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Analysis of technical efficiency of three fish processing methods and proximate assay on *Ilisha Africana* (Bloch, 1795)

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Abstract
The effect of processing fish (*Ilisha Africana*) using different kilns (firewood, charcoal and natural gas) on the proximate composition was investigated. The objective of the work was to estimate the technical efficiency of the different processing methods in enhancing the shelf life of fish and the best method which would improve the nutritive value and be acceptable in terms of organoleptic characteristics. Smoking process was carried out simultaneously for equal duration of time (5½Hrs) at an average temperature of 107.02^{0}C (Firewood), 148.66^{0}C (Charcoal) and 107.60^{0}C (Natural gas) respectively. The result of the proximate composition of the fish showed that fish processed using firewood, had the highest percentage of crude protein (47.37%) and Ash content (7.55%). The result of the organoleptic characteristics showed that charcoal processed fish, had the highest values in all parameters tested, In this regard, charcoal processing was adjudged to be a better means of processing *Ilisha Africana*.

Keywords:fish processing, technical efficiency, *ilisha africana*, proximate composition, organoleptic characteristics

1. Introduction

Fish are an important food resource for human, particularly valued for its high protein content, which is of high quality compared to those of plants and other animal source. The fast growth rate of aquaculture has made fisheries commonplace in the hinterlands and this has brought simple fish processing technique like smoking-drying to the hands of those who ordinarily wouldn't have engaged in it.[1]noted that a significant quantity of fish is lost as a result of the absence of adequate technology to prevent post-harvest losses. Fish spoilage could be due to poor handling, preservation and processing practices adopted by the artisanal fishermen, fish farmers and fish entrepreneurs. If fish is not sold life, preservation and processing becomes inevitable in order to extend its utility and shelf life.

Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries [2]. Thus, it is imperative to process and preserve some of the fish caught in the period of abundance, so as to ensure an all year round supply. This will invariably reduce post-harvest losses, increase the shelf-life of fish, and guarantee a sustainable supply of fish during off season with concomitant increase in the profit of the fishermen [3].

According to [4], the most important resource drawn from Cameroonian extensive mangrove forests ecosystem is wood, used for fish smoking, and the magnitude of mangrove wood exploitation has been identified both locally and regionally as a major threat to this ecotone. In Cameroon 90.7% of total fish landings are preserved through smoking process and the job is exclusively done by women and children or paid assistants, using preferred mangrove wood. This smoking system exposes the women and children to heat and smoke fumes, hence causing a series of health problems among women and children, mainly respiratory ailments, anemia, and stillbirths [4]. Acording to [5] indoor air pollution from biomass fuels combustion predominantly affects poor rural and urban communities in the developing countries who are at the lowest end of the energy ladder. The reliance on biomass fuel has emerged as one of the most important threats to public health. In 2000, indoor air pollution was responsible for more than 1.5 million deaths and 2.7% of the global burden of disease. In developing countries, it accounted for 3.7% of the burden of disease, making it the most important risk factor after malnutrition, the human immunodeficiency virus infection and lack of safe water [6]. Fish smoking combines the effects of drying, heating, and smoking; coupled sometimes with salting. The pre-treatment involves gutting, splitting, kench salting, brining, and/or drying depending on the smoking method. Smoke from the burning of biomass fuels has been shown to be a major risk factor for several respiratory ailments, such as asthma, chronic obstructive pulmonary disease (COPD), respiratory tract infections especially in children and the elderly, and lung cancer [7]. An estimated 50% of the world′s population (i.e. around 3 billion people) uses biomass fuel for cooking and heating purposes. Burning of biomass fuel produces more than 200 different chemical compounds, over 90% of which are in the inhalable size range. These include gaseous air pollutants such as carbon monoxide, sulphur dioxide, nitrogen dioxide, and particulate matter air pollutants such as those less than 2.5 microns (PM2.5) and those less than 10 microns (PM10) in aerodynamic diameter, polyaromatic hydrocarbons, chlorinated dioxins, arsenic, lead, fluorine, and vanadium; all of which are toxic to the human body [8].

