Journal of Aquaculture Research & Development

Ogundiran, J Aquac Res Development 2017, 8:9
DOI: 10.4172/2155-9546.1000508

Research Article Open Access

Nutritional Compositions and Heavy Metal Accumulation Potentials of Selected Fish Species from Ijede River, Lagos, Nigeria

Ogundiran MA*

Environmental Biology Unit, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Abstract

This work aimed at ascertaining the nutritional suitability of some selected fish species in Ijede River, Nigeria. Evaluating the proximate composition, amino acids, mineral compositions and heavy metal accumulation of food fish is the most important aspect in fish nutrition. These were evaluated in *Chelaeltiops bibie, Cithrarinus latus, Laeviscutella dekimpei,* and *Phago loricatus* obtained from Ijede River, Lagos State, Nigeria, using standard laboratory procedures. All the amino acids analyzed were present in all the species examined with the highest value of total amino acids found in *Laeviscutella dekimpei* (283.1 mg/kg^{-1}) except *Phago loricatus* that has the highest value of 70.00 ± 1.01. Minerals were also evaluated and the highest values were recorded in *Phago loricatus* with the exception of Calcium that has the highest value of 155.11 ± 1.22 mg/kg^{-1} in *Laeviscutella dekimpei.* It was observed that all the fish species analyzed bio-accumulate various metals and the concentrations of these metals exceeds their concentrations in the water sample analyzed. This data also revealed that the fish species sampled are of high nutritive value and are good sources of protein, amino acids and minerals. Amongst the sampled species, *Phago loricatus* appears to have the highest nutritive value but also the highest potential of heavy metal bioaccumulation.

Keywords: Bioaccumulation; Essential amino acids; Heavy metals; Minerals elements; Proximate composition

Introduction

Fish products have been identified as an important and cheap source of nutrients such as protein, lipid and minerals. Fish is consumed by a large percentage of population in the world due to its high-quality protein, availability and palatability [1]. It contains the most important nutritional components and serves as a source of energy for human beings [2]. Fish accounts for about 40% of the total animal protein intake in Nigeria [3,4]. Fish is also a vitamin and mineral rich food for young and old consumers [5]. Regular consumption of fish can reduce the risk of cancer, including colon, breast and prostate, lowers the risk of dementia, and Alzheimer's diseases [2]; and prevent the cardiovascular diseases [6,7]. The nutritional as well as culinary importance of fish depends not only on protein but also as a source of several other nutrients. Fish meat is also a rich source of minerals and the most abundant micro-elements are Zinc (Zn), Iron (Fe) and Copper (Cu) [8]. The most important mineral salts are calcium, sodium, potassium, phosphorous, iron while many others are also needed in trace amounts. The deficiency in these principal nutritional mineral elements induces a lot of malfunctioning; as it reduces productivity and causes diseases, such as inability of blood clot, osteoporosis, anemia etc. [9-11]. Fish meat contains significantly low lipids and high water compared to that of beef or chicken and is favoured over other white or red meats [12,13]. Fish comprises of all the ten-essential amino acid in desirable quantity for human consumption. Amino acids are mainly obtained from proteins in diet and the quality of dietary protein is assessed from essential to nonessential amino acid ratio. High quality proteins are readily digestible and contain the dietary essential amino acids (EAA) in quantities that correspond to human requirements [14]. There is a dearth of information on some important fish species in Nigeria in spite of their great demand. Water bodies in Nigeria are inhabited by a variety of fish species that serve as food and are of economic importance of the country. One of the major pollution sources that pose serious health risk and environmental concern is that which result from heavy metals. Four important edible fish species namely, *Chelaeltiops bibie, Cithrarinus latus, Laeviscutella dekimpei,* and *Phagos lericatus* were used for this work based on their economic importance and their abundance in Nigerian markets. The aim of this study is to analyse the proximate composition, minerals, amino acids and heavy metals in the collected samples.

