Comparative Study of the Nutritional Benefits and Potential Health Risk Assessment of Selected Heavy Metals in Cat Fish Cultured in Earthen and Plastic Ponds

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ABSTRACT- Cat fish (*Clarias gariepinus*) is an important stable food in most homes in Nigeria. It is consumed for it taste, flavour and nutritional benefit. Apart from being a source of protein, fish is known to be a source of essential fatty acids and minerals. Thus, it becomes imperative to investigate the nutritional benefits. In this study, an attempt is made to investigate the comparative nutritional benefit as well as health risk of trace metals accumulated in both cat fish cultured in earthen and plastic ponds. The dried fish at 105°C were subjected to proximate analysis which reveal that catfish found in plastic pond have a higher percentage of carbohydrate (40.30%), crude fat (12.04%), ash content (5.78%) with a lower amount of protein (41.86%) than fish from earthen pond which recorded carbohydrate (32.33%), crude fat (0.38%), ash content (5.3%) with a higher percentage of protein (61.02%). For trace metal analysis, high quantity of minerals like Na, Mg, Ca, P and K were recorded for both earthen pond and plastic pond compared to toxic metals like Cd and Pb, which were also analysed. Trace mineral element like Zn, Cu, Ni, Fe and Mn were found in catfish samples analysed, to be below WHO standard. However, the composition of these mineral in the 3 major part of the catfish were specifically observed to decrease in the sequence head > trunk> tail for both earthen and plastic pond.

The potential human health risk of selected trace metals upon consumption for this study is determined using the estimated daily intake (EDI), health risk Index (HRI), target hazard quotient (THQ) and cancer risk(CR). The HRI shows values > 1 for analysed trace metals in cat fish samples obtained from plastic pond, while earthen pond was relatively safe. Also result reveals THQ for Mn, Fe, Zn, Cu, Ni, Cd and Pb are less than 1, indicating its safety while CR conducted on Ni and Cd falls within USEPA permissive limit, but for Pb, there is potential risk of cancer.

Keywords: Cat fish, Cancer Risk, Estimated Daily Intake, Health Risk, Proximate Analysis, Target Hazard Quotient and Trace Metals.

1.0 INTRODUCTION

The fish has long been recognized as a valuable source of animal protein; vitamins A and D; minerals (K, Ca, Mg, P); fatty acids and dietary carbohydrate [1],[2]. As a product of aquaculture, it is an important stable food in every part of the world particularly in less developed countries [3]. As a means of culturing fish, aquaculture is necessary in order to meet the food demands of a growing global population. However, only a small number of the species are commonly consumed by humans. Of the common fish species that are consumed by humans are cat fish, (*Clarias gariepinus*), tilapia fish, (*Tilapia milotical*), mackerel,(*Scomber australasicus*) to mention a few. Many societies have moved from hunting and gathering to culturing aquatic species. Just like animals, fishes have been over fished beyond the sustainable level. Thus, aquaculture is practiced commercially with the aim of replenishing depleted fishery stocks to benefit all and also to enhance the local fishing economy. Commonly cultivated in Nigeria is the Africa Catfish (*Clarias gariepinus*), which is often cooked in a variety of stews. It is particularly cooked in a delicacy known popularly as catfish pepper soup, which is enjoyed throughout the nation.

The African catfish (*Clarias gariepinus*) belong to the family Clarridaeactinopterygii, subphyllum vertebrata, phylum chordata and kingdom Animalia. It is recognized by its long–based dorsal and anal fins which gives it a rather eel-like appearance. *Clarias* have slender body, a flat, bony head and a broad, terminal mouth with four pairs of barbels. It has a large, accessory breathing organ composed of modified gill arches with only the pectoral fins having spines. As a source of protein, micro-nutrients and essential fatty acid, fish provide important complement to the predominantly carbohydrate based diet eaten by most people especially the poor. Generally speaking, fishes are good source of high quality animal protein as well as dispensable and indispensable amino acid in human [3]. High percentage of polyunsaturated fatty acids found in fish is important in lowering the cholesterol level in the human blood. The oil from the fish contains vitamin A, D, E and K which has been successfully used in controlling coronary heart diseases like arthritis, arteriosclerosis, asthma, auto-immune deficiency diseases and also cancer [4],[5]. Most importantly, it is rich in vitamin D, Omega-3 fatty acids and has a much proportion of Omega-6 fatty acid and provides highly absorbable dietary minerals in human nutrition [6]. As a result, the knowledge of its tissue composition is essential for its optimal utilization as food. Also its chemical compositions vary widely, depending on its surrounding biota, length, weight and sex [7],[6].