But the most prominent fish preservation in Ebonyi State is smoke drying. This could be adduced to the fact that most of the fish communities have no access to electricity to freeze their products. Electricity itself is fast becoming a less reliable source of energy for fish processing and preservation [9]. This calls for assessment and upgrading of the traditional fish processing technologies with a view to developing a more environmental friendly, cost effective, less prone to health risks, better organoleptic properties and longer shelf life of processed fish.

2. Materials and Methods

2.1 Study Area

The experiment was carried out at the Department of Fisheries and Aquaculture, Ebonyi State University, Abakaliki situated between 06^0 19.370' North Latitudes and 008^{0}07.692' East longitudes. A total of 64 frozen *Ilishaafricana*within the ranges of50 to 55g and 35-40cm in terms of weight and total length were purchased from a cool room in Abakaliki, Ebonyi State and brought to the Fish Processing Unit of the Department of Fisheries and Aquaculture, Ebonyi State University Abakaliki where the research was carried out. The frozen fish samples were thawed and eviscerated via ventral incision to remove the visceral organs. Fish were washed thoroughly, curled into a shoe horse shape then weighed. Fish were randomly assigned to the three different fish processing methods as treatments and a control. Each treatment had 16 fish. Fish were arranged on the trays of the three processing kilns which were preheated before the fish were loaded.

2.2 Description of the Kilns

The two traditional kilns that use firewood and charcoal are made from an old circular drum of 75cm and 70 cm as diameter and height respectively. The tray is about 50 cm away from the bottom or fireplace, while it is 5cm away from the tip of the drum, the thickness of the drum metal is 2.5mm and the wall is a galvanized iron sheet lagged with 2cm clay. It has a unit compartment for heating up – with the burner placed underneath a metal pan of 5mm in diameter for distribution of heat, a drying chamber with three steps of trays, underneath the trays is an oil collection pan that is meant for collection of oil drips from fish, the kiln also has a chimney for the removal of vapour from the fish during processing.

The fish were smoked and allowed to cool and weighed at the end of the smoking, the fish from different kilns were tagged SFg, SFw, SFc for samples from Improved kilns with natural gas, kiln with firewood and charcoal respectively, while the control is a fresh fish sample from the same batch bought from the market. The duration and the processing temperature were equally recorded with a digital thermometer at the intervals of 10min between checks. Weight difference was determined with a weighing balance (s. mettler, china) prior to smoking and after smoking to determine the weight loss and percentage weight loss. The impact of the various methods of processing was examined by monitoring the level of smokes that were released into the atmosphere during the processing operations of the various methods and also by conducting a deductive inference on numberof trees felled in order to obtain a given Quantity of firewood and charcoal.

2.3 Proximate analysis

The method of [10] was used to determine the proximate composition of fish samples. This method was based on drying a sample in an oven and moisture content was determined by the weight difference between dry and wet material. Crude Protein was determined following the Kjeldahl's method, which evaluates the total nitrogen content of the sample after it has been digested in sulphuric acid with a mercury or selenium catalyst. Ether extract (Fat) determination method was used to determine the crude fat content of the fish. Ash content was also determined. The total carbohydrate content was determined by subtracting the sum of the percentage moisture, ash, crude protein from 100%, i.e. Carbohydrate = 100 - (% moisture + % ash + % crude protein).

2.4 Organoleptic Characteristics Method

After the smoking operation, subjective analysis was used for organoleptic characteristics analysis, in which staff and students were used to carry out the tests. Twenty members of the panel were selected for each parameter like flavour, texture, appearance and palatability trained on the rudimentary aspects of organoleptic characteristics and how to apportion mark to each parameter. Fish products samples were issued out in conjunction with questionnaires. The fish samples were given out with questionnaires for the panel members to feel and taste the fish products and scored based on how it appealed to the taste, texture, palatability and odour. The questionnaires were returned and marks were appropriately apportioned to each parameter. The organoleptic values generated are from the 9-point Hedonic scale of 20 men/women panel response to each attribute. The Hedonic scales are: 1=Dislike extremely; 2=Dislike very much; 3=Dislike moderately; 4=Dislike slightly; 5=Neither like nor dislike; 6=Like slightly; 7=Like moderately; 8=Like very much; 9=Like extremely.