Materials and Methods

Sampling site: The sample site is located at the Ijede end of the Lagos lagoon, ikorodu. The Lagos Lagoon lies between longitudes 3° 20" and 3° 40" E and latitudes 6° 15" and 60° 40"N. It has an area of 208 km^2 and is the largest of the lagoon systems of the West African sub-region and has supported decades of small-scale fisheries. The Ijede axis is not one of the deepest points of the lagoon with its depth ranging from 10-50 m. At Ijede, the lagoon receives discharges from the Egbin thermal station of the Power Holding Company of Nigeria, the Nigeria National Petroleum Cooperation (NNPC) gas plant, runoffs from dump sites and storm waters in the community, exhausts from automobile activities and agricultural runoff from the farming communities along the river course.

Sample collection and preparation

Specimens of *Chelaeltiops bibie, Cithrarinus latus, Laeviscutella dekimpei,* and *Phago loricatus* were purchased from the commercial fishermen in Ijede River, stored at 4°C in ice chest and transported to the Central Research laboratory of Ladoke Akintola university of Technology, Ogbomoso for further analysis. The samples were collected on monthly basis for six months. The samples were sacrificed, minced and homogenized.

***Corresponding author:** Dr. Ogundiran MA, Environmental Biology Unit, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, Tel: +2348034237739; E-mail: mogundiran@lautech.edu.ng

Received August 31, 2017; **Accepted** October 09, 2017; **Published** October 11, 2017

Citation: Ogundiran MA (2017) Nutritional Compositions and Heavy Metal Accumulation Potentials of Selected Fish Species from Ijede River, Lagos, Nigeria. J Aquac Res Development 8: 508. doi: 10.4172/2155-9546.1000508

Proximate composition analysis

Moisture content was determined by oven drying the homogenized samples at 105°C until a constant weight was obtained [15]. Pre-dried samples obtained from moisture content analysis were ashed in furnace (Barnstead, Iowa, USA) at 550°C overnight to determine the ash content [15]. Crude protein and lipid extractions were performed by modification of the method of Bligh and Dyer as described by AOAC [15].

Amino acids analysis

Homogenized samples were boiled in water for discarding fats (oils). Then, the cooked fish were pressed by cylinder drum and pistol to reduce the water quantity. All pressed meats were exposed to sunlight for three days until their weight were stable [16]. Amino acids contents were determined with SYKAM (57130 Amino Acid Analyzer) device. The total amino acids were screened in form of ug/umg and then converted into mg/100 g by using the following formula:

Conc. In ug/umg × 12.5= Conc. in mg/100 g

Mineral composition analysis and heavy metal analysis

Ashed products were digested by dissolving in nitric and perchloric acid mixture. The determination of the levels of inorganic mineral: Zn, Ca, Cu, Fe, Mn, P, Na and Mg were carried out using the Atomic Absorption Spectrophotometer model 420 Perkin-Elmer, Norwalk, C.T. [15]. Phosphorus and potassium were determined using the calorimetry method. Heavy metals were determined using atomic absorption spectrometer.

Statistical analysis

The statistical interpretation of the tabulated data was performed by using SPSS (21.0 version) for the mean standard deviation at 5% level of significance.

Results

Water analysis

Table 1 showed the concentration of some Physical, Chemical and

Parameters	Experimental Value (mg/L)	WHO Standard (2011)
Temperature	25.21 ± 1.22	
pH	7.28 ± 0.97	6.5 – 6.9
Turbidity	16.87 ± 1.21	--
Electrical Conductivity	2.12 ± 0.57	<0.01
Total Solids	35.55 ± 0.99	<1000
Biological Oxygen Demand	4.54 ± 0.72	<1.00
Dissolved Oxygen	15.21 ± 1.23	5.0 mg/l
Sulphate	13.30 ± 1.57	500
Nitrate	0.99 ± 0.01	50
Chloride	11.12 ± 1.26	10 µg/l
Sodium	0.90 ± 0.10	--
Calcium	20.28 ± 0.14	<200
Lead	0.12 ± 0.02	0.01
Copper	0.77 ± 0.11	0.1 mg/l
Iron	0.31 ± 0.01	1.0 mg/l
Zinc	0.55 ± 0.13	1.0 mg/l
Chromium	11.21 ± 0.09	0.05
Manganese	0.21 ± 0.76	0.55 mg/l
Cadmium	0.01 ± 0.03	0.003

Table 1: Mean values for physical, chemical and heavy metals parameters of water samples collected from Ijede River Ikorodu, Lagos, Nigeria.

