P-ISSN 2394-0522
E-ISSN 2347-2677
IJFBS 2014; 1 (6): 126-130

Received: 25-08-2014
Accepted: 11-09-2014

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The use of wood shavings as an alternative fuel wood in fish smoking

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Abstract
The study was conducted to investigate the use of wood shavings as an alternative source of energy for smoking fish. Fifteen kilograms of live mud fish, *Clarias sp.* were prepared into three equal portions of 5.0kg each and smoked between temperatures of 90-110 ^{0}C to constant weight using fuel wood and wood shavings. Analysis of the mean hedonic scores for appearance, flavor, texture, taste, and overall acceptability showed no significant difference ($P > 0.05$) among samples. Proximate analysis revealed higher crude protein value (61.25%) in wood shavings smoked fish and (53.38%) in fuel wood smoked fish. The Gross Margin analysis showed that wood shavings have the least cost combination. Since the wood shavings smoked fish is organoleptically acceptable, it is recommended that, wood shavings should be used as a source of energy for smoking fish as it is more economical to use than fuel wood.

Keywords: Fish, Fuel wood, Wood shavings, Hedonic scale, Proximate composition, Gross Margin.

1. Introduction
In Nigeria, the demand for fish is on the increase due to the health benefits of eating fish and secondly due to increase in human population, the Rinderpest disaster, and drought bane, which reduces the availability and affordability of red meat (cattle, sheep and goat). With the rising costs of these red meats and other animal protein sources, consumers have become increasingly interested in fish as a source of dietary protein (Albert, 2002) [1].
According to FAO (2003) [2], fish provides 22% of the protein intake in Sub-Saharan Africa. In Nigeria fish constitute 40% of animal protein intake (Olatunde, 1998) [3] and on a global scale; more fish is consumed on a per capital basis than other type of meat or animal protein (FAOSTAT, 2000) [4].
Smoked fish is a traditional part of the diet of a large section of the world's population. However, the gap between the demand and supply of fish is widening due to increase in population, poor post-harvest handling, lack of processing and storage facilities and utilization of unconventional fish species. For instance, the estimate fish demand in Nigeria in 1994 was put at 1,139,833 tones based on the population figure of 94,986,044 and per capital consumption of 12kg which was considered globally adequate for normal and healthy growth. However, only 280,307 tones were produced, indicating a deficit of 94,705,737 (FAO, 1999) [5].
The quality of the freshly caught fish and its usefulness for further utilization in processing is affected by the fish capture method. The Unsuitable fishing method does not only cause mechanical damage to the fish, but also create stress and the conditions which accelerate fish deterioration after death. Fish is highly susceptible to deterioration without any preservation or processing measures (Clucas and Sctcliff, 1987) [6] and (Okonta and Ekelemu, 2005) [7].
The FAO (2006) [8] estimated that in some developing countries, post-harvest losses of fish exceed those of any other commodity, often surpassing 50% of the landed catch.
Federal Department of fisheries estimated per output, consumption of fish in Nigeria to increase from 13.7 kg in 1998 to 14.49 kg in the year 2000 (FDF, 1982) [9]. The main causes of spoilage in fresh fish are Autolysis and bacterial decomposition (Eyo, 1983) [10]. At the death of fish certain endogenous biochemical changes occur which condition the fish for proliferation of the spoilage bacteria (Ikeda, 1979) [11]. A Few hours after death, stiffening of the fish muscle occurs. Whereby fish lose its flexibility through a process called Rigor Mortis (Regenstein and Regenstein, 1991) [12].

A decline in fish availability will have a detrimental effect on the nutritional status of the citizenry particularly in places where fish contribute significantly to the protein intake of the people (Eyo, 2001) [13]. The major compositions of fish tissue are water, lipids, and protein and micro nutrients. The proximate composition of fish varies within the individual fish. There are various reasons for the merits of eating fish. One of such reasons is that fish is less tough and more digestible compared to beef, mutton, chicken and bush meat. This is possible because of the greater ratio of muscle protein to connective tissue protein in fish in relation to other animals, thus making fish acceptable by infants and adult alike. Because of its greater digestibility, fish is usually recommended to patients with digestive disorders such as ulcers. Fish is a very good source of polyunsaturated fatty acids known to be beneficial in the prevention of cardio vascular diseases, breast and colon cancer, psoriasis etc. (Kaushik, 2000) [14]. The fat from fish helps the human body and therefore significantly lowers the risk of blood clots and the resultant heart attack or stroke (Anon, 2003) [15].