Fishes are also capable of accumulating high amount of toxic metals as they come in contact with the sediment and water body that houses them. Most oceans, rivers, lakes and sea are polluted due to increased disposal of heavy metal-laden industrial waste. This is a well-known phenomenon in less developed countries where there are few environmental laws and waste treatment standard to tackle this menace [8]. Different metals are introduced into the aquatic system through several means which includes weathering of rocks and soil, dissolution of aerosol particles in the atmosphere and through industrial activities such as mining, canning and electroplating which produce metal rich effluents [9],[10]. However, the presence of metal pollutant in fresh water is known to disturb the delicate balance of the aquatic ecosystem which has been noticed [11] to manifest in the presence of some irregularities in the fish physiology as the fish tends to concentrate some metals in their body tissue [10],[11] through bio-accumulation.

The demand for fish in Nigeria is relatively high, due to the nutritive value of its composition above meat. Fish can serve as vehicles for the accumulation of toxic metals which are dangerous to public health. Hence, this research work seeks to compare the nutritional, mineral and heavy metal composition of cat fish (*Clarias gariepinus*) reared in earthen and plastic ponds, further estimating its potential carcinogenic and non-carcinogenic risk using the USEPA approach.

2.0 MATERIALS AND METHODS

2.1 Study site and the ponds

The study was conducted within the research farm at the Federal University of Technology, Akure, Nigeria. A circular earthen pond (2 m diameter and 2 m deep) was dug manually and the surrounding area was weeded. As normally done by commercial fish farmers using earthen ponds, the dug pond was treated with Phostoxin to kill potential predators of fingerlings that would be grown in the pond. Such predators may include big snakes, tortoises and monitor lizards. The pond was then left for 2 weeks before stocking with 200 catfish (*Clarias gariepinus*) fingerlings, each weighing between 3 and 4 g.

A large plastic Geepee™ water tank, made of high density polyethylene, 2m (diameter) x 15 cm (thickness) was purchased and used for the plastic pond experiment. The tank was cut open at the top, so that the remaining length is approximately 2 m. It was placed beside the earthen pond and stocked with the same number of catfish fingerlings. Both ponds were operated with distilled water filled to about 1.8 m depth.

Fishes in both ponds were fed with Durante™ floating feed, sizes 1.5mm, 1.8 mm, 2mm and 4mm in succession for 2 months, and then switched to sinking feed 2mm to 8 mm until they are 6 months old, when they were all removed from the ponds.

2.2 Fish Sanpling and Sample preparation

Six adult cat fish *Clarias gariepinus* were sampled, however, each of these cat fish were patiently sampled to ensure they were of approximately equal weight and same sex. For analytical purposes, the fish samples were separated into head, trunk and tail and these were dried in an electric oven at 105^{o}C for one day. Fish samples were further grounded to powder and kept in air-tight plastic container in refrigerator for further analysis.

2.3 Proximate analysis

To access the nutritional compositional of the dried cat fish (*Clarias Gariepinus*), proximate analysis was carried out following [12] procedure: testing for parameters such as moisture content, ash content, crude protein, crude fibre, carbohydrate and crude fat. For these analyses, dried fish samples for head, trunk and tail were individually analyzed for both ponds.

