel consumption, SFC} = \frac{\text{Mass of fuel consumed}}{\text{Total mass of smoked fish}}$$

2.4 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 ^{0}C-110 ^{0}C) 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 be adjusted continuously to maintain the required temperature of 60 ^{0}C 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 look bags and stored at ambient room temperature of 25-30 ^{0}C.

2.5 Sensory evaluation

This was undertaken to determine the taste, odor, mouth feel (texture) and general appearance (color) of the Smoked Fish products. Taste panels of six members already familiar with scoring smoked fish were given the product scores at every two-week interval. Products were scored on a 5 point hedonic scale of 8 - Excellent, 6 - Good, 4 - Fair, 2 - Poor, and 0 - Bad. (Eyo, 2001).

2.6 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.

3. Results

The result of Table 1 indicates that physical characteristics of melon shell briquettes used for the smoking. One hundred and twenty seven (127) pieces were produced each having 0.12m length,0.09m breadth, 0.063m thickness with mass of 0.2kg. The combustion characteristics were also reflected

Table 1: Densification characteristics of melon shell briquettes produced

Parameters	Values
Physical	
Length (m)	0.12
Breadth (m)	0.09
Thickness (m)	0.063
Mass (kg)	0.2
Number produced	127
Combustion	
Residue moisture (%)	10.9
Briquettes moisture (%)	8.86
Maximum density (kg/m^3)	0.064
Relaxed density (kg/m^3)	0.033
Compaction ratio	0.002
Relaxation ratio	1.94
Density ratio	0.52

The result depict that fish smoked using firewood yielded 51.69% of body weight lost compared to 42.05% of that briquettes smoked fish product (Table 2)

Table 2: Weight obtained before and after smoking with firewood and briquettes

Energy sources	Fresh fish (kg)	Smoked fish (kg)	Weight lost (kg)	% weight lost
Firewood	4.45	2.15	2.30	51.69
Briquettes	4.40	2.55	1.85	42.05

Results of the analysis of fuel wood and melon shell briquettes consumption, smoking duration and temperature in the smoking of *C. gariepinus* (Table 3) showed that 4.10 and 3.82 kg each of firewood and melon shell briquettes were used to smoke a kilogram(kg) of *C. gariepinus* at average temperature ranges of 48-79 °C and 40-56 °C, respectively. The costs of smoking 1 kg of the catfish samples using the two energy sources were: ₦41.73kobo and ₦29.10kobo, respectively. While the length of time taken to smoke the samples using fuel wood, and melon shell briquettes has equal duration of 780 min. while the rate at which two energy sources burnt were: 0.023 and 0.022kg/min respectively.

Table 3: firewood and melon shell briquettes consumption in the smoking of *C. gariepinus*

Parameters	Firewood	Briquettes
Weight of fuel material used (kg)	18.2	16.8
Cost of fuel material used (₦)	185.71	127.83
Weight of fuel/kg of fresh fish (kg)	4.10	3.82
Cost of fuel/kg of fresh fish (₦)	41.73	29.10
Smoking duration (minute)	780	780
Smoking temperature (^{0}C)	48-79	40-56
Specific fuel consumption (kg)	8.47	6.59
Burning rate (kg / min)	0.023	0.022

The results of statistical analysis of the sensory (organoleptic) parameters of the experimental samples in Table 4 showed that the samples were not significantly different (p>0.05) in the (taste, odor and texture) sensory attributes of fish smoked

using melon shell briquette and firewood on the data obtained from the panel members. But there was a statistically significant difference (p<0.05) in color of the smoked fish using firewood and melon shell briquette with a mean value of 1.40±0.103 and 1.80±0.147 respectively.

Table 4: Sensory attributes of smoked *C. gariepinus* using firewood and melon shell briquettes

Parameters	Taste	Odor	Texture	Color
Firewood smoked fish	1.77±0.104	1.80±0.130	1.67±0.246	1.40±0.103
Melon shell, smoked fish	1.83±0.118	1.83±0.118	1.43±0.114	1.80±0.147

4. Discussion

From the result of laboratory analysis, the moisture contents of 10.9 were recorded for melon shell residues, while the corresponding moisture contents of the briquettes were (8.86) The moisture contents of the residues are within the limits of 15% recommended by Grover and Mishra (1996) [9] and Kaliyan and Morey (2009) [11] for agro-residues, while the moisture contents of the briquettes obtained in this study are also satisfactory as it is within the limits recommended by Yang *et al*. (2005) [24], which stated that the difference between the moisture content of agro-residues and their briquettes ideally should be in the ratio of about 2%.