Apart from this, the fish is abundant and to some extent occurs free in nature. This may account for its relatively low cost compared with other meat. Fish is available in most markets, as fresh, smoked, dried, chilled or frozen and as such the problem of scarcity is removed. There is hardly any religious taboo affecting the consumption of fish unlike pork and cow meat (Eyo, 2001) [13]. The objective of this study is to investigate the use of wood shavings as an alternative source of energy for smoking fish in relation to its organoleptic characteristics, proximate composition and economic analysis.

2. Materials and Methods

2.1 Study Area

The research study took place in the faculty of Agriculture, Department of Forestry, Wildlife and Fisheries, Lafia Campus, Nasarawa State, Nigeria. The smoking Kiln used for smoking the fish samples were the modern Altona Kiln. Fuel wood was purchased in Ombi 2, Lafia, the wood shavings were purchased from the timber shed in Lafia town. The wood shavings and fuel wood were weighed and use for smoking the fish.

2.2 Fish Sample

15 kg of live fishes (*Clarias gariepinus* Burchell, 1822) were purchased from Lafia market. The fishes were killed by breaking their skulls. They were then cut open from the ventral side and all their viscera were removed skillfully. They were thoroughly rinsed in municipal pipe borne water. The fishes were divided into three portions of 5.0 kg each. One portion was used for the fuel wood another for the wood shavings and a replicate treatment. Fishes were smoked properly for thirty-six hours in temperatures of 90 – 110 ^{0}C to constant weight using fuel wood and wood shavings.

2.3 Sensory Evaluation

A total of forty taste panelists were used to access the organoleptic properties. The panelists comprising of male and female judges were selected randomly from the Faculty of Agriculture Lafia, staff and students, college of Agriculture Lafia, staff and students. Each of the samples was properly labeled and served to them on a table. Scoring was based on hedonic scale with 1-5 options on each of the parameters listed that is, Excellent 5, Good 4, Average 3, Poor 2, Bad 1). Data collected were analyzed by analysis of variance (ANOVA) (SAS, 1995) [16].

The Duncan's multiple range tests was used to compare differences among means (Gomez and Gomez, 1985) [17].

2.4 Chemical Analysis

Each of the three fishes was analyzed for proximate composition according to AOAC (2005) [18 methods. The following parameters were assessed: (a) Moisture content, (b) Crude protein, (c) Crude fiber, (d) Ash content, and (e) Fat.

2.4.1 Moisture Content

Moisture or water content of the fish samples was determined using the hot oven method. Two grams of the fish samples were transferred into labeled crucibles of known weights. The crucibles with the samples (2 g) were covered with a lid. On placing the crucibles in the oven, the lid was removed and the temperature of the oven was set at 100 ^{0}C to effect proper drying the samples were allowed to remain in the oven until it was dried to constant weight. Then the fish samples were removed and cooled in a desiccator prior to weighing.

The percentage of moisture content was calculated thus;

$$\% \text{ Moisture Content} = \frac{\text{Difference in weight before and after drying}}{\text{Weight of sample taken}} \text{ X } 100$$

2.4.2 Crude Protein

Crude protein percentage in various fish samples were determined using the Kjeldahl method. 2 g of each fish sample was weighed and put into a 150 ml Kjeldahl flask. Three grams of already mixed catalyst (Na_2SO_4: $CuSO_4$: S_2O_2) were added into the flask. 5 ml of concentrated Tetraoxosulphate (VI) acid was added. Observation after this step showed that the contents in the flask turned black. Pumice stones or granules were then added to the flask so as to prevent bumping (anti-bumping granules) then the flask was placed on the digestion rack. Digestion was carried out for 1 hour and careful observation after this showed that the mixture became clear; the anti-bumping materials were seen below the liquid. The mixtures turned completely green after about two and a half hours ($2^1/_2$ hours) but were then cooled and distillation was later carried out. The Markham apparatus for steam distillation was then set up. 5 ml of 2% boric acid solution was put into a conical flask. A pipette was used to siphon 5 ml of the digested sample into the sample receiver in the distillation apparatus. This was followed immediately by the addition of 10 ml of 40% NaOH. On covering the sample receiver; water was added to the jacket from the distillation apparatus to prevent ammonia (NH_3) from escaping.