2.4 Determination of crude protein

The protein content of the fish samples is estimated from the organic nitrogen content and determined by the Kjedahl procedure which was carried out in 3 steps;

The first step involved digestion in which 1.0 g of the sample was digested with concentrated H_2SO_4 in a dry 500 mL Kjedahl digestion flask together with 0.8 g of digestion catalyst mixture (400 g of Na_2SO_4, 16 g of hydrated $CuSO_4$ and 3 g of selenium dioxide). The mixture was then swirled together and the flask was fitted with a loose pair stopper in an inclined position. It was then placed in a fume cupboard, heated and the mixture was swirled intermitently in order to wash down any charred material adhering to the flask. The flask was allowed to cool, after which the clear solution was diluted with distilled water to 100 mL and transferred into Kjedahl distillation flask. The second step was the distillation stage. This involved steam distillation of cooled, diluted, digested sample to which 25 mL of 40 % NaOH was added. To the receiving flask, 5 mL of boric acid solution was added and few drops of screen methyl red indicator (0.016 g of methyl red and 0.083 g of bromocresol green were dissolved in 100 mL of alcohol) were also added to produce a pink colour solution. As the distillation proceeds, the pink colour of the receiver turned deep green indicating the presence of NH_3. Distillation continued until the distillate was about 50 mL after which the delivering end of the condenser was rinsed with distilled water into the receiver.

Digestion

(a) Sample plus concentrated $H_2SO_4 \longrightarrow (NH_4)_2SO_4$ + Excess conc. H_2SO_4

(b) $C + O_2 \longrightarrow CO_2$

Distillation

(a) $(NH_4)_2SO_4 + 2NaOH \longrightarrow 2NH_3 + Na_2SO_4 + 2H_2O$

The receiving NH_3 forms a complex with boric acid as $NH_4{}^+H_2BO_3{}^-$

Titration

The final stage involves titration in which NH_3 received in the acid solution is titrated with 0.1M HCl solution.

$NH_4{}^+H_2BO_3{}^- + HCl \longrightarrow NH_4Cl + H_3BO_3$

The colour changes from green to pink

Calculation:

%Nitrogen = [(M x V x DF) ÷ W] x 100 (1)

Where M = molarity of the acid, V = volume of acid used, DF = dilution factor, W = weight of sample

Crude Protein = %N x 6.25 (2)

Where 6.25 is a general factor of food sample containing high protein content [5].

2.5 Dietary and heavy analysis on fish

Minerals were analyzed from solution obtained by first dry-ashing. 3g of each sample (head, trunk and tail) from the two ponds were placed in dishes and heated gently on a burner in a fume cupboard until the charred mass had ceased to emit smoke and they were transferred to muffle furnace at 550°C to be charrred. The dishes plus ash was transferred to a desiccator to be cooled after which 20mL of 0.1M HCl solution was added to the ash. They were then filtered through acid wash Whattman number 43 filter paper into 100 mL standard volumetric flask and made up to the mark with distilled water. Atomic absorption spectrophotometer was used for the analysis of the following dietary minerals: P, Na, K, Ca and Mg and also for heavy metals such as Mn, Fe, Zn, Cu, Ni, Cd and Pb. They which were all determined with flame photometer, while P by Vanado molybedate method and the standard for each metal using suitable salt of each metal was prepared.

2.6 Health risk calculations

2.6.1 Estimated Daily Intakes (EDI)

Estimated Daily Intakes (EDI) of the analyzed metals gives an indication of their phytoavailability and it is defined as the average daily metal loading into the body of a specific human consumer with a known weight [13]. It is calculated based on the formulae below where MC= Mean metal concentration and DFC= Daily Fish Consumption.

EDI = MC x DFC (3)

2.6.2 Health risk index (HRI)

Health risk index (HRI) also known as the hazardous quotient for consumers [14] of contaminated cat fish, assessed as the ratio between the EDI and the oral reference doses (RfD) stipulated for each metal [15]. HRI values equal to or greater than 1 is considered unsafe for human health, thus protective measurements should be taken and for HRI values less than 1 is safe health wise [15].

HRI= EDI ÷ RfD (4)

2.7 Target health quotient (THQ)

Target health quotient (THQ)would be used to assess the non-carcinogenic risk for heavy metals (Mn, Fe, Zn, Cu, Ni, Cd and Pb) present in the whole fish. It is calculated by the method described by the United States Environmental Protection Agency(USEPA) [16],[17].

