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ORGANOLEPTIC AND ECONOMIC APPRAISAL OF FISH SMOKED WITH WATER HYACINTH BRIQUETTES AND TRADITIONAL ENERGY SOURCES

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ABSTRACT

The study was conducted to investigate the organoleptic and economic assessment of water briquettes and traditional energy sources (red mangrove wood, charcoal and common wood). The parameters investigated were colour, appearance, texture and taste acceptability and performance evaluation of energy sources and their economic analysis of their utilization. The water briquettes competed favourably with charcoal, common wood and red mangrove wood. The specific fuel consumption (kg fuel per kg fresh fish) revealed mangrove wood had 0.2, firewood 0.29, charcoal 0.16 and briquette 0.15. From the data, it was clear that briquettes had the least specific consumption while firewood had the highest. The mean fuel charge required to smoke one kg fresh fish for briquettes was 0.15kg, charcoal was 0.16kg, red mangrove wood was 0.2kg and 0.24kg for common wood. The cost per kg of fuel of each of the energy sources revealed mangrove wood used for smoking varied from N45.50 per kg, firewood N41.9 per kg, charcoal N51.20 per kg and briquette N23 per kg. This showed that mangrove recorded highest price per kg while the lowest was briquettes. The total cost of fuel for smoke processing for all the energy sources revealed mangrove wood was N589.50, common wood N493.76, charcoal N428.40 and N222.07 for briquette. This is an indication that had the highest total cost for fish smoking while briquettes had the lowest. The energy sources used in smoking 1kg fresh fish for mangrove N9.07, common wood N9.95, charcoal N8.27 and briquettes N3.42. The results confirm the possibility of utilizing water hyacinth as fuel briquette of good source that support combustion. The water hyacinth briquettes possess the high material strength as well as high value combustible fuel, which qualify them as alternative to traditional fuelwood for domestic and industrial energy sources.

KEYWORDS: Energy, Combustion, Briquettes, Fuelwood, Binder and Cost.

INTRODUCTION

Niger Delta of Nigeria is characterized by extensive network of rivers and creeks which discharge their waters into the Atlantic Ocean. Fishing is the major occupation of the people in Niger Delta. Presently, about 97% of the fish processors depend solely on mangrove trees as their fuel [1]. In Niger Delta, the average weight or volume of fuelwood per day (16.45kg or 7.5m^3) exceeds the Food and Agriculture Organization (FAO) average allowance (0.46m^3) [1]. Mangrove (*Eichhornia crassipes*) wood is the predominantly source of fuel available to the fish processors in the riverine fishing communities and *Anthonotha macrophylla* wood for the upland fishing communities [3, 4, 5]. Adegbulugbe [6] reported that the demand for fuelwood is expected to be risen to about 2,134,000 metric tonnes, while the supply would decrease to about 28,400 metric tonnes by the year 2030. That study suggested development of appropriate fish processing equipment that will reduce fuel consumption.

One of the most invasive and prolific aquatic weed that smoother and devastate lakes, canals, rivers and pond as well as choking other aquatic lives, prevent navigation, favour mosquitoes breeding and fosters water borne diseases, environmental nuisance and threat to ecodiversity in the Niger Delta is water hyacinth (*Eichhornia crassipes*). This aquatic weed blooms heavily in Niger Delta due to favourable climatic condition [1]. The harvest frequency for aquatic plants tends to be in the order of days, whereas the frequency for trees and crops are the order of years and months. The abundance, availability, low cost, and rapid growth of water hyacinth make them an ideal candidate for biofuel, particularly in the developing countries [7]. Over dependent on mangrove trees as source of fuel has led to serious deforestation which has destroyed the ecosystem. In the past few years, mangrove have been over-depleted and fuelwood price have gone up considerably leaving them to lean profit, causing women and children to travel long distance for its collection. Associated problem of desert encroachment and soil erosion amongst others are becoming aggravated. The situation in the rural areas of the country is that most end users depend on fuelwood. Fuel is used by over 60% of Nigeria living in the rural areas. Nigeria consumes over 50million metric tons of fuelwood annually. Traditionally, wood in form of fuelwood, twigs and charcoal are predominantly sources of renewable energy in Nigeria, accounting for about 51% of the total annual energy consumption. Other sources of energy as reported by Akinbami [8] include natural gas (5.2%), hydroelectricity (3.1%), and petroleum products (41.3%).