It was observed that as the distillate dropped into the boric acid/indicator solution, it started to turn green. 50 ml of the boric acid/indicator solution and distillate in the conical flask was titrated against 0.1 M hydrochloric acid (HCl).The end point of the titration was observed when the color of the solution of boric acid/indicator/distillate turned pink as it was originally.

A blank titration was also carried out and the result was subtracted from the titer values obtained for each sample. This was followed immediately by the addition of 10 ml of 40% NaOH. On covering the sample receiver; water was added to the jacket of the distillation apparatus to prevail ammonia (NH_3) from escaping. It was observed that as the distillate dropped into the boric acid/indicator solution, it started to turn green.

50 ml of the boric acid/indicator solution and distillate in the

conical flask was filtrated against 0.1M hydrochoric acid (HCl). The acid end point of the filtration was observed when the color of the solution of boric acid/indicator/distillate turn pink as it was originally.
A blank filtration was also carried out and the result was subtracted from the titer values obtained for each sample.

$$\% \text{ Crude protein (CP)} = \frac{T \text{ X } 0.0014 \text{ X } 100 \text{ X } 250/5 \text{ X } 6.25}{\text{Weight of Sample}}$$

$$\% \text{ Crude protein (CP)} = \frac{T \text{ X } 43.75}{\text{Weight of Sample}}$$

Where,
T = Titer value of the sample – Titer value of blank
0.0014 = Relative molecular mass of Nitrogen
6.25 = Conversion factor
250/5 = Volume made.

2.4.3 Crude Fiber
The defatted samples were transferred into the 1000 ml conical flask (Air dried). This was followed by acid digestion by adding 200 ml of 0.1275 m sulfuric acid (H_2SO_4) and boiling for 30 minutes using heating apparatus and maintaining a constant volume, the flasks was swirled every few minutes to ensure that the particles of the samples on the sides of the flask were brought into the boiling medium, and thorough mixing enhanced too. The samples were allowed to stand for 1 minute after boiling for 30 minutes prior to filtration. The mixture was poured immediately into a shallow layer of hot water in the prepared funnel. The filtration was done within 10 minutes to ensure accuracy and then followed by washing with boiling water until the washing were free from acid.
Alkaline digestion was done by returning the washed residue into same conical flasks and adding 200 ml of 0.314M NaOH solution and followed by boiling for 30 minutes taking the same procedures as in acid digestion. After the procedures the residues were successfully washed with boiling water, followed by 1% hydrochloric acid, boiling water then alcohol followed by ether and lastly acetone.
The insoluble matter was then transferred into the crucibles and oven dry at 100 ^{0}C to a constant weight, and then cooled in a desiccator prior to weighing. The insoluble matters in the crucibles were ashed in a muffle furnace at 550 ^{0}C for 1 hour, cool in a desiccator and weighed again.
% crude fiber was determined using the formula:

$$\% \text{ Crude fiber} = \frac{\text{Weight of insoluble matter} - \text{Weight of ash}}{\text{Weight of Sample}} \text{ X } 100$$

2.4.4 Ash
In determining the ash content of the fish samples, the dried fish sample used for moisture content determination in the crucibles was charred on a hot plate or fume cupboard with increasing temperature. Gradually, the samples became thoroughly charred when smoke ceases. The crucibles were then placed inside the muffle furnace and ashed at 550 ^{0}C.
The crucibles were then removed from the muffle furnace and placed in a desiccator for 1 hour so as to cool down after which they were weighed. The percentage of Ash content was determined using the formula:

$$\% \text{ Ash content} = \frac{Wa}{Ws} \text{x} 100$$

Where,
Wa = Weight of ash (g)
Ws = Weight of sample (g) before ashing
Wa = Wca – Wcs
Where,
Wca = Weight of crucible and ash
Wcs = Weight of crucible and sample