THQ=EFr x ED x FIR x CRfD x ABW x TA x 10^{-3} (5)

Where, EFr= exposure frequency(365dyear^{-1}); ED = 54 year which is the average life expectancy in Nigeria; FIR= 49.5g/person/day, which is the food ingestion rate for fish [17].; C =the concentration of the metals in mg/kg; RfD: Oral reference doses and this is different in different metals for (Mn= 0.14 mg kg^{-1}bw d^{-1} , Fe= 0.7 mg kg^{-1}bw d^{-1} , Zn= 0.3 mg kg^{-1}bw d^{-1} , Cu= 0.04 mg kg^{-1}bw d^{-1} , Ni= 0.02 mg kg^{-1}bw d^{-1} , Cd= 0.001 mg kg^{-1}bw d^{-1} , Pb= 0.004 mg kg^{-1}bw d^{-1} ; ABW = (60kg) average Body weight ;TA= average exposure time for non-carcinogenic (ED 365dyear^{-1}). If THQ >1, then the exposed population needs medical intervention as there are adverse health effect; for THQ<1, there is no potential health hazard for the exposed population.

2.8 Carcinogenic risk (CR)

Carcinogenic risk (CR) is computed by multiplying the cancer slope(CSF) by the estimated daily does as provided by the USEPA [17]. The ingestion CSF estimates the probability of an individual to develop cancer through oral exposure to contaminated levels of a specific heavy metals over a life time [16]. The equation is given below;

CR= CSF x EDI (6)

The carcinogenic slope factor for Cd is 0.3800085(mg/kg/day)$^{-1}$,Ni 0.0085(mg/kg/day)$^{-1}$, Pb0.0085(mg/kg/day)$^{-1}$, according to Integrated Risk Information system USEPA 2012, the CR for the acceptable carcinogenic risk in human ranges between 10^{-4} to 10^{-6}. Above this specification is unsafe, and below requires further consideration as Cd, Ni and Pb are chemicals of concern [16].

3.0 RESULT AND DISCUSSION

3.1 Proximate analysis

Table 1 shows the comparison of proximate composition (%) of heads, trunks and tails of fish from earthen and plastic ponds.

3.2 Fish head

Mineral content in food is roughly measured by it ash content [18]. The ash content in the fish head is greater in plastic pond (5.92%) than in earthen pond (5.14%). This result as showed for ash in Table 1 disagreed with that reported (6.40) by [19]. Moisture was not detected in the head for the two ponds because the fish samples were already properly dried and this indicates that dried fish are not susceptible to microbial attack. Crude fat of the fish head in plastic pond (8.20%) was also higher compare to that from earthen pond (0.49%). Fibre was not detected in the fish from plastic pond but was detected fish from the earthen (1.12%) pond as shown in Table 1. The crude protein in the fish from earthen (76.1%) was found to be higher than that of plastic pond (48.13%). The high value of protein in the fishes from both ponds indicates that they are rich source of protein to the consumer [1]. Overall cat fish head has the highest amount of protein as shown in Table 1 compared to the trunk and tail. The carbohydrate content of fish from earthen pond (16.89%) was higher than that of plastic pond (37.7%)

3.3 Fish trunk

In the trunk, mineral content recorded as ash for cat fish found in earthen pond (6.03%) was similar to that found in plastic pond (6.14%). Table 1 also showed that fish trunk is rich in minerals compared to the other two parts; this is due to the possibility of the fish accumulating metals in the guts [8]. Again moisture content and crude fibres for both fish trunks analyzed from both earthen pond and plastic pond were undetected. This observation is understandable as the trunk is majorly composed of flesh and digestible protein. However, plastic ponds recorded a high crude fat for the cat fish trunk (10.59%) than cat fish in earthen pond (0.5%). The crude protein content and carbohydrate was high 68.01% and low 25.46% respectively for fish trunk analyzed for earthen pond however, low 38.51% and high 44.77% in comparison with those from plastic pond for protein and carbohydrate respectively.