Parameters/ Species	*Chelaethiops bibie*	*Cithrarinus latus*	*Laeviscutella dekimpei*	*Phago lericatus*
Crude Protein	21.01 ± 2.00	41.22 ± 3.23	19.18 ± 1.98	23.21 ± 2.20
Carbohydrate	36.21 ± 2.98	55.08 ± 0.98	30.00 ± 1.87	38.22 ± 2.23
Moisture Content	49.31 ± 2.22	5.91 ± 0.02	52.21 ± 3.23	54.04 ± 1.11
Ash Content	21.32 ± 1.94	27.20 ± 2.22	1.21 ± 0.56	6.00 ± 0.91
Fat Content	1.11 ± 0.78	6.01 ± 0.21	3.33 ± 0.03	24.22 ± 1.16

Table 2: Proximate composition of edible fishes from Ijede River, Ikorodu, Nigeria (Expressed in mg/kg^{-1} of dry wt.).

Parameter/ Species	WHO Standard	*Cithrarinus latus*	*Chelaethiops bibie*	*Laeviscutella dekimpei*	*Phagos loricatus*
Isoleucine	28	32.21 ± 1.01	33.23 ± 0.01	39.22 ± 1.12	30.30 ± 0.00
Leucine	66	69.92 ± 1.23	65.00 ± 1.00	56.21 ± 1.16	70.00 ± 1.01
Lysine	58	55.59 ± 1.12	62.21 ± 0.01	69.11 ± 1.22	60.21 ± 1.00
Aspartic Acids	25	22.21 ± 1.11	30.31 ± 0.02	32.01 ± 0.01	28.21 ± 0.03
Glutamic Acids	11	13.55 ± 1.12	12.00 ± 1.00	17.36 ± 2.16	14.23 ± 1.00
Arginine	19	21.10 ± 1.45	23.89 ± 2.77	26.00 ± 0.03	16.23 ± 0.01
Alanine	35	30.12 ± 1.22	38.23 ± 1.00	43.19 ± 2.20	36.11 ± 0.02

Table 3: Concentration of major amino acids in the four-fish species collected from Ijede River, Ikorodu, Lagos, Nigeria (mg/kg^{-1}).

Heavy metals parameters in water samples collected from Ijede River Ikorodu Lagos Nigeria. Virtually all the parameters analyzed proofed higher than the World Health Organisation standard of 2011. The pH, Electrical conductivity, Biological Oxygen Demand, Lead and Chromium values were found to be higher that the permissible limit of the WHO standards.

Proximate analysis

The mean proximate composition of the fish samples is as presented in Table 2 with *Cithrarinus latus* having the highest values for all the parameters analysed except moisture content and Fat content which recorded higher values for *Phago loricatus*.

Amino acid composition

Seven essential amino acids namely leucine, lysine, alanine, isoleucine, aspartic acid, arginine glutamic acid was obtained in descending order of concentration in the four fish samples analysed as shown in Table 3. *Laeviscutella dekimpei* contained more amino acids than any other fish species with the exception of leucine which has its highest value in *Phago loricatus*.

Mineral composition and heavy metal accumulation

Table 4 shows the eight mineral elements found in the sampled edible fishes from Ijede River. Amongst all the analysed fish samples, *Phago loricatus* contains the highest amount of phosphorus, potassium, iron, magnesium. *Laeviscutella dekimpei* contains the highest amount of calcium, zinc and copper. The highest amount of sodium was obtained in *Citharinus latus*. The highest heavy metals accumulation was found in *Phago loricatus* compared to the remaining three species while *Laeviscutella dekimpei* has the lowest accumulation potential for heavy metals (Table 5).

