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# Chemical Analysis of Nutritional Composition of Mudskipper, *Papyrocranus papillio* (Gunther) and Silver Catfish, *Chrysichthys nigrodigitatus* (Lacepede) smoked with Red Mangrove in Akwa Ibom State, Nigeria

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**ABSTRACT**

Chemical analysis of proximate composition of mudskipper, *Papyrocranus papillio* and silvercatfish, *Chrysichthys nigrodigitatus* smoked with red mangrove (*Rhizophora racemosa*) was carried out with standard analytical procedures. Mudskipper smoked with red mangrove recorded moisture content of 0.00±0.00%, ash (22.46±0.40%), crude fibre (13.72±0.03%), crude protein (58.35±0.17%), crude fat (4.17±0.06%), carbohydrates (1.29±0.31%) and caloric value (276.07±1.60kcal). The fresh form had moisture content of 79.99±0.28%, ash (18.23±0.1%), crude fibre (12.12±0.05%), crude protein (52.87±0.6%), crude fat (9.69±0.13%), carbohydrates (7.09±0.21%) and caloric value (327.02±0.40%). Silver catfish smoked with red mangrove had for moisture (1.08±0.06%), ash (9.40±0.025%), crude fibre (6.27±0.02%), crude protein (56.06±0.45%) and crude fat (8.25±0.048%). Carbohydrate and caloric value were 10.63±0.28% and 355.94±0.0406 kcal respectively. The fresh sample recorded for moisture (67.41±0.0025%), ash (8.84±0.025%), crude fibre (5.89±0.02%), crude protein (54.25±0.35%), crude fat (16.63±0.045%); while carbohydrate was 14.39±0.35% and caloric value (424.26±0.05 kcal). The smoked samples of mudskipper and sliver catfish were nutritionally richer in protein, fibre and ash contents than the fresh samples. Increase in the proximates could be attributed to the smoking process and the quality of phenolic compounds released from the burnt (mangrove) wood.

**Keywords:** Nutritional Composition, Mudskipper, Silver Catfish, Red Mangrove, Smoking.

## INTRODUCTION

Fish is a very important source of animal protein in the diet of man and constitute about 60% of the total protein intake of adult in the riverine areas (Adeleye, 1993; Anibeze, 1995). Though Nigeria is a fish-eating nation, the per capita consumption of 11kg is significantly lower than the 21kg global average of the United Nations recommendations. Fish production in Nigeria with 37 rivers and 175 lakes and reservoirs; besides the oceanic coastal offshore fisheries come from three sources: artisanal (inland waters, lakes, coastal and brackish waters), aquaculture (fish farm) and industrial fishing such as oceanic/high sea fisheries (Otubusin, 2011). The 2016 total fish demand based on the 2014 Nigerian Population estimate of 180 million is 3.32 million metric tonnes, but total domestic fish production from the three fishery subsectors stands at 1,123 million metric tonnes; contributing only 0.48% GDP of the 20.2% (GDP) whole contribution from Agriculture (NFS, 2016). Out of this figure, the artisanal fishery which supplies the bulk of fish in the Nigerian markets today produces over 500,000 metric tonnes; or about 85% of the total fish production (Chilaka *et al*., 2014).

Post harvest losses through fish spoilage are greatest in artisanal fishery which operates mostly in the farflung fishery settlements with no access to electric power supply, cold room facility, ice making plants, landing jetties and insufficient power-driven fishery crafts to bring aquatic outputs to the shores. Besides, the fishery is labour intensive, no capital outlay and operates with hand-driven dugout canoes. Thus, the post-harvest losses associated with artisanal fishery during bumber catch; between fishing time, landing and processing time, are enormous. These accrue from poor handling methods, lack of processing facilities, physiological and microbial deterioration, oxidative and autolytic decomposition; including insect infestation and storage loss which are all estimated at over 30% of the total catch. This economic loss emphasizes the need for preservation to curtail fish deterioration and spoilage.