3.4 Fish Tail

From Table 1, tails of fish in plastic ponds (5.29%) are rich in minerals due to the higher % ash content compared to earthen pond (4.73%) [1]. Also moisture content and crude fiber were undetected in fish tail samples from both ponds. This implies fish is not a rich source of dietary fibers which aids digestion in man. The fat content in tail was much higher compared to fish trunk and fish head, with fish tails from earthen (2.46%) and plastic pond (17.29%) having the highest possible fat content. The protein content in fish from earthen pond (38.98%) was not significantly different from those from plastic ponds (38.94%). Fish tails also contain a considerable high amount of carbohydrate, second only to protein for all the parameters. The carbohydrate content in fish tail from earthen pond (54.64%) is however higher than plastic pond (38.44%), this can be due to possibility of feeding on aquatic plants which are rich in carbohydrate.

Table 1: Comparison of proximate composition (%) of heads, trunks, and tails of fish from earthen and plastic ponds

Proximate parameter	Earthen Pond Head	Plastic Pond Head	Earthen Pond Trunk	Plastic Pond Trunk	Earthen Pond Tail	Plastic Pond Tail
Ash Content	5.14±0.01	5.92±0.010	6.03±0.01	6.14±0.01	4.73±0.01	5.29±0.01
Moisture content(%)	N.D	N.D	N.D	N.D	N.D	N.D
Crude fat (%)	0.49±0.00	8.20±0.25	0.50±0.000	10.59±0.25	2.46±0.01	17.29±0.21
Crude fiber(%)	1.12±0.15	N.D	N.D	N.D	N.D	N.D
Crude Protein (%)	76.10 ±2.4	48.13±1.75	68.01±0.4	38.51±0.88	38.98±0.80	38.94±0.44
Carbohydrate (%)	16.89±0.22	37.70±1.75	25.46±0.40	44.77±0.62	54.64±0.02	38.44±0.24

Data are mean values of triplicate determination ± standard deviation.

ND= Not detect

3.5 Dietary and heavy metal analysis in fish

Table 2 showed the result of nutritionally valuable minerals and heavy metals in the head, trunk and tail of fish from plastic pond. The most common minerals in fish are potassium, sodium and calcium, which are important for proper functioning of the nerves, bone formation and also act as enzymes co-factors. Manganese is essential for reproduction and for normal functioning of the nervous system [20]. Also other essential heavy metals like Iron is essential in blood formation; Zinc (Zn) is essential for the proper function of these various enzymes [21]. Metals like Pb and Cd are non-nutritive and are therefore carcinogenic and toxic to the fish and human body [15]

3.6 Fish Head

Cat fish live in fresh water with a low amount of dissolved minerals optimum for it survival (Emmanuel *et al.*, 2016). As shown in figure 2,the concentration of Na(256.42mg/kg), K(1103.58mg/kg),Mg(327.21mg/kg),Ni(0.014mg/kg),Cd(0.002mg/kg), Pb (0.001mg/kg) is higher in earthen pond due to possible dissolution of these minerals and their compounds from the earth into the pond. From this result, it can also be noted that non-essential minerals such as Cd and Pb are in trace quantity in the fish head and poses no threat to human life. However, others such as Ca (562.96mg/kg), Mn(13.07mg/kg),Fe(17.23mg/kg),Zn(8.46mg/kg),Cu(2.72mg/kg) and P(731.58mg/kg) are higher in plastic pond. A possible justification for this is possibility of such trace metals in the formulated feed used to feed the fish, as this appears to be the only source alongside the biota used for culturing the fish. In general, the cat fish head is a good source of Na, Mg, K, Ca, and phosphorus [1].