2.5 Statistical Analysis

Results were expressed as mean values ± standard deviation (SD). Data were analyzed using statistical package (IBM SPSS version 20). The data were subjected to one way ANOVA and means were separated by Duncan's multiple range tests. Significant difference was declared at 5%.

3. Results

3.1 Percentage Weight Loss and Fuel Consumption for Processing *Ilisha Africana*

Table 1 contains the estimates of percentage weight loss of *Ilisha Africana* after smoking with gas, firewood and charcoal to be 50.11% (gas), 55.50% (firewood) and 58.92% (charcoal). The fuel consumption in kilogrammes per processing method was 1.9kg (gas), 20.1kg (firewood) and 19.85kg (charcoal). In Table 2, the smoking process was carried out simultaneously for equal duration of time (5½Hrs) at an average temperature of 107.02^{0}C (Firewood), 148.66^{0}C (Charcoal) and 107.60^{0}C (Natural gas) respectively. The kilogramme value of fuel exhausted during the smoking process, showed that firewood as fuel source had the highest (6.179kg o) consumption rate. This was closely followed by charcoal (5.765kg) and finally gas with 0.713kg. (Table 1).

Table 1: Percentage Weight Loss and Fuel Consumption for Processing *Ilisha africana*

ProcessingMethod	Total weight (Kg)	Mean weight(Kg)	Weight Loss (%)	Fuel used(Kg)	QTY of fuel per kg of smoked fish
Gas				1.9	
FRESH	5.312	0.265			
SMOKED	2.650	0.132	50.11		0.713
Firewood				20.1	
FRESH	5.843	0.265			
SMOKED	2.600	0.118	55.50		6.197
Charcoal				19.85	
FRESH	5.843	0.265			
SMOKED	2.400	0.109	58.92		5.765

Table 2: Technical Performance Processed Fish Using Firewood, Charcoal and Natural Gas

Treatment	Weight of fish before smoking(kg)	Weight of fish after smoking(kg)	%weight loss	Weight of fuel used(kg)	Processing duration (hours)	Processing temperature (Range)	Processing temperature (Average)
Firewood	5.8432	2.600	55.50	20.1	5.30	83.5^0C – 151.7^0C	107.02^0C
Charcoal	5.8432	2.400	58.92	19.85	5.30	98.2^0C – 259.1^0C	148.66^0C
Natural Gas	5.312	2.650	50.11	1.9	5.30	70.0^0C – 142.9^0C	107.60^0C

3.2 Proximate composition of *Ilisha Africana* processed using three different processing methods

The mean proximate composition of *Ilisha africana* are given in Table 3.The percentage moisture of the control fish (73.66%) was significantly ($p \leq 0.05$) higher than the treated group. The percentage moisture of the charcoal processed fish was the least (25.86%). The percentage Ash of control fish (3.06%) was significantly ($P \leq 0.05$) lower than the processed group. There was no significant difference between the charcoal and firewood processed fish. Similarly the percentage fat/lipid of control fish (0.05%) was significantly ($P \leq 0.05$) lower than that of the processed group. There was significant ($P \leq 0.05$) difference between percentage fat of charcoal processed fish (9.60%) and firewood processed fish (5.33%). The percentage crude protein of control fish (20.77%) was also significantly ($P \leq 0.05$) lower than the processed group with gas (35.63%), firewood (97.30%) and charcoal (45.76%). Among the treated group, gas processed fish had the lowest percentage crude protein, followed by charcoal processed fish. The percentage carbohydrate of the processed fish by natural gas, firewood and charcoal was significantly ($P \leq 0.05$) higher than the control fish. Charcoal processed fish had the highest percentage carbohydrate (7.99%) and it differed significantly ($P \leq 0.05$) from gas and firewood processed values.