Fish is a highly perishable commodity especially in the fresh form; and therefore require certain forms of preservation to prolong the shelf-life. Fish is most susceptible to decomposition of taste, odour and

microbial attack. Preservation of foods and other perishable products like fish generally involve processes that impede growth of microorganisms either by addition of growth inhibiting ingredient or adjusting the storage condition by freezing and preservation. Common processing and preservation techniques currently utilized; involve salting, drying and smoking (Schafer, 1990; Arason *et al*., 2014). Smoking alone preserves fish effectively (Ikeme, 1990); and has the advantage of increasing the shelf-life of fish since water that creates favourable conditions for mould or bacterial growth is drastically reduced. The colour, flavor and aroma or odour of the smoked products are also enhanced.

Hot smoking and drying accounts for over 45% of total preservation methods available for rural fisheries in Nigeria (Tobor, 1995). While the acceptability of smoked fish depends on different types of firewood used (Olokor *et al*., 2007), the fuel wood preferences of most fish smokers relate with the physical characteristics of the wood and how they affect the smoked products (Lartey *et al*., 1994). Different fuel wood affects the quality of smoked fish differently. The organic constituents of wood mainly include; cellulose and lignin and when the wood is burnt, the chemical compounds are broken down into many smaller compounds as a result of incomplete combustion (FAO, 1981; Storey, 1982; Wheaton and Lawson, 1985). Hardwood is mostly preferred in fish smoking because it has higher hemicellulose content compared to softwood.

Water is the main component of the proximates and can form as much as 70% content. It is an index to measure perishability and the keeping quality of any food item. Higher moisture content indicates that the food item cannot keep long in the fresh form without deteriorating in value and spoiling. The mudskipper, *Papyrocranus papillio* belongs to the family, Gobiidae (Murdy, 1989). They are completely amphibious and use their pectoral fins to walk on land. They are usually adapted to intertidal habitat and are quite active when out of water for feeding and interacting with one another to defend their territories (Graham, 1997; Swanson and Gibb, 2004; Harris, 1960).

Mudskipper constitutes a vital source of food for many people especially the low income earners in the fishing communities. They are delicacies in certain parts of Nigeria especially the riverine areas and are largely involved in cooking stews, soups and are fried with fish specialities. The fresh mudskipper is often used as a side dish (appetizer) with cereal-base recipes in many parts of the country. In Nigeria, mudskipper is consumed fresh, smoked/roasted, and can be salted or dried. It is sold fresh or smoked but the smoked form is the most popular product in West Africa and particularly, Nigeria.

Silver catfish, *Chrysichthys nigrodigitatus* belongs to the family, Bagridae. They are mostly bottom feeders and remain negatively buoyant in water due to possession of a gas bladder. They are identified with a heavy bony head, four pairs of barbels, naked and silvery body, adipose fin lobe and a dorsal fin supported by a spine. They are commercial food fish of worldwide acceptance with whitish meaty flesh that is highly cherished by humans.

With the yearly increase in fish production, evidenced with huge catch landings at the Nigerian coastal beaches/landing sites, post-harvest losses are on the increase due to inadequate fish processing and preservation methods. Fish processing using traditional methods within the fishing communities is slow and labour intensive. This makes it impossible to process all the excess fish caught in times of abundance. It has therefore become increasingly important to ensure that fish caught is fully and efficiently utilized to avoid deterioration and spoilage. This work examines the use of red mangrove, *Rhizophora racemosa* in smoking mudskipper and silver catfish; in order to assess/establish the nutritional status and physical characteristics of the fish types.

## METHODOLOGY

Samples of fresh mudskipper and silver catfish were collected from the brackish water environment of Ebughu in Mbo Local Government Area of Akwa Ibom State. The fresh specimens of the fish types were washed with clean tap water to remove debris and each divided into two groups. While one group of a fish type was taken for moisture content analysis in the laboratory and oven-dried to a constant weight between 50 – $60^0$C, the remaining group was placed on fish rags and

smoked with red mangrove (firewood) in the traditional smoking kilns. Samples of the fresh and smoked fish types were ground separately into power, sieved and stored at low temperature in dry air-tight containers for subsequent analysis.