3.7 Fish Trunk

As shown in Table 2, fish from earthen pond are richer source of Na(192.17mg/kg),K (968.32mg/kg),Ca(491.17mg/kg),Mg(313.11mg/kg),Ni(0.009mg/kg) and P(728.62mg/kg) compared to plastic ponds, which indicated that the fish is capable of concentrating these trace elements in its Trunk (composed of intestines and guts). The essential mineral elements can complement the amount prepared in the feed formulation except for Cd which is toxic [9], but present in trace quantity 0.002mg/kg. Furthermore, the extensive feeding of fish in plastic pond compared to earthen pond can be responsible for the higher amount of essential element such as Mn(11.28mg/kg), Fe(16.18mg/kg),Zn(8.14mg/kg), Cu(2.31mg/kg), which accumulates in the guts of the fish [22] and made available due to limited absorptive surfaces in the pond [21], which the biota in earthen pond provides. Pb(0.001mg/kg) was also observed to be present in very trace quantity in the samples from plastic pond which were analyzed. In similar trend as the fish head, the fish trunk is a good source of dietary minerals like Na, Na, Mg, K, Ca, and phosphorus [1],[21].

3.8 Fish Tail

The fish tail also contains trace metals, but they are in much smaller quantity compared to the fish head [2]. However, in comparison, sampled fish tails from plastic ponds are richer in K (952.37mg/kg), Ca (528.64mg/kg), Fe (12.05mg/kg), P(693.14mg/kg) compared to earthen pond. K, Ca, Zn, Fe and P are basic trace metal in cat fish feed, thus justifying it abundance in the fish. In earthen ponds, fish tails are found to have higher amount of Na (195.08mg/kg),Mn(12.21mg/kg),Mg(320.72mg/kg),Cu(2.21mg/kg), Ni(0.012mg/kg) and heavy metals like Cd(0.001mg/kg) as shown in Table 2. However, Pb was not detected in the tail for both fish samples from earthen and plastic pond.

The variation in the amount of these metals at different areas in the fish body is dependent on their availability in the waterbody [22] and the absorptive tendency of the fish part [23]. For all 3 sub-samples (Head, Trunk and Tail), the amount of mineral is much higher in both the head and the trunk. The concentration of non-essential metal is very low and hence possess no potential threat to the fish. Also, other heavy metals such as Mn, Fe, Zn, Ni, Cu, Fe is low, but excess consumption might be toxic. Lastly, fish from plastic pond is fit for consumption as the level of heavy metals in it is lower compare to that from earthen pond.

Table 2: Comparison of Mineral Composition of Head, Trunk and Tail of fish from earthen and plastic pond

Proximate Parameter	Earthen Pond Head	Plastic Pond Head	Earthen Pond Trunk	Plastic Pond Trunk	Earthen Pond Tail	Plastic Pond Tail
Na (mg/kg)	256.42±0.04	213.86±0.03	192.17±0.04	188.62±0.03	195.08±0.02	174.19±0.03
K (mg/kg)	1103.58±0.03	1008.4±0.03	968.32±0.04	931.74±0.01	852.93±0.02	952.37±0.03
Ca (mg/kg)	520.08 ±0.05	562.96±0.04	491.17±0.04	474.13±0.03	513.24±0.03	528.64±0.02
Mn (mg/kg)	12.17±0.01	13.07±0.02	10.06±0.02	11.28±0.01	12.21±0.02	12.08±0.01
Mg (mg/kg)	327.21±0.05	306.64±0.04	313.11±0.02	298.41±0.01	320.72±0.03	316.12±0.02
Fe (mg/kg)	15.17±0.02	17.23±0.01	12.00±0.01	16.18±0.02	11.08±0.01	12.05±0.03
Zn (mg/kg)	6.97 ±0.01	8.46±0.02	5.12±0.01	8.14±0.01	6.43±0.02	9.08±0.01
Cu (mg/kg)	2.16±0.02	2.72±0.01	2.03±0.01	2.31±0.02	2.21±0.02	2.09±0.01
Ni (mg/kg)	0.014±0.001	N.D	0.009±0.001	N.D	0.012±0.001	N.D
Cd (mg/kg)	0.002±0.001	N.D	0.001±0.000	N.D	0.001±0.000	N.D
Pb (mg/kg)	0.001±0.000	N.D	N.D	0.001±0.000	N.D	N.D
P (mg/kg)	641.94±0.07	731.58±0.05	728.62±0.05	715.83±0.06	634.19±0.04	693.14±0.03

Data are mean values of triplicate determination ± standard deviation.