2.4.5 Fat
The lipid content of each fish sample was determined using the Soxhlet extraction method. 2 g of each fish sample weighed on a filter paper and put into labeled thimbles. These thimbles were plunged with cotton wool. The thimbles were placed inside the condenser individually for extraction. After placement, a weighed flask (extraction flask) containing 150 ml of petroleum spirit (40 – 60 ^{0}C) as well as the reflux condenser (Davis double surface condenser) were connected to the extractor. The Extractor was carried out under reflux on the heating mantle for 4 hours. The thimbles were removed and most of the solvent from the flasks were distilled into the extractor recovering each fraction. After extraction, the solvent and residual water contents in the extraction flasks were evaporated by drying in the oven for 1 hour at 100 ^{0}C, after which they were removed, cooled in a desiccator and weighed.

$$\% \text{ Crude lipid} = \frac{\text{Weight of extracted oil}}{\text{Weight of Sample taken}} \text{x} 100$$

$$= \frac{Wa - Ww}{Ws} \text{ x} 100$$

Where,
W_a = Weight of sample before extraction (g)
W_w = Weight of flask without fat (g)
W_s = Weight of flask with fat (g)

2.5 Gross Margin Analysis
Gross margin analysis was used to measure the net revenue of the two treatments. According to Berman (2006)[19] Gross Margin can be expressed as:
GM = GR – TVC

Where,
GM = Gross Margin
GR = Gross revenue
TVC = Total Input Cost
Input used for the gross margin analysis was cost of fresh (*C. gariepinus)*, cost of wood shavings and fuel wood, cost of labor, cost of matches and cost of transportation.

3. Results

Table 1: Mean Hedonic Scores for the Fish Samples Smoked with fuel wood and wood shavings.

Treatment	Appearance Color	Flavor	Texture	Taste	Overall Acceptability
A. Fuel wood	4.25	3.93	4.03	4.10	4.03
B. Wood shavings Replicate 1	4.18	3.90	3.93	3.95	3.98
C. Wood shavings Replicate 2	4.38	4.00	4.00	4.15	4.08

Note; There are no significant differences among Means (P > 0.05)

Table 2: Proximate Composition of the 3 smoked fish samples

Treatment	% Moisture	% Ash	% Crude protein	% Fat	% Crude fiber
A. Fuel wood	27.90_a	4.25_a	53.38_a	17.60_a	7.00_a
B. Wood shavings Replicate 1	27.20_b	2.55_a	52.50_b	26.20_c	4.95_b
C. Wood shavings Replicate 2	19.25_a	3.60_c	61.25_a	23.00_a	8.25_c

a, b, c,: Means with same subscripts within each column have significant difference ($P < 0.05$)

Table 3: Gross Profit Margin Analysis for Fish Smoked with Fuel wood and Wood shavings

TREATMENT A				TREATMENT B			
Input	**Quantity**	**Unit Cost**	**Total (N)**	**Input**	**Quantity**	**Unit cost**	**Total (N)**
Fresh fish	5kg	500	2,500.00	Fresh fish	5kg	500	2,500
Fuel wood	25 sticks	18	450.00	Wood shaving	4 bags	50	200
Matches	1 box	5	5	Matches	1 box	5	5
Labor			100.00	Labor			150
Transport			160	Transport			100
Total Cost			N3,215.00	Total Cost			N2,955.00

Gross Revenue

1 kg = 3 pieces

1 piece = N250.00

5 kg =15 pieces = N3, 750.00

Gross Profit = Gross Revenue – Total cost

Treatment A

Gross Profit = ₦3, 750.00 - ₦3, 125.00 = ₦535.00

Treatment B

Gross Profit = N3, 750.00 - N2, 955.00 = N795.00

4. Discussion

The mean hedonic scores obtained for the appearance, flavor, texture, taste, and overall acceptability of the two different smoked fish samples were presented in Table 1. There were no significant differences ($P>0.05$) among the mean scores of the two samples. Brownish appearance was observed in the sample of fish, smoked with wood shavings. The brownish color of the firewood smoked sample had a glossy oily appearance.

