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Nutritional Value, and Heavy Metal Contents of Fish from the Lower River Niger at Agenebode, Edo State, Nigeria

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ABSTRACT: *Fish constitutes a vital component of human diets due to their rich nutritional compositions. They serve as a remarkable source of proteins, vitamins, and fatty acids, which are indispensable for the effective growth and development of humans. The need to explore the nutritional compositions of various species of fish in different water bodies becomes paramount. Presently, consumer concern is not just on food's nutritional value but also on the safety level. Environmental contamination by heavy metals has become an issue of pressing concern in recent times. Heavy metals, due to their ubiquitous nature, are found in various water bodies as they are released from various anthropogenic activities. This work investigated the proximate compositions, mineral contents, and heavy metals concentrations of four different species of fish (P. annectens, L. niloticus, G. niloticus, and H. niloticus) collected from the lower Niger at Agenebode using standard procedures. The highest protein contents were in Gymnarchus niloticus (37.32%), while the least was in Heterotis niloticus (20.41%). Protopterus annectens had the highest carbohydrate content (34.55%), while Heterotis niloticus had the least (12.24%). The highest lipid content (14.41%) was in Gymnarchus niloticus. The highest concentration of potassium was 21.00 ppm. The concentrations of heavy metals in ppm ranged from 0.01 – 1.4 (Cd), 0.07 – 2.89 (Pb), 0.02 – 16.4 (Hg), 0.88 – 5.1 (Cu) and 1.2 – 8.23 (Zn). The concentrations of Hg, Cd and Pb in some of the samples investigated were higher than the permissible limits based on international standards. There is a pressing need for further study focusing on various species of animals and plants in the area due to the alarming contents of these metals; remedial measures could also be ensured for safety.*

KEY WORDS: trace metals, nutritional value, human health, crude protein, lipid content

INTRODUCTION

There is an increasing demand for fishes as source of proteins in human diets due to their remarkable nutritional values. Other factors which have been linked to the higher demand for fish when compared to most other protein sources are the ease in affordability, quality of their nutrients due to high amount of highly desirable polyunsaturated fatty acids such as omega 3 and essential and non essential fatty and amino acids. Also, the proteins obtained from fishes can be digested easily [1]. More recently, various

studies have reported the vital roles played by the polyunsaturated fatty acids present in fishes in preventing various diseases such as inflammation, cancers, rheumatoid arthritis and heart related ailments. Furthermore, unlike some other sources of protein with high selectivity on religious ground, almost all religious groups tend to welcome proteins obtained from fishes. The vast amount of water bodies available in Nigeria further promotes fishing as a primary source of livelihood for people living around the fishing regions such as the bank of river Niger [2].

In spite of the high demand for fishes and the increasing fishing activities as a reliable source of livelihood the contamination of water bodies due to various anthropogenic activities such as farming, industrial discharge amongst others and their consequential impacts on quality of aquatic life has become an issue of serious concern in recent times. Most of the chemicals used at home, industries and related sources find their ways into water bodies. Amongst the pollutants of concern, heavy metals are one of the most common classes [3],[4]. Since fishes are found in the water bodies, they readily take in these metals into their systems from sediments. Some of the metals such as mercury, cadmium, lead and arsenic have no known functions in biological systems, but rather are highly toxic even at trace concentrations. Some of these metals have also been linked to various degenerative diseases, such as cancer, high blood pressure and some other neurological disorders. Some heavy metals have also been connected to various severe damages of vital body organs of animals such as kidney, liver, lungs and brain [5],[6].

Various studies have been carried out on proximate and heavy metal compositions of fish species, however there is dearth in information on compositions from fish species in this part of the bank of River Niger hence this study becomes necessary. Also the proximate compositions of fishes is affected by several factors which include biological variations, environmental conditions and seasonal changes. More recently, while exploring the nutritional compositions of various species of fishes in different environments, emphasis has also been shifted to the pressing desire to evaluate their safety level in terms of various environmental contaminants of which heavy metals constitutes a major group of concern. The present studies therefore investigates the proximate, mineral and heavy metal contents of four different species of fishes collected from the bank of lower Niger in Agenebode, Edo State Nigeria.