ND- Not Detected

3.9 Estimated daily intake

The estimated daily intake rate of metals and minerals in *Clariasgariepinus* iscalculated that a 60kg person consumes 49.5g of fish daily [17]. The mean concentration of the nutritionally valuable minerals and trace metal values from the head, tail and trunk were used to estimate the daily intake. The estimated daily intake for essential minerals like P, Na, K, Ca and Mg is shown in table 3. From this study, fish from earthen pond is richer in Na(10.63mg/kg), K (48.26 mg/kg) and Mg (15.86 mg/kg) compared to plastic pond, but fish from plastic pond is richer in Ca (25.83mg/kg) and P (35.32mg/kg) than fish from earthen pond as observed in table 3. Other trace metals like, Mn, Fe, Zn, and Cu is higher in fish reared in plastic ponds (0.6011mg/kg, 0.7501mg/kg, 0.4237mg/kg and 0.1175mg/kg respectively) than fish reared in earthen pond (0.5683 mg/kg, 0.6311 mg/kg, 0.3056 mg/kg, and 0.1056 mg/kg respectively). For more toxic metals Ni, Cd and Pb, they are present in a very insignificant quantity in both ponds studied however, fish from earthen pond seems to hold insignificant amount of Ni and Cd, while both ponds holds insignificant amount of Pb.

Table 3: Mean value and estimated daily intake of metals in fish from both earthen pond and plastic ponds

Metal	Mean(Earthen Pond)	Mean(plastic Pond)	EDI(Earthen Pond)	EDI(plastic Pond)
P (mg/kg)	668.250± 52.430	713.520± 19.320	33.078	35.320
Na (mg/kg)	214.700± 36.530	192.220± 20.080	10.630	9.515
K (mg/kg)	974.900± 125.450	964.170± 39.670	48.300	47.730
Ca (mg/kg)	508.200± 15.110	521.910± 44.800	25.150	25.830
Mg (mg/kg)	320.300± 7.057	307.060± 8.860	15.860	15.200
Mn (mg/kg)	11.480± 1.230	12.140± 0.900	$5.683x10^{-1}$	$6.011 x10^{-1}$
Fe (mg/kg)	12.750± 2.146	15.150± 2.740	$6.311 x10^{-1}$	$7.501 x10^{-1}$
Zn (mg/kg)	6.17± 0.951	8.56± 0.480	$3.056 x10^{-1}$	$4.237 x10^{-1}$
Cu (mg/kg)	2.13± 0.093	2.37 ± 0.320	$1.056 x10^{-1}$	$1.175 x10^{-1}$
Ni (mg/kg)	$1.167x10^{-2}$± 0.002	ND	$5.775x10^{-4}$	ND
Cd (mg/kg)	$1.333x10^{-3}$± 0.001	ND	$6.6x10^{-5}$	ND
Pb(mg/kg)	$3.333x10^{-4}$ ±0.006	$3.333x10^{-4}$ ±0.006	$1.65x10^{-5}$	$1.65x10^{-5}$

Values are means of three replicates ±SD.
ND= Not detect

3.10 Health risk index

Health risk index for trace micronutrients as shown in table 4 shows that health risk due to Mn(4.294mg/kg),Fe(1.072mg/kg),Zn(1.412mg/kg) and Cu (2.937mg/kg) in cat fish cultured in plastic pond are unsafe and require urgent intervention as HRI>1, except for Pb (0.003713mg/kg). Values obtained in earthen pond are much safer as Fe (0.9016mg/kg), Ni (0.0297mg/kg),Cd(0.06435mg/kg) and Pb(0.003713mg/kg) as HRI<1 except for Mn (4.059mg/kg) and Zn (1.019), which is harmful to the local consumer of catfish.

Table 4: HRI and THQ for metals found in fish cultivated in both earthen and plastic ponds.

