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Trace Metal, Proximate Composition and Anatomical Properties of Four Fish Species Commonly Consumed in South-Western, Nigeria

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Abstract. Proximate and trace metal contents of fish is of great interest to the consumer and the nutritionist. In the study, trace metal concentrations and proximate compositions of local and imported fish species were examined. The result of the analysis showed that all fish species have adequate amount of fish proteins necessary for human consumption. The high yield of fillet makes Atlantic mackerel the best source of raw materials for canning and great value when added to other products. The lipid content reveals that all fish species can be preserved using local methods. The result of the analysis shows that the levels of Cd in all the fish samples were between 0.03 mg/g in cat fish species and 0.09 mg/g in Tilapia fish species. The concentration of Zn was found high in catfish species while low concentration was recorded for Tilapia fish species. It was further revealed that the levels of Cd and Zn were below permissible levels for human consumption. Pb was not detected in the entire species understudy. These findings conclude that the fish species understudy were safe for human consumption and adequate for various methods of preservation.

Keywords: Anatomical properties, fish species, permissible levels, proximate composition, trace metal analysis

1. Introduction

The processor, the nutritionist, the cook and the consumer have a direct interest in the composition of fish. The processor needs to know the nature of the raw material before he can apply correctly the techniques of chilling, freezing, smoking or canning. The nutritionist wants to know what contribution fish can make to the diet and to health and the cook must know whether a fish is normally lean or fatty in order to prepare it for the table. The consumer is interested not only in the fish but also in its nutritional value. The estimated fish demand in Nigeria is 1.80 million tonnes while the average total fish supply including those from distant water travelers is about 900,000 tonnes [1]. The yield of preliminary processing of fish has to do with its anatomical properties. Processing of the fish involves beheading filleting, gutting and quality features of fish. The percentage yield of fish is affected by the ratio of edible parts of the fish and non-edible parts. Thus, the yield percentage is high when the ration of edible part is higher than non-edible parts [2]. Unfortunately, one reason for the rather poor reputation of fish in the past has been poor quality due to lack of rapid transport. Nowadays, with modern techniques for freezing, storing and transporting very fresh fish, the consumer can receive fish that has a composition and flavour virtually unchanged from when it was caught [3]. The perception of what is regarded as better quality fish are however subjective. Some consumers consider big size fish as characteristics of good quality. However, the external morphology of fish cannot guarantee safety

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from contaminants. Heavy metals ranks high amongst the chief contaminants of food [4]. Fish take up heavy metals by absorbing them from contaminated sediments, seaweeds as well as from the exposed air, which dissolves in water in polluted environments. Fish living in heavy metal contaminated water can accumulate high concentration of trace elements that may cause health risk to consumers [4].The dietary intake of food may constitute a major source of long-term low-level body accumulation of heavy metals. The detrimental impact becomes apparent only after several years of exposure [5]. Regular monitoring of these metals from effluents, sediments in water bodies and food materials is essential for preventing excessive build up of the metals in the food chain.

High level of Pb and Cd or trace metals in food is associated with a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases [5]-[7]. Based on the persistent nature and cumulative behavior as well as the probability of potential toxicity effects of trace metals because of consumption of fish, there is need to test and analyze these food items to ensure that the levels of those trace elements meet the agreed international requirements. This study therefore presents data on the levels of Pb, Cd and Zn in some fish species consumed in Southwestern, Nigeria. Catfish (*Clariasgariepinus),* Tilapia *(Oreochromisniloticus)* Atlantic mackerel (*scomberscombrus)* and Roughearscad *(decapterus tabl)* are prominent fish species that have dominated the Nigerian market. This study was made to provide data on the amount of edible flesh fish for further processing into canned products or other value added products and the amount of wastes generated which could be used for other products. This work will go a long way in improving on the processing and effective utilization of the fish species as well as improving on the nutritional value of fish species. There is little information on the anatomical properties and proximate composition of the fish species and this work is aimed at improving on their processing and utilization.