Table 3: Proximate Composition of *Ilisha africana*

ProcessingMethod	Moisture (%)	Ash (%)	Fat (%)	Crude protein (%)	Carbohydrate (%)
FRESH SAMPLE	$73.66^a \pm 1.17$	$3.06^c \pm 0.40$	$0.50^c \pm 0.26$	$20.77^d \pm 0.35$	$2.06^c \pm 0.23$
GAS	$45.06^b \pm 0.61$	$4.77^b \pm 0.19$	$10.06^a \pm 0.15$	$35.63^c \pm 0.36$	$4.48^b \pm 0.34$
FIREWOOD	$36.60^c \pm 2.11$	$7.55^a \pm 0.19$	$5.33^b \pm 0.15$	$47.30^a \pm 0.52$	$4.73^b \pm 0.14$
CHARCOAL	$25.86^d \pm 1.81$	$7.17^a \pm 0.16$	$9.60^a \pm 0.80$	$45.76^b \pm 0.69$	$7.99^a \pm 0.44$

Means with the same superscript along columns are not significantly different ($p < 0.05$) (Mean values $\pm$SD) n=3

3.3 Organoleptic Properties

Organoleptic properties of natural gas, firewood and charcoal processed *Ilisha Africana* are shown in Table 4. The overall performance showed that for flavour, the highest value recorded was 7.90 in charcoal processed *Ilisha Africana*. This was followed by firewood (7.050) and the least was natural gas (6.050). The charcoal value was significantly ($p \leq 0.05$) higher than gas and firewood. Charcoal processed *Ilisha Africana* had 7.40 in appearance parameter, which is the highest value. This was followed by firewood (7.25) and gas (6.05) processed fish. The palatability parameter showed that charcoal processed *Ilisha Africana* had the highest value of 7.85, which was significantly ($p \leq 0.05$) higher than gas processed value. This was followed by firewood (6.70) and gas (6.05) processed fish respectively. The texture of charcoal processed *Ilisha Africana* had the highest value of 7.55. This differed significantly ($p \leq 0.05$) only from gas (6.15) processed fish. The general acceptability parameter showed that charcoal processed *Ilisha Africana* had the highest value (8.25±0.96) which was significantly higher than the value recorded under firewood (7.25±1.12) and gas (6.15±1.66) processed fish.

Table 4: Organoleptic Properties of *Ilisha africana*

ProcessingMethod	Flavour	Colour	Taste	Texture	GeneralAcceptability
GAS	$6.050^c \pm 1.66$	$6.050^b \pm 1.63$	$6.050^b \pm 1.79$	$6.15^b \pm 1.95$.	$6.15^c \pm 1.66$
FIREWOOD	$7.050^b \pm 0.94$	$7.250^a \pm 1.20$	$6.700^b \pm 1.30$	$6.60^{ab} \pm 1.53$	$7.25^b \pm 1.12$
CHARCOAL	$7.900^a \pm 1.02$	$7.400^a \pm 1.66$	$7.850^a \pm 1.38$	$7.55^a \pm 1.70$	$8.25^a \pm 0.96$

Means with the same superscript along columns are not significantly different ($p \leq 0.05$)

4. Discussion

The result of the total Wight of fish before (62.7, 25.45 and 9.85kg) and after smoking with different fuel source (42.1, 5.6 and 7.95kg), the quantity of different fuel source (20.1, 19.85 and 1.9kg) used and their cost in (N) (480.86, 779.96 and 475) for firewood, charcoal and gas respectively. 20.1kg of firewood and 19.85kg of charcoal were spent to smoke 11.16kg of fish in the traditional kilns [11].Reported that 61% of about 194,000 metric ton of dried fish in Nigeria was smoked annually. In fact an estimate of more than 400,000 metric ton of firewood and charcoal are required to maintain the present trend of smoked fish consumption of Nigeria. These indicate the level of harm that smoking fish with firewood and charcoal could unleash to the Nigerian environment. During the smoking process with firewood and charcoal, a lot of discomforting and chocking smoke was generated. This also has adverse health implications. The natural gas is smokeless and no tree need be felled for its use [4]. Reported that smoking system exposes the women and children to heat and smoke fumes, hence causing a series of health problems among women and children, mainly respiratory ailments, anemia, and stillbirths. Massive forest destruction has been documented in areas such as Virunga National Park in the Democratic Republic of Congo, where it is considered a primary threat to the survival of the mountain gorillas [12].