Metals	HRI (Earthen Pond)	HRI (Plastic Pond)	THQ(Earthen Pond)	THQ(plastic Pond
Mn (mg/kg)	4.059	4.294	$6.765x10^{-2}$	7.15610^{-2}
Fe (mg/kg)	$9.016x10^{-1}$	1.072	$1.503x10^{-2}$	$1.786x10^{-2}$
Zn (mg/kg)	1.019	1.412	$1.698x10^{-2}$	$2.354x10^{-2}$
Cu (mg/kg)	2.640	2.937	$4.400x10^{-2}$	$4.895x10^{-2}$
Ni (mg/kg)	$2.970x10^{-2}$	ND	$4.810x10^{-4}$	ND
Cd (mg/kg)	$6.435x10^{-2}$	ND	$1.100x10^{-3}$	ND
Pb(mg/kg)	$3.713x10^{-3}$	$3.713x10^{-3}$	$7.860x10^{-5}$	$7.860x10^{-5}$

ND – Not Detected

3.11 Non carcinogenic risk

Non-carcinogenic risk is estimated through THQ. The THQ is determined for essential micro-minerals to estimate the non-carcinogenic risk associated them as well as some few heavy metals. According to table 3, studies shows that fish cultivated in plastic ponds are richer in Mn(0.07156mg/kg),Fe(0.01786mg/kg),Zn(0.0235mg/kg) and Cu(0.0490mg/kg) compared to earthen pond. These statistics show that THQ values are less than 1 which 1implies there is no significant health risk if the intake of heavy metals is through the fish only [17]. For more toxic metals like Ni, Cd and Pb, the THQ values are very low in both ponds and also less than 1 according to table 3 and this makes it safe

3.12 CARCINOGENIC RISK

However, the potential health risk measured through the carcinogenic risk revealed that there is need for further study of Pb in both ponds as it is a chemical of concern capable of causing cancer. Pb values of $1.4025x10^{-7}$ in earthen pond and $1.4025x10^{-7}$ in plastic pond, which are beyond USEPA 10^{-6}-10^{-4}permissible limits. For Ni ($4.90875x10^{-6}$mg/kg) and Cd ($2.50806x10^{-5}$mg/kg) in fish from earthen pond are within the USEPA limits. However, for plastic pond they were not detected

Table 5: Carcinogenic Risk of Heavy Metal

Metal	CR (Earthen pond)	CR (Plastic pond)
Ni	$4.90875x10^{-6}$	ND
Cd	$2.50806x10^{-5}$	ND
Pb	$1.40250x10^{-7}$	$1.40250x10^{-7}$

ND – Not Detected

4.0 CONCLUSION

Being a popular stable food in most homes around the world and Nigeria, the consumption of cat fish can serve as a supplementary protein diet. The proximate study of cat fish from both earthen and plastic ponds reveals fish as a good source of crude protein, carbohydrate, crude fat and minerals, with higher percentage of protein, carbohydrate and fat. From this study, the concentration of trace metal element Pb in fish is insignificant in both ponds however, Ni and Cd are found insignificantly in earthen pond and undetected in plastic pond. Essential trace mineral element Mn, Fe, Zn and Cu in cat fish cultured in plastic pond have a higher concentration than fish reared in earthen pond. Other mineral elements Mg, K, Ca, Na and P are present in very significant amount in fish from both earthen and plastic ponds. As recorded in this study the concentrations of trace and toxic metals in fish is low in both ponds. However, in accessing the potential health risk, parameters like EDI, HRI and THQ were used. The EDI showed that essential trace metals are ingested at high amount while toxic metals are ingested in the fish at low amount. The non-carcinogenic risk measured using THQ showed that trace metals and heavy metals in both ponds are safe as they are below 1. However, there is HRI values for fish in plastic ponds is higher than that from earthen pond. Also the cancer risk for Ni and Cd falls within the USEPA standard of 10^{-4} and 10^{-6}, but for Pb there is need for constant monitoring as it lies outside this boundaries and hence unsafe for consumers.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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