2. Methodology

The fish samples were purchased locally from the market and wrapped in sterile nylon bags. The fish samples, Atlantic Mackerel and RoughearScad samples were imported into Nigeria from New York, while farmers locally bred Tilapia and Catfish species. Fish samples were immediately transported to the laboratory and stored in the refrigerator prior to analysis. Fish species (30 samples), after identification, were examined for length and weight frequency measurement. The total length and standard length were measured using standard graduated fish measuring board. The weight was measured using top loading electronic weighing balance (Pioneer ™). Anatomical measurements were carried out by beheading, gut removal and filleting. These were weighed and the weights related to the total body weight of the fish. The frames from the samples were passed through a Baadar® machine to separate the flesh of the fish from the bones. The flesh of the fish was minced, weighed and labeled [8]. The bones were also labelled. Triplicate samples were analyzed for proximate composition analysis according to official methods of (AOAC 2000) Moisture content of the fish was determined by drying samples to a constant weight at 100-102 ^{o}C for 16 hours in a draft air oven. The loss in weight was reported as moisture. Crude ash was determined by incineration of the fish samples in a muffle furnace at 500-600 ^{o}C.

The water and other volatile constituents were evolved as vapours. The organic constituents in the fish were also burnt to carbon dioxide and water. The inorganic residue constitutes the ash in the food products. The crude protein of the fish sample was determined by the Kjeldahl nitrogen method. This gives the amount of all the reduced nitrogen in the food in the form of amines, ammonium compounds urea and amino acid. The protein value was obtained by multiplying the total nitrogen by a factor, 6.25 for fish products [8]. The crude fat was determined by the soxhlet method and was based on the sparingly solubility of lipids in water and their considerable solubility in non-polar organic solvents. Crude fibre that is indicative of the indigestible matter or roughage in the fish was determined by Trichloroacetic acid method. The raw fish was defatted and the protein and carbohydrate content hydrolyzed using a mixture of trioxonitrate (v) acid, glacial acetic acid and trichloroacetic acid.

For trace metals analysis the gills and viscera organs of different fish species were separated and washed to remove blood and particles [8].The gills were blended using a commercial blender for acid digestion. The heavy metals in the fish were extracted following the acid digestion procedure that is as follows: 1gm of the blended fish sample was weighed into a digestion tube and 10 mL of 98 % nitric acid was added. This was then placed in a water bath and allowed to boil for about 72 hours. After the completion of digestion, the resulting pale yellow solution was made up to 25 mL with de-ionised water and stored for AAS analysis. The digested solution was analyzed for Zn, Pb and Cd using a Flame Atomic Absorption Spectrophotometer (AAS, Perkin Elmer model 2130). Recovery analysis was also conducted to ascertain the precision of the analytical procedures used in this study, since certified reference material was not available to us when this study was carried out. Blank and standards were run after triplicate determinations to calibrate the instrument [8].

3. Results

Table 1 presented the mean and standard deviation values for the concentration of trace metals in the species of fish studied. The trace metal concentrations determined were based on the fish dry weight. The result of the analysis shows that the levels of Cadmium (Cd) in all the fish samples were between 0.03 mg/g in catfish species and 0.09 mg/g in Tilapia fish species [9]. Safe limit for the consumption of Cd in fish is 0.2mg/kg Cd is a non-essential element in foods and natural waters and it accumulates principally in the kidney and liver. Various sources of environmental contamination have been reported for Cd toxicity [1]. Investigations made on Cd for this present study is below safe limits. Among all metals, zinc is the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system. Zinc deficiency in the diet may be highly detrimental to human health. Zinc deficiency in the human diet may be due to inadequate dietary intake, impaired absorption, excessive excretion or inherited defects. The recommended dietary allowance for zinc is 15 mg/day for men and 12 mg/day for women, but high concentration of zinc in fish may cause vomiting, renal damage and cramps [10]. In the study, the concentration of zinc was found high in catfish species while low concentration of zinc was observed in the sample of Tilapia fish species. The content of zinc in the fish species ranges from 0.43 to 0.77 mg/g, which is within safe limits [11].