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According to study conducted by Davies and Davies [17] revealed that fuelwood (50%) was highly preferred energy source for fish processing followed by charcoal (21%), wood shaving (17%), sawdust (14%) electricity and gas, (2%) each being the least. This present observation on source of energy adopted for fish processing is in accordance with the reports of FAO [3, 9].

NEST[10] estimated the total annual consumption of wood in Nigeria at about 50-55 million cubic meters of which 90% is firewood, while estimated shortfall of fuelwood in the Northern part of Country is about 5-8 million cubic meters. While the annual deforestation of the wood lands in the Northern part of Nigeria run to about 92, 000 hectare a year. The fuel wood extraction rate in the country is estimated to be about 3.85times the rate of re-growth or afforestation. According to Emerhi [11] reported that most of the world's energy demand is not met by fossil fuel mainly coal, crude oil, and natural gas. Fossil fuel, which is non-renewable, provides about 80% of man's energy sources now and this may start to depreciate in the next twenty to thirty years. If biomass or agro-waste briquettes are to be used efficiently and rationally as fuel, they must be characterized to determine parameters such as ignition time and burning rate, moisture content, ash content, density, volatile matter, and heating value among others. Akinbami [8] reported that the increasing pressure on forest resources for energy has led to what is called "Other Energy Crisis of wood Fuel".

This has led to environmental degradation, deforestation and misuse of soil forests and water resources. The uncontrolled level of cutting of wood for firewood and charcoal for combustion, and for other domestic and industrial uses, is now a serious problem in Nigeria. The studies by ENC [12] and Sambo [13] showed that national demand for traditional energy (mostly fuelwood and charcoal) is 39 million tonnes per annum (about 37.4% of the total energy demand and the highest single share of all the energy forms). It is projected to increase to 91 million tonnes by 2030. The deforestation rate will continue to increase if nothing is done to discourage the use of fuelwood and promote the use of alternatives and replenish through deliberate afforestation and fuel lots. Utilization of water hyacinth as biofuel, is an important way of managing the weed problem and contributing to environmental management, saves trees that can prevent soil erosion and desertification by providing an alternative to burning wood for domestic and industrial heating and cooking as well as creating employment and generating income for those who are most affected by it. Combustion of briquettes is environmental friendly briquettes.

The results obtained from the tests carried out shows that the water hyacinth briquette was able to cook the various food items although cooking took a longer time when compared with the conventional kerosene stove. This is due to the fact that the heat generated reduced over time and was concentrated only at the center of the hole. By aiding the biomass briquette with small pieces of wood a reduced and better

time of cooking was obtained. The conversion of water hyacinth into biomass for cooking purposes will help. The objective of this study is to investigate the combustion characteristics of the existing energy sources used by fish processors and compare with the combustion characteristics water hyacinth briquettes.

MATERIALS AND METHODS

Preparation of briquette sample

The pre-treatment processing of briquette sample for this study comprised of drying, size reduction and compaction operations. The raw materials were sun dried for 5-7days. The dried raw materials were chopped using chopper (knives) and ground using hammer mill. The particle size distribution was achieved by using Particle Size Analysis Equipment consisting of sieve shaker and Tylers sieves of various diameter or particles size openings. This equipment vibrated and forced the material through the screens with mesh. For this experiment, sieves size corresponding to 4.0mm. Water hyacinth ground was mixed with binder (ground plantain peels). The agitating process was done in a mixer to enhance proper blending prior compaction. The blends were briquetted under ambient condition in a manually operated hydraulic powered press having capacity of 20tonnes.

Compaction Tests

Compaction tests on the blend samples were carried out using hydraulic press machine. A steel cylindrical die of dimension 14.3mm height and 4.7mm in diameter was used for this study. The die was freely filled with known amount of weight (charge) of 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. The blend was compacted at 9.0MPa pressure. The pressure was applied at a time to the material in the die and was allowed to stay for 45 seconds (dwell time) before released and the briquette formed was then be extruded. Stop watch was used for purpose of timing.

Smoking process and sensory evaluation of smoked fish

The fish species that was used for the experiment was catfish (*Clarias gariepinus*). The total weight of the fish used for each experiment was 65kg. The fish was degutted and wash thoroughly with water to get rid of blood dirty and body slime. The fish were dried in an improved kiln.