Discussion

The physical and chemical parameters investigated in this work have

Species/ Element	*Chelaethiops bibie*	*Cithrarinus latus*	*Laeviscutella dekimpei*	*Phago loricatus*
Phosphorous	3.12 ± 0.22	3.43 ± 1.21	3.21 ± 1.19	5.21 ± 2.20
Calcium	150.00 ± 2.21	151.01 ± 1.91	155.11 ± 1.22	150.02 ± 0.96
Sodium	33.21 ± 0.87	35.39 ± 1.99	30.00 ± 0.75	32.32 ± 1.23
Potassium	56.22 ± 1.02	56.62 ± 0.92	49.09 ± 1.11	57.52 ± 1.99
Iron	10.10 ± 1.12	10.21 ± 1.32	10.01 ± 1.00	11.21 ± 0.98
Magnesium	45.44 ± 1.65	40.09 ± 2.21	32.21 ± 2.21	47.71 ± 3.02
Zinc	1.11 ± 0.21	0.92 ± 0.01	1.90 ± 0.11	1.21 ± 0.99
Copper	0.01 ± 0.01	0.11 ± 0.06	0.21 ± 0.98	0.09 ± 0.15

Table 4: Mineral composition of edible fishes from Ijede River, Ikorodu, Nigeria (Expressed in mg/kg^{-1} of dry wt.).

Species/ Parameters	*Chelaethiops bibie*	*Cithrarinus latus*	*Laeviscutella dekimpei*	*Phago loricatus*
Pb	3.29 ± 2.00	3.21 ± 3.23	2.99 ± 1.98	4.01 ± 2.20
Cu	1.87 ± 2.98	2.33 ± 0.98	1.90 ± 1.87	2.00 ± 2.23
Fe	1.12 ± 2.22	1.98 ± 0.02	1.33 ± 3.23	2.09 ± 1.11
Zn	7.21 ± 1.94	7.46 ± 2.22	6.01 ± 0.56	8.09 ± 0.91
Cr	2.11 ± 0.78	3.43 ± 0.21	2.56 ± 0.03	3.79 ± 1.16
Mn	1.00 ± 0.12	1.22 ± 1.00	2.02 ± 0.18	2.99 ± 2.17
Cd	4.11 ± 1.32	4.21 ± 0.04	2.29 ± 1.44	5.21 ± 1.71

Table 5: Heavy metal accumulation potential of edible fishes from ijede River, Ikorodu, Nigeria (expressed in mg/kg^{-1} of dry wt.).

been widely used to assess the water quality of African lakes, ponds, reservoir, freshwater and marine waters. The results obtained from analysis of water samples from Ijede River are shown in Table 1. The reported values refer to the mean values of the concentration of some physical, chemical, and heavy metals parameters in the water samples. Virtually all parameters analysed deviated from WHO standard value of 2011. The pH, Electrical conductivity, Biological Oxygen Demand, Lead and Chromium values were found to be higher than the permissible limit of the WHO standards and this may be attributed to the high level of anthropogenic activities around the river course. These parameters along the stretch of Ijede River revealed different level of variations from the WHO standards.