Table 1: Trace Metal Result (mg/g)

Fish species	**Cd**	**Zn**
Atlantic mackerel	0.04±0.01	0.54±0.51
Cat fish	0.03±0.01	0.77±0.38
Tilipia	0.09±0.01	0.43±0.17
Roughearscad	0.04±0.01	0.45±0.07

Table 2 presented the anatomical measurements for Atlantic mackerel, Catfish, Tilapia and Roughearscad. Weights of head and gut were regarded as wastes because these parts are neither useful for the consumer nor the producer. The mean anatomical measurements of the species, Atlantic mackerel gave 20.28±6.19 as wastes and 136.34±0.24 as fillet. Fillet is the edible part of the fish that is of interest to the producer and the consumer. The yield of fillet for Atlantic Mackerel and RoughearScad makes them good source of raw materials for canning and great value when added to other products because a greater mass of fish is useful and not wasted [8]. Tilapia fish species will not be of much value in the food processing industry due to a very low percentage of fillets skin [9], [13]. Fish yield depends on the fish species. Fish species therefore affects the ratio of the edible part of the fish, which is mostly the flesh or fillet to the non-edible part of the fish that consists mostly of the head and guts. Thus, the yield of the fish edible part is a function of fish anatomical structure and gives detailed information on the study of the body of the fish species. Therefore, Atlantic mackerel has the highest yield and technological value compared to the other fish species with tilapia specie showing the lowest value of anatomical properties.

Table 2: Anatomical Composition (Weight in Grams)

Fish species	**Gut**	**Head**	**Fillet**	**Waste**
Tilipia	12.81±1.24	20.28±1.90	9.20±1.20	42.62±1.25
Cat fish	42.38±1.62	52.49±2.65	32.65±3.28	70.62±0.51
Roughearscad	143.87±2.22	160.48±2.44	70.26±1.22	308.12±4.56
Atlantic mackerel	50.60±1.34	43.48±1.66	136.34±0.24	20.28±6.19

Catfish and Roughearscad had large head structure compared to Atlantic Mackerel. This is the reason why lower fillet percentage values were recorded in these fish species when compared with Atlantic Mackerel. This is in accordance with the [12] who found that fish with larger head structure and viscera produced low yield since the head and viscera (gut) are non-edible parts of the fish. The low percentage of fillet skin and the high waste makes Tilapia fish sample not desirable for canning but it could be processed in other ways such as drying, roasting or smoking. Catfish sample showed a considerable percentage of fillet skin. Due to lack of indigenous food processing companies in Nigeria, the locally bred specie is not utilised for canning. Atlantic Mackerel is specie usually found in the North Atlantic Ocean. It is utilised maximally in the processing industry and canned Mackerel fillet in tomato sauce is extremely high in vitamin B^{12} and Omega 3 [2].

The proximate composition of Atlantic Mackerel, Catfish, Tilapia and RoughearScad are presented in Table 3. The data revealed that Atlantic Mackerel contained the highest oil content. This is as a reason of low moisture. RoughearScad has the highest moisture content. The variation in the percentage of fat is reflected in the percentage of water since fat and water normally constitute around 80 % of the fillet and since water content is inversely propositional to lipid content in fish [13], [14]. Atlantic Mackerel is a fatty fish whose total lipid content varies with season. The lipid content ranges from 6-23 %. There is a corresponding variation in the water content also, the range being between 74-56 %.

Table 3: Proximate Composition (%)

Fish species	**Moisture content**	**Ash content**	**Lipid content**	**Protein content**
Atlantic mackerel	58.80	1.20	16.30	18.50
Cat fish	60.90	0.70	1.10	11.5
Tilipia	63.20	1.10	14.80	16.10
Roughearscad	70.30	1.50	11.60	22.80

4. Conclusion

All fish species have adequate amount of fish protein for food for infants and adults. The lipid content in all fish species reveals that they can be preserved using local methods of smoking, drying and roasting. The levels of Cd and Zn were below the permissible levels for human consumption. Pb content was not detected in the entire species understudy. Summarily, we can conclude that the species understudy was safe for human consumption but further environmental monitoring is highly recommended.

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