The effects of fish processing methods on proximate composition of *Ilisha africana* are presented in table 3. Fresh red fish recorded the highest moisture content of 73.66% this was in the range given by [13] who peg fish to be made up of 70-84 percent water. The other parameters viz crude protein, ash, fat and carbohydrate are lower in the fresh sample when compared with the processed ones. This observation is in line with the report of [14] that smoking resulted in the concentration of nutrients due to low residual moisture level. Among the three samples processed in the different media, the moisture level of the sample processed in the Gas is significantly higher (45.07%) than those of firewood (36.60%) and charcoal which is significantly the lowest among the three. This observation was made even though the processing times are equal among the processing media, however, the quantity in weight of the different fuels are not the same. The natural gas was the least in weight (1.9kg) with an average processing temperature of 107.6^0C while that of charcoal was 19.8kg with average processing temperature of 148.66^0C. This could explain the rationale between the disparities in the moisture levels of the processing media especially that of the Natural Gas media, the report of fresh fish having the lowest ash and crude fibre content is in agreement with [15] and [16].

The percentage crude protein of control fish (20.77%) was also significantly ($P\leq0.05$) lower than the processed group with gas (35.63%), firewood (47.30%) and charcoal (45.76%). The firewood sample being the greatest (47.30%) followed by the charcoal sample (45.76%), these recorded highest crude protein content of the smoked fish in this experiment, was in accordance with the findings of [17] and [16]. The significant increase in protein levels ($P\leq0.05$) in smoked *Ilishaafricana*, when compared with the raw fish, suggests that protein nitrogen was not lost during smoking and thus increase in crude protein level can best be explained thus, smoking resulted in concentrating crude protein components of *Ilishaafricana* [16]. And this concentration effect is basically as a result of loss of moisture by the smoked fish as opined by [18] that, the percentage of total protein, lipidand ash contents of smoked garfish increased due to water loss during smoking.

The initial value of ash was 3.06%. The results generally showed an increase in the ash content of the smoked *Ilisha Africana*.This result is in agreement with earlier studies by [19] which stated that the ash content of fresh *Clarias gariepinus* increased from 1.79% (fresh) to 4.85% (solar dried) and 3.08% (electric oven dried).

A good source of instant energy that comes to the mind is the carbohydrates. It also helps in the body development and growth. The percentage carbohydrate of the processed fish by natural gas, firewood and charcoal was significantly ($P\leq0.05$) higher than the control fish which was 2.06%. The carbohydrates content in the fish is small and practically considered zero [20]. This coincides with the result obtained in this work indicating that the fish processed contained low values of carbohydrates. The relatively low values of carbohydrates could be due to higher values of moisture and relatively high value of protein contents.

The percentage fat/lipid of control fish (0.05%) was significantly ($P\leq0.05$) lower than that of the processed group. The fat content of smoked *Ilisha africana* was (9.60± 0.80%, Charcoal), (5.33±0.15%, Firewood) and Gas (10.06±0.15%) [21].Reported the fat content of smoked samples of *S. galilaeus* and *O. niloticus*, are 10.44±0.16% and 10.21±0.31 % respectively. Ikeme and [22] opined that the distribution of fat on the surface of the fish is known to change during the smoking process and with a possible modification of smoke absorption.

The organoleptic properties of the fish species were determined using questionnaires. Many of the important compounds present in smoke from hardwood lead to production of flavor, colour, antioxidative, bacteriostactic and bactericidal compounds. The smoking process for *Ilisha Africana* was carried out simultaneously for equal duration of time (5½Hrs) at an average temperature of 107.02^0C (Firewood), 148.66^0C (Charcoal) and 107.60^0C (Natural gas) respectively. The general acceptability of the fish were high, this is because the temperature used in smoking were not excessively high and was constantly controlled. This made most of the nutritive and physical qualities to be retained at the end of smoking, giving rise to products that were very delicious and attractive. This study clearly indicated that the proximate values obtained could be of help in choosing fish based on nutritional values.

5 Conclusion

Natural gas processing unit is more economical in fuel consumption and causes less havoc to the environment, as no tree were felled for this operation as evident from the operational cost alone rather than the capital cost of acquiring the materials. However, fish processed with fire wood had the best carcass quality in term of crude protein and ash content, followed by charcoal treatment. The quality of output of the natural gas treatment was less, when compared with that of charcoal and firewood energy source.

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