



EVALUATION OF MINERAL CONTENTS IN AFRICAN CATFISH SPECIES - *Clarias gariepinus*, *Heterobranchus bidorsalis* AND HYBRIDS OF BOTH SPECIES

OLANIYI, W.A.

Department of Environmental Biology and Fisheries, Adekunle Ajasin University, PMB 001, Akungba-Akoko, 342111, Ondo State, Nigeria
waolaniyi@googlemail.com

ABSTRACT

In this study, mineral contents of African catfish species of Clarias gariepinus, Heterobranchus bidorsalis and hybrids of both species were evaluated. Essential mineral elements such as available phosphorus, exchangeable cations (calcium, magnesium, potassium and sodium) and micronutrients (copper, zinc and iron) were determined. Data showed that the samples are excellent sources of all the minerals by providing optimal recommended dietary allowance except in calcium element. There were no significant differences ($P > 0.05$) in the mineral content of zinc (11.27 – 18.68 mg/kg), iron (50.5 – 105.76 mg/kg), calcium (0.33 – 0.49 Cmol/kg), phosphorus (10342.82 – 18956.80 mg/kg) and magnesium (2.35 – 2.89 mg/kg). Copper (mg/kg) varied significantly ($P < 0.05$) across the samples of C. gariepinus (2.92 ± 0.06), H. bidorsalis (1.48 ± 0.07), hybrid (1.69 ± 0.50) and reciprocal hybrid (1.36 ± 0.27). Manganese (mg/kg) indicated significant differences ($P < 0.05$) between C. gariepinus (3.19 ± 0.24) and H. bidorsalis (2.16 ± 0.22); while potassium (Cmol/kg) content of hybrid (33.65 ± 1.25) was significantly higher ($P < 0.05$) than that of H. bidorsalis (20.59 ± 0.01). Sodium levels (Cmol/kg) of C. gariepinus (17.53 ± 0.96) and reciprocal hybrid (27.58 ± 4.07) revealed significant difference ($P < 0.05$). These catfish products showed good composition of highly essential nutrients that promote nutrition security; therefore mineral contents should be the underlying determinant for quality products.

Keywords: mineral, catfish, *Clarias gariepinus*, *Heterobranchus bidorsalis*, hybrids

INTRODUCTION

Fish and its products avail numerous individuals and households in many countries the opportunities to achieve minimum required protein and minerals in their diets. Fish serve as means and source of food security to many individuals, households and countries by providing the cheapest food source and high foreign earnings. It importantly contributes to nutrition security and provides essential minerals such as iodine, selenium, zinc, iron, calcium, phosphorus and potassium; several vitamins, and micronutrients (e.g. vitamins - such as A and D, with B group vitamins, Omega-3 fatty acids, etc.). These minerals and nutrients are highly necessary in the diets, especially to the vulnerable population groups such as infants, children, pregnant and nursing women. In addition, the consumption of (oily) fish has proven to lower the risk of coronary heart diseases mortality (FAO, 2014). The fish products, that is fish meal and fish oil are respectively useful in the formulation of high-protein feed while fish oil are essential for the replacement of mineral oil or to treat diseases or conditions such as diabetes, hypertension etc. (FAO, 2014).

Fish are nutritious and contain important minerals for improved human diet. Its production has been contributing significantly to global employment, annual fish production and nutrition improvement; being good sources of protein, with low input

requirements and high returns (Omitogun and Aluko, 2002; Olaniyi and Omitogun, 2014). In Nigeria, *Clarias* and *Heterobranchus* are the two popular *Clariid* genera of aquaculture importance but the former is more popular than latter because it is readily more available (Fagbenro *et al.*, 1993; Adebayo and Fagbenro, 2004; Olaniyi and Omitogun, 2014). Tilapia is also one of the common freshwater species that commands market. The hybrids of *Clarias* and *Heterobranchus* have really been propagated for species improvement of desired one (or more) characteristic(s) sought-after in the either parent such as robustness, salinity or thermal tolerance, morphology, flesh quality among others (Lenormand *et al.*, 1988).

Fish is the cheapest source of mineral in human diet, and its deficiency can lead to biochemical, structural and functional pathologies, hence the presence and availability of its mineral should be documented. There are few studies on the mineral composition of fishes (Watanabe *et al.*, 1997), therefore the present study is a good contribution on the evaluation of the mineral contents of catfish species.

MATERIALS AND METHODS

Location, Fish Source and Processing

The study was carried out at the Departments of Animal Sciences, and Soil and Land Management,

Obafemi Awolowo University, Ile-Ife, Nigeria. Table sized catfish species of 800 ± 100 g were obtained from the stock held in the Wet laboratory of Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria. The samples consisted of parent species *Clarias gariepinus*, *Heterobranchus bidorsalis*, the hybrid (*C. gariepinus* \times *H. bidorsalis*)¹, and reciprocal hybrid (*H. bidorsalis* \times *C. gariepinus*). The species were all raised in the same rearing condition. Each sample species was firstly weighed and then dried in a hot air oven at 70 °C to a constant weight, and eventually ground to powder. Thereafter the tests for the following minerals were carried out, viz: Zinc, Iron, Copper, Manganese, Magnesium, Calcium, Phosphorus, Sodium, and Potassium.