The relaxation ratio obtained from this study 1.94 is good enough, as it is stated by (Yang, *et al*. 2005) the lower the value of relaxation ratio, the higher is the stability of briquettes produced and is close to the values obtained by Olorunnisola (2007) [18], where a relaxation ratio of between 1.80 and 2.25 was achieved for briquetting of waste paper plus the admixture of coconut husk and oladeji (2012) [16] with a relaxation ratio of 1.95 for melon shell briquettes and 1.69, 2.29, 1.92 and 1.78 for corn cob, ground nut shell, cassava peel and yam peel briquettes respectively.

The variation of the burning rate values 0.023 Kg/min and 0.022 Kg/min of fuel types, melon shell briquettes was recorded with the lowest burning rate than firewood energy sources. This observation could be due to porosity exhibited between inter and intra– particles which enable easy infiltration of oxygen and out flow of combustion briquettes. Onuegbu *et al.* (2011) [20] reported factors that could be responsible for burning rate of biomass (briquettes) such as chemical composition, volatile matter content and geometry (bulk and packing orientation) of the biomass.

The specific fuel consumption of the two fuel sources were 8.47 kg (firewood), and 6.59 kg (briquettes) (Table 3). Hence, biomass of higher ash content tends to consume more fuel for cooking than the biomass of lower ash content. According to Onuegbu *et al*. (2011), percentage ash content is one of the factors that affect specific fuel consumption of fuel briquettes negatively. The percentage ash content of melon shell as reported by ogbe *et al* (2013) [15] 7.73% and Jekayinfa and Omisakin (2005) [10] reported the ash content values for some agricultural wastes as follows: palm oil effluent (10.97%), corn cob (4.85%), yam peels (4.56%), mango peels (4.33%), black walnut hull (4.10%), cherry (3.80%), coconut shell (3.47%)

The sensory attributes as observed by the response of the six member evaluator panel showed that people preferred fish, smoked using melon shell briquettes than the ones smoked using firewood in terms of mouth feel (texture). However, there was no significant difference (p<0.5) in the (taste, odor and texture) sensory attributes of fish smoked using melon shell briquette or firewood on the data obtained from the panel members. But there was a statistically significant difference (p<0.5) in color of the smoked fish using firewood and melon shell briquette with a mean value of 1.40±0.103 and 1.80±0.147 respectively in which fire wood smoked fish product gives golden brown color and that of briquettes gives a dark brown till the end of the termination period Which might be as a result of phenolic and hemicellulose compound present in smoked of hardwood materials. At the beginning of storage, all the sensory parameters of these two treatments were rated as excellent and good based on the grading scale. The highest mean of the sensory evaluation score was found to be 1.40±0.103 in case of firewood smoked, dried fish product and 1.43±0.114 in case of melon shell briquettes smoked dried fish product. This, however, agree with an earlier research finding of Oyewole et.al, (2006) [23] stated that the fish treated with salt (brining) and The enormous heat value coupled with thermal efficiency and right flame temperature of wood dried the fish and also (Oladeji, 2012)[16] stated that The higher heating value of (21,887) for melon shell briquettes produced from his research is sufficient enough to produce heat required for household cooking and small scale industrial cottage applications. There by reducing the moisture content to a level that will prevent the growth of microorganism. And this might lead to better quality attributes of the two sources of fuel used for this research. Fish therefore could be smoked using fire wood or melon shell briquettes without any fear of acceptability by the consumers, but at this juncture fish processors are advised to smoked fish using melon shell briquettes than firewood as it has been observed that briquettes have under gone proper combustion which has reduced the amount of sulphur and smoke-lading with phenolipic compounds that have been said to be carcinogenous (Eyo, 2001).

5. 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 in 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 application. 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).

The compaction of the wastes increases their energy density and reduces the problems associated with their disposal in the environment. Based on the various results obtained from this study, the following conclusions can be drawn:

1) Briquettes made in this study would make better biomass fuels.
2) All the briquettes produced from these residues will not crumble during transportation and storage because of it low relaxation ratios.
3) Generally, briquettes produced from melon shells have more positive attributes of biomass fuel compared to so many agricultural biomass briquettes

6. Recommendation

Since Both Firewood and melon shell briquettes yielded best-smoked fish products. Then 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. And also in order to obtain a high quality of smoked fish product 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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