Smoking process

The kiln comprises of two chambers namely combustion and drying chamber. Drying chamber was divided into three steps. The initial weight of each of the fuel charge for the four different fuel used for experiment was measured by weighing machine. The stopwatch was used to monitor the smoking duration. Temperature was taken at interval of one-one hour from each of the three steps in the drying chambers and was recorded. At the end of the smoking, time taken and the quantity of fuel used was recorded. The data collected was used in calculating specific fuel consumption (the amount of fuel required to obtain 1kg of smoked fish). The specific fuel consumption used in the experiment was expressed as:

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

$$\text{Time spent smoking /kg smoked (Ts)} = \frac{\text{Total time spent in smoking}}{\text{Total weight smoked fish}}$$

Sensory evaluation of smoked fish

Sensory evaluation of different organoleptic properties of the dried fish namely: colour, texture and overall acceptability were carried out by ten (10) untrained panelists selected from fish processors and ten (10) fisheries scientists. They were of different age groups on the basis of 9 point Hedonic scale according to standard procedures [14, 15] (Table 1). Each assessor was given four samples each from four different solid biofuel investigated (that is, briquettes from water hyacinth, charcoal, mangrove wood and common wood). Evaluation was carried out in well illuminated environment. The panel were asked to complete questionnaires that required demographic information and as well as their perception towards smoked fish consumption.

Table 1. 9-Point Hedonic Scale

Grade	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Source: [15]

RESULTS AND DISCUSSION

The results of sensory evaluation of the smoked fish prepared using the four different energy sources are shown in Figures 1-4. The response of panel of judges to organoleptic assessment of smoked fish revealed that all the four energy sources were acceptable but at different levels. Smoking and cooking as food processing technique is aimed at improving the organoleptic quality of food [16, 17].

The colour of the fish smoke-dried with briquette, charcoal, common wood and mangrove had acceptability of 6.74±0.12, 6.41±0.09, 7.21±0.13 and 7.34±0.20 as shown in Figure 1. The result showed that no significant different between mangrove wood and common wood (P>0.05). Mangrove wood and common wood were most preferred due its golden brownish (mangrove) and dark brownish (common wood) while the least was charcoal (light brown). There was significant different between fish smoke-dried with briquettes and charcoal (P< 0.05). The observed result in terms of colour for the four energy sources revealed high acceptability (scores > 6). Colour codes 1, 2, 3 and 4 were used for white, light-brown, brown and deep brown colours by Ndrika [18] to indicate degree of doneness of cake at a given time. The colour is one of the major parameters of food that can be easily attract the consumers and also play a significant role in food acceptability.

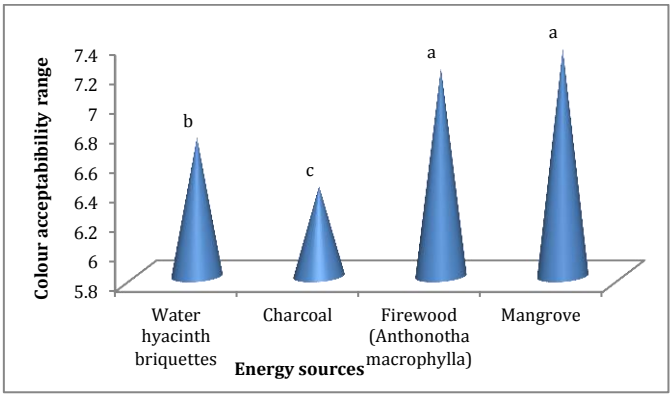

Figure 1. Colour acceptability of smoked fish (Means of different letter are significantly different (P<0.05))

The taste of the fish smoke-dried with briquettes, charcoal, common wood and mangrove recorded acceptability of 7.27±0.06, 6.82±0.04, 6.93±0.26 and 7.46±0.05 as shown in Figure 2. The results showed that mangrove wood and briquettes had no significant different (P>0.05). The highest acceptability in terms of taste was corresponded to mangrove and briquettes. The taste of smoke-dried fish using charcoal and common wood was not significantly different (P> 0.05). The observed results in terms of taste for the four energy sources revealed high acceptability (scores > 6).