MATERIALS AND METHODS

Sampling Method

Different species of fishes (catfish, bony fish and lung fish) were collected for the purpose of this study. A total of 10 of each species were collected from the Lower River Niger at Agenebode in Etsako East Local Government Area of Edo State, from February 2018 to August 2018. Fish samples were obtained from catch landings of fisher folks by the use of traps, nets and canoes. Sampled fishes were washed using distilled water and taken to the laboratory for identification by [7] for pretreatment and subsequent analyses.

Identification

Fish samples were identified using keys, diagrams and descriptions as described by [7], [8].

Sample pre-treatment
The samples were washed using deionized water and de-boned. They were then oven dried for two days at 40^{o}C. The dried samples were grounded using mortar and pestle into fine form. These were used for subsequent analyses.

Proximate Analysis
Moisture content was determined by oven drying of 1g of sample at 105^{o}C. It was calculated using the formular:

Moisture content =(M1-M2/M1-M)×100

Where M1= initial mass in g of the dish and lid with the material taken for analysis.M2= the final mass in g of the dish and lid with the material after drying. M = mass in g of the empty dish.

Crude fat was obtained by extracting the dried and ground fish sample with petroleum ether in Soxhlet extraction apparatus in line with [9]. The protein content is calculated from the total nitrogen determined by Kjeldahl method. Total carbohydrate was estimated as the difference after subtracting other constituents. The determinations were in line with [10].

Mineral Analysis
Digestion of the fish samples was done using a mixture of nitric and perchloric acid in line with the method reported by [11] with slight modifications. 1g of the impulverised sample was placed in a digestion tube, acid mixture, 10 mL, 70% high purity HNO_3 and 65% $HClO_4$ combined in 4:1 v/v was then added to the sample. The mixture was digested at 70 °C till the transparent solution became clear. It was then cooled at room temperature and filtered using Whatman no. 42 filter paper and the filtrate was diluted to 25 mL with deionised water. The content of Zn, Mn, Fe, Cr, Fe, Pb and Cd was then determined using using an Atomic Absorption Spectrometer (AAS). A blank solution was also prepared for each group of sample by using all reagents except the sample. This was also analysed for heavy metal content. Standard solutions of metals (1000ppm) were prepared; these were then diluted to prepare other standards for making the calibration curve.

Quality Assurance
Quality assurance measures were observed. All reagents used for the analysis were of analytical grade. Reagent blanks were also run. Glass wares were rinsed using demonized water. The data collected was analyzed using SPSS. All analyses were carried out in duplicates.

RESULTS AND DISCUSSION

Four fish: *Protopterus annectens*, *Lates niloticus*, *Gymnarchus niloticus* and *Heterotis niloticus* were analyzed for proximate composition, mineral value and the possible deposition of heavy metals in the flesh. The results are presented on the tables below.

Table 1. Proximate composition of flesh of Fishes from the River Niger at Agenebode

Fish Species	Proximate Content				
	Protein	Carbohydrate	Lipid	Ash	Moisture
Protopterus annectens	29.42±0.47^{b}	34.55±0.91^{c}	11.23±0.51^{b}	12. 19 ± 0.22^{c}	11.31±0.91^{a}
Lates niloticus	27.66±0.61^{b}	36.75±0.51^{c}	09.91±0.56^{a}	4.45±0.87^{ab}	10.38±0.65^{a}
Gymnarchus niloticus	37.32±0.71^{c}	19.38±0.61^{b}	14.41±0.33^{c}	5.36±0.44^{b}	13.20±0.57^{b}
Heterotis niloticus	20.41±0.44^{a}	12.24±0.66^{a}	11.91±0.55^{b}	3.82±0.91^{a}	35.21±0.45^{c}

Results are expressed as mean±SD for triplicate determinations. Values with the same superscript alphabets on the same column do not differ significantly at p<0.05.

Table 2: Heavy Metal Concentration (ppm) in Fishes from the River Niger at Agenebode

Fish Species	Heavy metal				
	Cu	Zn	Pb	Cd	Hg
Protopterus annectens	5.1^{b}	2.76^{b}	1.10^{b}	1.4^{b}	1.90^{b}
Lates niloticus	0.63^{a}	08.23^{c}	0.03^{a}	0.03^{a}	16.40^{d}
Gymnarchus niloticus	0.88^{a}	3.11^{b}	0.07^{a}	0.01^{a}	0.02^{a}
Heterotis niloticus	4.1^{b}	1.2^{a}	2.89^{c}	0.01^{a}	1.10^{c}
Limits	40***	5.00*	0.2*	0.05*	
		4.81**	0.48*	0.03*	

***[12] ** [13] ***[14]**

Results are expressed as mean±SD for triplicate determinations. Values with the same superscript alphabets on the same column do not differ significantly at p<0.05.