**PROXIMATE ANALYSIS**

The proximate composition of moisture, ash, crude fibre, crude fat and crude protein were determined using the standard procedures of AOAC (2004), Secret (1975), Pearson (1976) and Onunwaka (2005). Moisture content was determined by weighing 5.0g of each sample and oven-dried at $105^0$C to a constant weight. The loss in weight of the samples was calculated as moisture content. Ash content was determined by incineration of 5.0g of each powdered sample in a muffle furnace at $550^0$C. Crude fat was obtained by the soxhlet extraction method while crude protein was determined using the micro jeldhal method. Crude fibre was determined using the acid and alkaline digestion method (AOAC, 2004). Carbohydrate was estimated as the difference obtained after subtracting total organic nitrogen (protein), fat, ash and fibre from the total dry matter. Caloric value was obtained by multiplying the value of crude protein, crude fat and carbohydrate by 4, 9, 4 kcal respectively and taking the sum of the products which was expressed in kilocalories per 100g (kcal/100g).

**RESULTS**

The results of chemical analysis of nutritional composition of mudskipper and silver catfish in the fresh and smoked with red mangrove are presented in table 1 below:

The fresh samples of mudskipper recorded moisture content of 79.00±0.28%, followed by crude protein (52.87±0.06%), ash (18.23±01.0%), crude fibre (12.12±0.03%), crude fat (9.69±0.13%) and carbohydrates (7.09±0.21%). Caloric value was 327.02±0.40kcal. The smoked mudskipper revealed a moisture content of 0.00±0.00% while crude protein was 58.35±0.17% followed in descending order by ash (22.46±0.40%), crude fibre (13.73±0.03%)_, crude fat (4.17±0.06%) and carbohydrate (1.29±0.31%). Caloric value recorded 2.76.07±1.60kcal.

The fresh sample of silver catfish revealed a moisture content of

67.41±0.025%, crude protein (54.25±0.35%), crude fat (16.63±0.045%), carbohydrates (14.39±0.35%), ash (8.84±0.025%) and crude fibre (5.89±0.02%); while caloric value was 424.26±0.05kcal. The smoked silver catfish had a moisture content of 1.08±0.06%, crude protein (56.06±0.45), carbohydrate (10.63±0.28%), crude fat (8.25±0.048%), ash (9.40±0.25%) and crude fibre (5.27±0.02%). caloric value was 355.94±0.0406kcal.

There was increase in crude protein, ash and crude fibre contents in both smoked fish types, indicating a higher nutritive profile over the fresh samples. However, the general decrease in moisture content, crude fat and carbohydrates in the smoked mudskipper and silver catfish indicate dehydration and decomposition of fat and carbohydrate by the smoking process, to prolong the shelf-life of the food fish for future consumption.

**Table 1: Proximate Composition of Fresh and Smoked Mudskipper and Silver Catfish; using Red Mangrove, at Ebughu Fishing Community in Mbo L.G.A**

| Parameters | Mudskipper | | Silver catfish | |
|---|---|---|---|---|
| | Fresh (%) | Smoked (%) | Fresh (%) | Smoked (%) |
| Moisture | 79.99±0.28 | 0.00±0.00 | 67.41±0.025 | 1.08±0.06 |
| Ash | 18.23±0.10 | 22.46±0.40 | 8.84±0.025 | 9.40±0.25 |
| Crude fibre | 12.12±0.03 | 13.73±0.03 | 5.89±0.02 | 6.27±0.02 |
| Crude protein | 52.87±0.06 | 58.35±0.17 | 54.25±0.35 | 56.06±0.45 |
| Crude fat | 9.69±0.13 | 4.17±0.06 | 16.63±0.045 | 8.25±0.048 |
| Carbohydrate | 7.09±0.21 | 1.29±0.31 | 14.39±0.35 | 10.63±0.28 |
| Caloric value | 327.02±0.40 (kcal) | 276.07±1.60 (kcal) | 424.26±0.05 (kcal) | 355.94±0.0406 (kcal) |