Fish smoke-dried with briquettes recorded the highest acceptability with respect to appearance 7.59±0.22 and the lowest was recorded for fish smoke-dried with charcoal 6.55±0.13 as revealed in Figure 3. The appearance of the smoke-dried fish using mangrove wood and common wood showed no significant difference (P> 0.05). The observed results in

terms of appearance for the four energy sources revealed high acceptability (scores > 6).

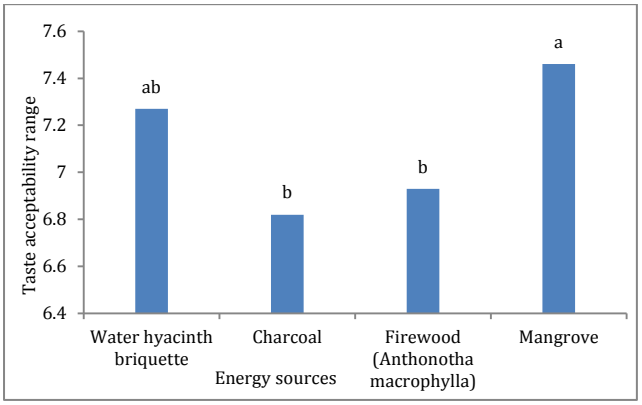

Figure 2. Taste acceptability of the smoked fish (Mean of different letter are significantly different (P<0.05))

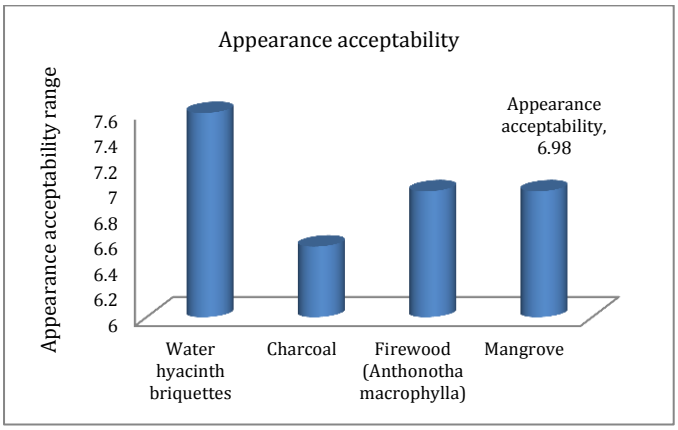

Figure 3. Appearance acceptability of the smoked fish (Means of different letter are significantly different (P<0.05))

The texture of the fish smoke-dried with briquettes, charcoal, common wood and mangrove had acceptability of 7.40±0.13, 7.12±0.22, 7.34±0.22and 7.34±0.13 as shown in Figure 4. The texture of the smoke-dried fish using different energy sources were not significantly different (P> 0.05). The observed results in terms of texture for the four energy sources revealed high acceptability (scores > 7).

Table 2. Performance evaluation of the energy sources

Energy sources	Weight of fresh fish (kg)	Weight of smoked fish (kg)	Weight loss (%)	Fuel consumed (kg)	Duration of smoking (hours)	Kg of fuel per kg fresh fish	Specific fuel consumption
Mangrove	65	28.78	55.80	13.10	7.00	0.46	0.20
Firewood	65	29.42	54.70	15.43	8.25	0.52	0.24
Charcoal	65	26.21	59.70	10.51	9.43	0.40	0.16
Briquette	65	25.54	60.70	9.69	12.22	0.38	0.15

The interpretation of this observation is that fuel used in smoking process had no effect on the texture of the smoke-dried fish. The obtained result was similar to the report of Okilya *et al.* [15] on effect of solar drying on the quality and acceptability of Jackfruit leather. Determination of cake texture was conducted by punching it with finger to feel sponginess. The texture code 1, 2, 3 and 4 were employed for pasty, slightly, spongy and very spongy respectively by Ndrika [18].