Table 3: Mineral Composition of flesh in Fishes from the River Niger at Agenebode

Fish Species	Mineral Composition				
	Calcium (mg^{-1})	Magnesium (mg^{-1})	Sodium (mg^{-1})	Potassium (mg^{-1})	Iron
Protopterus annectens	0.18±0.61^{b}	0.64±0.22^{a}	0.91±0.21^{a}	21.00±0.12^{b}	0.99±0.62^{a}
Lates niloticus	0.50±0.34^{a}	0.34±0.02^{a}	0.79±0.88^{a}	18.19±0.21^{a}	0.39±0.31^{a}
Gymnarchus niloticus	0.40±0.01^{a}	0.37±0.03^{a}	0.56±0.64^{a}	17.88±0.14^{a}	0.89±.0.47^{a}
Heterotis niloticus	0.45±0.32^{a}	0.46±0.24^{a}	0.78±0.56^{a}	19.28±0.44^{ab}	0.61±0.32^{a}

Results are expressed as mean±SD for triplicate determinations. Values with the same superscript alphabets on the same column do not differ significantly at p<0.05.

Table 1 presents the proximate compositions of the various species of fishes investigated. The protein, carbohydrate, lipid, ash and moisture contents range from 20.41-37.32%, 12.24- 36.75%, 9.91 – 14.41%, 3.82 – 12.19% and 10.38 – 35.21% respectively. The highest content of protein was in *Gymnarchus niloticus* (37.32%). The protein contents obtained in this work is higher when compared to the range of 16.8 to 19.3% reported by [15] in their work. The values obtained from this study are a clear indication that the fishes are highly nutritious and therefore recommendable for human consumption. The Crude

Protein (CP) values obtained in this study varied amongst the different fish species. The nature of the different fish species, the genetic makeup and the feeding habits could be a factor to explain the different protein levels recorded in different fishes. [16], also reported that different crude protein values were obtained from different body parts in different fishes from the same water body attributing the vary to ecological factor and nature of fish.

The lipid content obtained in this result varied among the fish tested. It was evident that the fish with higher protein content coincidentally had higher lipid content. For instance, *G. niloticus* and *P. annectens* had higher CP values ($\mathbf{37.32 \pm 0.71}$ and $\mathbf{31.42 \pm 0.47}$) respectively to correspond to higher values in lipid ($\mathbf{14.41 \pm 0.33}$ and $\mathbf{11.23 \pm 0.51}$) respectively. It is important to note that as long as the feeding regime is adequate in fish, the CP and lipid content seems to be predetermined by nature and genetic makeup. This is supported by the report of [17] on the nutritional content of fish. The levels of lipid content obtained in this study are within the recommended permissible limit for healthy consumable fish. Furthermore, it is an indication that it can be used as supplements in diets for persons that are at risk in relation to lipid induced disorder.

The ash content is an indicator of product quality and the nutritional value of food products. Ash in proximate analysis is determined solely to determine the nonorganic matter component of dry matter. The ash content in *P. annectens* in this result is high, a clear indication of matter rich in nutritional values. The highest amount of carbohydrate was in *Lates niloticus* (36.75%) while the least was in *Heterotis niloticus* (12.24%). The carbohydrate content was higher when compared to the range of 0.13 to 0.24 reported by [2] from fish samples obtained from a river in Lagos. *Gymnarchus niloticus* had the highest amount of lipid (14.41%). [2], in a related work reported a lipid content ranging from 0.54 – 1.42% which is lower than the value from this work. The highest amount of ash (12.19%) was in *P. annectens*. Ash content gives information about the mineral compositions or inorganic matter of a food material. This therefore implies that the sample (*P. annectens*) contains a higher level of inorganic materials. The least moisture content amongst the various species was 10.38% which was observed in Lates niloticus. Moisture content determination is paramount in proximate analysis as it gives reliable information for the prediction of the shelf life of the food materials [18],[19]. The highest moisture content of *Heterotis niloticus* as obtained in this work is an indication that this species can easily be spoilt by microbial influence when stored in comparison with the other samples. A high amount of moisture promotes microbial activities [1]. There was however no significant difference in the moisture contents of *P. annectens* and *L. niloticus* at $p < 0.05$. [15], documented the moisture contents of fish samples to range from 75.9 – 80.1%. This fish samples from this study will therefore have a longer shelf life compared to that from their study [18]. The findings from the proximate analysis generally indicate that the various samples investigated contain remarkable amount of the various proximate parameters [15].