The proximate composition of *Phago loricatus, Laeviscutella dekimpei, Cithrarinus latus* and *Chelaethiops bibie* show encouragingly high crude protein contents of 23.21%, 19.18%, 41.22% and 21.01% respectively. The relatively high to moderate percentage crude protein could be attributed to the fact that; fishes are good source of pure protein, but the differences observed, in the obtained values may also be attributed to fish's consumption or absorption capability and conversion potentials of essential nutrients from their diet or their local environment into such biochemical attributes needed by the organisms' body [17]. The variations recorded in the concentration of the different nutritional components in the fish examined could have been as a result of the rate in which these components are available in the water body, and the ability of the fish to absorb and convert the essential nutrients from the diet or the water bodies where they live. This is supported by the findings of [18-22]. Studies have shown that concentrations of the amino acids depend on the nature of the tissues analyzed [3]. The amino acids were not significantly different between the species and thus, eating any of these species would provide virtually the same type of amino acids in the diet. Many amino acids in the body are in the form of protein component [21]. Amino acids are important biomolecules that both serve as building blocks of protein and are intermediates in various metabolic pathways. They serve as precursors for synthesis of a wide range of biologically important substances including nucleotides, peptide hormones, and neurotransmitters. Leucine is an essential amino acid and it was the most obtained in all the fish samples compared to other amino acids with the highest total amount found in *Phago loricatus.*

Of the mineral element analysed, copper (Cu) concentration recorded between 0.01 to 0.21 mg/kg^{-1} in the samples investigated. Furthermore, the highest average concentration of Cu was observed in *L. dekimpei* (0.21 mg/kg^{-1}). Copper is essential for good health, but very high intakes can cause health problems such as liver and kidney damage [23,24]. Iron (Fe) level was highest in *Phago loricatus* (11.21 mg/kg^{-1}). Fish is a major source of Fe for adults and children and iron deficiency causes anemia [25]. The levels of potassium (k) and Sodium (Na) in all samples range from 57.52 mg/kg^{-1} - 49.09 mg/kg^{-1} and 35.39 mg/kg^{-1} - 30.00 mg/kg^{-1} respectively. Potassium is required for the normal functioning of nerves and muscle, the heart, the sugar metabolism, acid – base balance and oxygen metabolism in the brain. Sodium regulates the electrolyte and acid – alkali balances, conductive capacity of the nerves, muscles contraction and the production of adrenaline and amino acids. L. *dekimpei* and *P. loricatus,* recorded high level of calcium, and the feeding habit of these species and their relative preference for consumption of hard structure could be a contributing factor. This is in correlation with the work of Adewoye et al. and ATSDR [22,23] that the high calcium content recorded in *P. lericatus and L. dekimpei* could probably be due to preferential accumulation and calcification of scales and hard tissues. From nutritional point of view, fish composite of very high nutritional quality is rich in most of vitamins, proteins, minerals, fats and essential amino-acid and a nutritious part of human diet; an idea which had been justified by some biological experiments that it is nutritionally equivalent to those of meat, milk and eggs [26,27]. Despite the high nutritive value of *P. loricatus,* it also has the highest accumulation potential for heavy metals in all the fish samples analysed. This may be due to the discharges from the thermal station, the Nigeria National Petroleum Cooperation (NNPC) gas plant, runoffs from dump sites in the community as well as waste from car exhaust and other contributing anthropogenic activities.

Conclusion and Recommendations

This study revealed the importance of all the fish samples as good sources of protein and other essential nutrient for the proper functioning of the body. Of all the fishes, *Phagos lericatus* has the highest nutritive level followed by L. *dekimpei, C. latus* and *C. bibie*. This however will be an eye opener to the nutrient these fishes can provide and thus be a guide for the choice of consumption. Also, human activities that alter the ecosystem should be discouraged and prohibited. Therefore, it is strongly recommended that the culture of these fish species in Nigeria should be encouraged and its meal for growing children is highly advocated with caution. Also, it is recommended that fish meat should be properly assessed for quality assurance before consumption and anthropogenic activities around our water course be discouraged to avoid build-up of heavy metals in aquatic habitat.

Conflict of Interests

Authors declare that there has been no conflict of any sort throughout the period of this research till now.

Acknowledgement

This project is self-sponsored by the author, and hence would like to thank the staff and laboratory workers of the Fisheries and Hydrobiology laboratory of the Department of Pure and Applied Department, Lautech, Ogbomoso, Nigeria for their efforts during the course of this work.

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