The result of comparative performance evaluation of smoked fish using briquette, mangrove wood, firewood and charcoal are given in Table 2. A total of 65kg of catfish were smoked with each of the energy source, making the total smoked fish 260kg.The time taken to smoke 65kg ranged from 7.00hrs for mangrove wood to 10.22hrs for briquette. The observed that smoking with mangrove had shortest processing time while briquette had longest processing time. Economically, it is cheaper to engage labour for 7hrs than 10.22hrs and also less stressful. The initial weight of fish for each of the energy sources was 65kg.The final weight of smoked fish varied from 25.54kg for briquette to 29.42kg for charcoal. The interpretation of this observation is that more than fifty percent weight loss was recorded. The total fuel utilized for the smoking process ranged from 9.69hrs for briquette to 15.43 for firewood. The specific fuel consumption (kg fuel per kg fresh fish) revealed mangrove wood had 0.2, firewood 0.29, charcoal 0.16 and briquette 0.15.

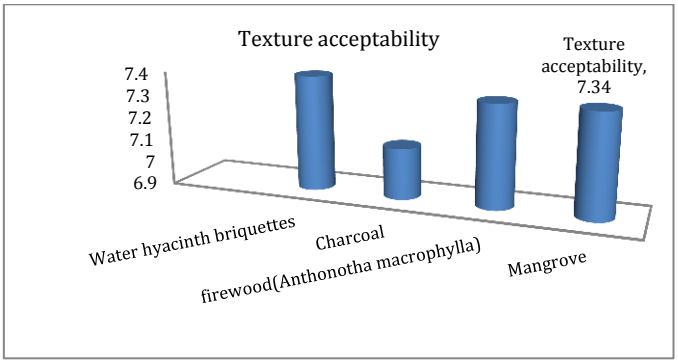

Figure 4. Texture acceptability of the smoked fish (Means of different letter are significantly different (P<0.05))

From the data, it was clear that briquette had the least specific consumption while firewood had the highest. The mean fuel charge required to smoke one kg fresh fish for briquette was 0.15kg, charcoal was 0.16kg, mangrove wood was 0.2kg and 0.24kg for firewood. The cost per kg of fuel of each of the energy sources revealed mangrove wood used for smoking varied from N45.50 per kg, firewood N41.9 per kg, charcoal N51.20 per kg and briquette N23 per kg as shown in Table 3. This showed that mangrove recorded highest price per kg while the lowest was briquette. The total cost of fuel for smoke processing for all the energy sources revealed mangrove wood was N589.50, firewood N493.76, charcoal N428.40 and N222.07 for briquette. This is an indication that had the highest total cost for fish smoking while briquette had the lowest. The energy sources used in smoking 1kg fresh fish for mangrove N9.07, firewood N9.95, charcoal N8.27 and briquette N3.42. This is an indication that use of briquettes can be as an important source of saving of fuel as compared to every other fuel sources. Water hyacinth and plantain peel attract no cost. And it is therefore an attractive and good alternative to firewood, mangrove and charcoal. The Niger Delta traditional fuels; firewood, mangrove wood and charcoal are relatively very expensive thus seeing the utilization water hyacinth briquettes as respire. Considering, the economics of briquettes making compared favourably with prices at which traditional fuels can be bought. Its environmental friendliness is an added advantage over other energy sources studied.

CONCLUSION

Water hyacinth briquettes production is feasible and its profitability is not in doubt. The combustion characteristics of the produced water hyacinth briquettes competed favourably with those of firewood, mangrove wood and charcoal hence water hyacinth briquettes can be regarded as better source of energy. The Niger Delta traditional fuels; firewood, mangrove wood and charcoal are relatively very expensive thus seeing the utilization of water hyacinth briquettes as respire. In consideration, economics of briquettes making competed favourably with prices at which the traditional fuels are sold. The produced water hyacinth briquettes are healthy, environment friendly and economical as compared to firewood, mangrove wood and charcoal.

Table 3. Economic analysis of energy sources

Energy source	Cost of fuel\kg (N)	Weight of fuel consumed (kg)	Total cost of fuel (N)
Mangrove	45.50	13.10	589.50
Firewood	41.90	15.43	493.76
Charcoal	51.20	10.51	428.40
Briquette	23.00	9.69	222.07

In the aspect performance evaluation test showed that mangrove had shortest processing time while briquettes had longest processing time. The specific fuel consumption (kg fuel per kg fresh fish) revealed firewood had the highest value. The cost per kg of fuel energy sources revealed that briquettes had the lowest cost. The least cost of energy source used in smoking 1kg fresh fish was briquette.

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