The concentrations of the various heavy metals investigated are presented in table 2. The contents of the metals were observed to range from 0.63 – 5.1ppm, 1.2- 8.23ppm, 0.03 – 2.89pm, 0.01 – 1.4 ppm and 0.02 – 16.4 ppm for copper, zinc, lead, cadmium and mercury respectively. The concentrations of Hg in *Lates niloticus* (16.4ppm) and *Protopterus annectens* (1.9ppm) and *Heterotis niloticus* (1.1ppm) were

observed to be higher than the maximum limits based on international standards. Cd in *Protopterus annectens* (1.4ppm) was also higher than 0.01 and 0.03ppm which is the permissible limit for this metal based on international standard [12]. The contents of Cd is however lower when compared to 1.53 – 7.88 mg/kg reported by [18], on various species of fishes from River Ogun. The highest value of lead obtained in this study was 2.89ppm and this is also higher than 0.2 ppm which is the limit of Pb in fish [13]. The concentration of Pb was also lower that the highest value of 10.mg/kg reported by [15]. The concentrations of Cu and Zn were however within the permissible levels based on standard. The high contents of mercury, cadmium and lead in some of the samples therefore calls for serious concern because these are metals of most serious concern due to their remarkable deleterious effects on humans and animals [20],[21]. Mercury, lead and cadmium have been labeled as highly toxic heavy metals that do not have a biological benefits in the body system [22]. They are highly toxic even at trace concentrations. These metals have been linked to various diseases in humans such as cancer, and other degenerative diseases. They also have the potential of causing damages to various vital organs in human bodies such as kidney, liver and brain. They have been associated with various cognitive and neurological diseases in humans and other organisms. Zinc and copper in the range reported in this work do not constitute damage but are rather useful because these metals are identified as trace elements that are required in plants and also useful in the physiological systems of animals where they act as co-enzymes and co-factors [2],[20].

The mineral contents of the metals investigated are presented in table 3. The contents of the mineral elements studied are in the following ranges: 0.18-0.50ppm, 0.34 – 0.64ppm, 0.56 – 0.91ppm, 17.88 – 19.28ppm and 0.39 – 0.89ppm for calcium, magnesium, sodium, potassium and iron respectively. The highest amount of potassium (21.00ppm) and magnesium (0.64ppm) were in *Protopterus annectens* while the least amount of Ca (0.18ppm) was in the same species. The high contents of some of these mineral elements in *P. annectens* further connect to its high ash content. Ash contents indicate the mineral elements composition of a sample. The high potassium content of *P. annectens* makes it of vital mineral value. A diet rich in potassium is cherished due to its suitability for people with high blood pressure due to the tendency of potassium to replace sodium [23],[24]. There was however no significant difference in the contents of K amongst the other three species of fish. The least amount of Na (0.56ppm) was in *Gymnarchus niloticus*. A diet poor in sodium has been recommended for people most especially elderly that have cases of high blood pressure. High sodium content has been linked to the retention of water in the blood which is a contributing factor to hypertension. The concentrations of most of the essential minerals investigated were generally within safe limits for humans [25].

CONCLUSION

The proximate, mineral and heavy metals concentrations of selected species of fishes collected from Lower Niger in Agenebode have been investigated in this work. The remarkably high proximate parameters (proteins, carbohydrate and lipid) show their quality nutritional values making them rich food values. The results on their safety level from heavy metals analysis however revealed high concentrations of cadmium, lead and mercury which call for serious concern. Further studies focusing on the heavy metals

concentrations of water, sediments and plants in the vicinity are therefore recommended for human safety assessment.

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