Means values are triplicate determinations ± SD

## DISCUSSION

Fish is a good source of high quality protein, minerals, fat-soluble vitamins (A, D. E. K) and essential fatty acids, all of which are vital for the healthy functioning of the

human body. Smoked fish is a good source of lean fat, minerals, high quality protein, and forms an important diet especially for people that use their muscle mass for regular and intensive exercise programme. Fish muscles contain 20% protein content (Nelson, 2006). Fish has high biological value in providing higher protein assimilation and retention in the body compared to other animal protein sources like goat, chicken, beef and pork. The low cholesterol content is one of the safest sources of animal fat. The polyunsaturated fatty acids, particularly Omega-3-fatty acids play important roles in improving cardiovascular health.

Little is known about the nutritional value of mudskipper and silver catfish inhabiting Ebughu brackish water creeks and smoked with red mangrove; especially with locally constructed fish smoking kiln/oven. Smoking had been an age long traditional practice of preserving food fish by fish mammies in West Africa, for future use. The smoked samples of mudskipper and silver catfish showed a defined decreasing order on the proximate profile in moisture, crude fat and carbohydrate contents; and an increase in crude protein, crude fibre and ash contents; indicating a higher nutritive profile over the fresh samples. These findings agree with the works of Oladimegi and Sadiku (1991), Teeny *et al*., (1984); Olayemi *et al*., (2011); Essien *et al*., (2016).

Increase or decrease in proximate of the fresh and smoked samples (table 1) is largely associated with the smoking process, which involves flavouring, cooking and preserving the fish flesh to have a longer shelf-life by exposing the food item (fish) to smoke and heat from the burnt mangrove wood. The use of red mangrove as a hardwood and source of burnt fuel is in line with the catalogue of common fuel wood materials used for smoking in West African fishing communities (FAO-CDR, 1993; Edet, 2016). The fuel wood contains phenolic compounds released in the smoke and which act both as antioxidants that slow down rancidity of animals fats and as antimicrobials that lower bacterial growth. Antimicrobials in wood smoke include; formaldehyde, acetic acid and other organics which give wood smoke a low pH of about 2.5, a brownish colouration of fish skin, good flavor (taste) and attractive appearance (Serot *et al.*, 2004; Harboure, 1980; Benyami, 1991).

Phenolics are compounds with hydroxyl groups (OH)bonded directly to an aromatic hydrocarbon group. They are abundant in plants and exhibit considerable physiological and morphological functions in plants especially in growth, reproduction and protection against pathogens and predators. They also serve as anti-allergenic, anti-inflammation and antimicrobial agents (Harbourne, 1980; Serot *et al*., 2004).

Decrease in moisture content of fresh mudskipper from 79.99% to 0.00% in the smoked sample and reduction of water content of fresh silver catfish from 67.41% to 1.08% shows dehydration from heat generated by the burnt fuel wood. Equally the 50% decrease in values of crude fat and carbohydrate from the fresh to smoked samples of the fish types (table 1) can be attributed to decomposition of these proximate by the combustible heat of red mangrove. The nutritive values of any food item depend on the content of the proximates. Moisture and oil are inversely proportional in fish. Fish usually contain about 55 – 88% moisture content in the body structure (Johnson and Peterson, 1994), with the average of 70%. Fat content of fish varies from species to species depending on feeding condition, food type (plankton), state of maturity, location of catch and part of the fish tissue used for analysis.

Higher moisture range of 60-70% in the fish types indicate that they are highly perishable especially in the fresh form. Fats and carbohydrate are good sources of energy while ash expresses the mineral richness of the fish types. The human body needs minimum intake of food energy to sustain body metabolism. The caloric values ranging from 276kcal to 424kcal in the fish types expresses generation of greater food energy for the metabolic machinery of the human body. Generally the percentage of fat and protein in animal tissue normally increase with the level of food intake and feeding habit. Red mangrove generates greater heat energy and phenolics that produce nutritive smoked products with good flavor, odour, brownish and attractive skin colouration with longer shelf-life. This however deviated from the works of Edet (2017) with coconut husks that produced characteristic dull colouration; but coincided with the use of red mangrove on silver catfish.