Krasemann (2006) [20] reported that smoking of white fish with soft wood material added appreciable color to the smoked product. Akinneye, Amoo and Arannilewa (2007) [21] reported that smoke-dried fishes had the most attractive color as against the oven and sun dried sample. The highest mean score was 4.38 on the sample smoked with wood shavings and the lowest mean score was 3.93 on the sample smoked with fuel wood. The highest mean value of 4.03 was obtained for texture for fuel wood smoked sample, while the lowest was obtained in sample smoked with wood shavings (4.00). The range of textures in food is very great and a departure from an expected texture is a quality defect.

The color of a food often affects our perception and evaluation by other senses. Norman and Hotchkiss (1996) [22] reported that food color helps to determine quality, degree of processing or spoilage. Taste response to many organic compounds is highly specific, taste sensations and thresholds are affected by many factors, including food, temperature, overall food composition, concentrations of individual components, age, and individual variations among taste (Clifton, 1996) [23].

The sample smoked with wood shavings has higher mean scores for appearance, flavor, taste and overall acceptability except for texture were the sample smoked with fuel wood is higher. The moisture content of the sampled smoked with wood shavings is lower (19.25%) than that of fish sampled smoked with fuel wood (27.90%). According to Clifton (1996) [23], the moisture content of fresh fishes ranges from 50% to 70%. He reported that the rate at which moisture can be removed from the surface of a solid phase is a function of water vapor pressure and of the drying temperature which was reflected in the smoke temperature. Eyo (1997) [24] equally reported that burning reduces moisture content by up to 15.56%, whereas smoking reduces it up to 35.03%.

The value of protein content for sample smoked with wood shavings was relatively higher (61.25%) then the sample smoked with fuel wood. This may be due to the intensity of the heat generated by the Kiln which led to protein denaturation (Akinneye *et al.*, 2007) [21] as heat generated by the wood shavings was observed to have been relatively lower than the firewood and also the reduction in moisture content increased the crude protein content of wood shavings smoked fish than fuel wood smoked fish. The significant increase in protein level in dried catfish, when compared with the raw fish, suggests that protein nitrogen was not lost during drying. This is in accordance with the findings of Puwastien, Judprasong, Kethwan, Vasanachitt, Nakngamonong and Bhattacharjee (1999) [25] and Gokoglu, Yerlikaya and Cengiz (2004) [26].

A similar trend was observed in values for percentage Ash and lipid content of this same treatment. The opinion of Eyo (2001) [13] seems to be applicable in the case of sample smoked with wood shavings and fuel wood. As the heat intensity had a relationship with moisture content and a direct relationship with crude protein content.

Crude fibre percentage was higher (8.25%) in sample smoked with wood shavings than the sample smoked with fuel wood (7.00%). Generally, according to Mauron (1970) [27], a number of chemical reactions may take place during heat treatment, including decomposition, dehydration of serine and threonine, loss of sulphur from cysteine, oxidation of cysteine and methionine, cyclization of glutamic acid and aspartic acids and threonine. However, since highest values of crude protein were obtained in sample smoked with wood shavings, consumption of sample smoked with wood shavings by human beings of all age groups may help to increase their protein intake.

The gross margin analysis of the sample smoked with fuel wood and sample smoked with wood shavings are represented in Table 3. It shows that the total cost of sample smoked with fuel wood has the higher cost (N3, 215.00) than the sample smoked with wood shavings (N2, 955.00) and their gross revenue is N3, 750.00. Giving an increase rate in the net revenue of sample smoked with wood shavings (N795.00) to the sample smoked with fuel wood (N535.00).

5. Conclusion

The results have shown that wood shavings is a good smoking material and that its utilization will help in prolonging the shelf of smoked fish and reduces the cost of producing smoked fish. Based on the findings, wood shavings are the best method because it elevates the protein contents of the fish, reduces the moisture content that could result to spoilage and also provides a better taste and appealing color. There is profit in the production of smoked fish with the wood shavings source than the fuel wood source.

6. Acknowledgement

We thank Dr. V.O. Ayuba for her advisory and supportive role in the course of this research and towards the proximate composition and statistical data analysis of samples.

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