Smoking is the commonest and cheapest method of preventing fish spoilage in Nigeria especially in the far-flung fishing settlements where electricity, cold storage facilities and ice-making plants, etc are non-existent. Thus, inadequate preservation techniques which generally characterize artisanal fishery, often result in post-harvest loss and substantial short-fall in fish availability, quality and reduced protein intake. Smoke fish can have a shelf-life of up to 9 months (Okoko, 1996, FAO-CDR, 1993), but this however depends on the degree and extent of smoking. The proximate composition of food substances generally vary according to fish species, water body, nutrient input, seasons, feeding habit, processing method, fire wood type and severity of smoking. Red mangrove have more hemicelluloses, generate intense heat energy and releases more phenolics to produce good product; whereas coconut husk and saw dust, etc is associated with slow burning fire, produce more smoke but smoked products are usually dull and not attractive. Wood smoke results from incomplete combustion and is a mixture of gases, vapours and gaseous droplets.

The best smoked fish with good quality are achievable at $60^0$C for 15 hours or at $70^0$C for 10 hours. Idah and Nwankwo (2013) had observed poor quality products of Bonga smoked at $70^0$C for 15 hours. The moisture content decreases with increasing temperature and drying time. Idah and Nwankwo (2013) and Nwuba *et al*., (2004) had recommended a safe moisture content range of 6-8%; but shelf-life of smoked fish product is usually extended primarily following reduced water activity. For short time storage of dry fish that is safe from moulds and bacterial infestation, the moisture content must be less than 30% (Eyo, 2004).

Drying temperatures and time largely affects the nutritional properties of smoked fish. Antai (2014) reported that fish are smoked actively for 2-3 hours at 70-$80^0$C followed by mild smoking (30-$35^0$C) for 24 – 48 hours at Ebughu fishing communities. However, the technology employed by the local women is not standardized since most parameters remain uncontrolled. Smoking at $24^0$C and $32^0$C with liquid smoke vapourization allows for deposition of high quality phenolic compounds on the fish to improve the

nutritional contents but below this temperature to about $16^0$C, little deposition is made. Other than temperature, the smoking methods used can influence deposition of phenolic compounds during smoking process. Maximum smoke deposition is achieved at $60^0$C relative humidity. High humidity accelerates reabsorption of moisture and development of fungal moulds. Shelf life is mostly reduced by blow flies that attack products with high moisture contents during storage. Antai (2014) recommended a smoking time of 2-5 hours for smaller fishes like *Sardinella* and Bongafish to yield a versatile products with keeping quality between 10-18 hours for up to three days at low temperature, rich proximate contents, good flavor but short shelf-life. Fish smoke-dried with 0 – 2% moisture content usually have reduced percentage of most proximates including protein but can keep longer than moderately smoke-dried fish which are often the best in terms of rich proximates (Idiong, 2014).

## CONCLUSION

The smoked samples of mudskipper and silver catfish appreciated more in protein, ash and fibre contents than the fresh forms. The smoked fish samples were generally more nutritively richer in proximates than the fresh samples. The smoking process which promises to be an age long strategy for preserving fish even in the absence of social amenities like electricity together with the heat generated from the burnt wood drastically dehydrated water content from the fish samples to enhance longer shelf-life.

The red mangrove wood contains high complex phenolic compounds released in the fuel smoke; and which act both as antioxidants to slow down rancidity of animal fats and as antimicrobials that lowers bacterial growth; thereby preventing spoilage. The heat generated from the burnt wood dehydrates and kills bacteria in the smoked sample. Smoking and phenolic compounds prolong the keeping qualities of smoked fish, produced high quality nutritive products with brownish skin, good flavour/aroma, taste and attractive appearance. Smoking makes fish easier to pack, transport, improves market value and enhance market income generation.

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