Phosphorus determination

The determination of available Phosphorus was carried out using Bray-1 method (Bray and Kurtz, 1945). Two grammes of dried sample was weighed into a 250 ml Conical flask and 20 ml of Phosphorus extracting (P-A) solution (0.025 N HCl + 0.03 N NH₄F) was added and shaken for 5 min. The suspension was filtered with Whatman filter paper into laboratory bottles. Three millilitres of the filtrate was transferred into a colorimetric tube and 3 ml of reductant (P-B) solution, made of 0.87 N HCl, 0.38% ammonium molybdate and 0.5% H₃BO₃, was added in order to form a complex. 5 drops of colour developing (P-C) solution containing 2.5 g of 1-amino-2 sulfonic acid, 5 g sodium sulfite and 146 g of sodium metabisulfate were then added to each tube and mixed immediately in order to generate blue colour of the complex (Jackson, 1958). Thereafter, the absorbance of P was determined at 660 μ m wavelength using the spectrophotometer, and the concentrations of P in the samples were read. The analysis was carried out in duplicate.

Exchangeable cations (Ca, Mg, K and Na)

The exchangeable cations were determined by extraction method following Thomas (1982). The extraction from the samples was done using 1 N ammonium acetate solution buffered at pH 7. 10 g each of the sample were weighed into a 250 ml conical flask in duplicates. Thereafter, 100 ml of neutral ammonium acetate (NH₄OAc) extracting solution was added and agitated for 30 min. The suspension formed was then filtered with Whatman filter paper into 50 ml plastic bottles. Calcium, Na and K concentrations in the filtrate were then determined using flame photometer while Mg and Ca

were determined using Atomic Absorption Spectrophotometer (AAS).

Micronutrient determination

The following micronutrients, Cu, Zn and Fe of the samples were determined by extraction with 0.1 N HCl. 10 g of each sample was weighed into a 250 ml conical flask in duplicates followed by addition of 100 ml of 0.1 N HCl extracting solution and agitated for 30 min. The suspension formed was then filtered with Whatman filter paper into laboratory bottles. Copper, Zn, Fe, Mn were then determined using AAS.

Statistical analysis

Data for the catfish samples were subjected to statistical testing to verify differences between the groups by General Linear Models procedure through one way analysis of variance (ANOVA) using SAS[®], 2003.

RESULTS

The moisture and mineral contents evaluation in African catfish species of *C. gariepinus*, *H. bidorsalis* and their hybrids is shown in Table 1. The moisture content revealed very high values in all the fish samples and showed no significant differences ($P > 0.05$). Zinc mineral showed no significant differences across all the catfish samples ($P > 0.05$). The revealed data (mg/kg) respectively for *C. gariepinus*, *H. bidorsalis*, hybrid and reciprocal hybrid species were 11.27 ± 4.68 , 18.68 ± 1.07 , 13.77 ± 4.68 , and 17.76 ± 1.61 . Iron (mg/kg) also revealed no significant differences ($P > 0.05$) for *C. gariepinus* (103.28 ± 2.87), *H. bidorsalis* (105.76 ± 18.42), hybrid (80.05 ± 28.63) and reciprocal hybrid (50.50 ± 45.81). However, unlike Zn and Fe, copper (mg/kg) showed significant differences ($P < 0.05$) across the samples, *C. gariepinus* (2.92 ± 0.06), *H. bidorsalis* (1.48 ± 0.07), hybrid (1.69 ± 0.50) and reciprocal hybrid (1.36 ± 0.27). Manganese (mg/kg) revealed significant differences ($P < 0.05$) between the two parent species, *C. gariepinus* (3.19 ± 0.24), *H. bidorsalis* (2.16 ± 0.22), while the two hybrids; hybrid (2.37 ± 0.2) and reciprocal hybrid (2.46 ± 0.54) were neither significant from each and nor from the two parent stocks.

For Phosphorus (mg/kg), there were no significant differences ($P > 0.05$) in all the catfish samples *C. gariepinus*, *H. bidorsalis*, hybrid and reciprocal hybrid respectively, 10342.82 ± 1680.65 , 18956.80 ± 6557.09 , 14319.87 ± 5187.63 , 11713.82 ± 969.45 . For Magnesium (Cmol/kg⁻¹), there was no significant difference across the samples ($P > 0.05$), *C. gariepinus* (2.35 ± 0.06), *H. bidorsalis* (2.82 ± 0.08), hybrid (2.66 ± 0.57) and reciprocal hybrid

¹ The female parent species are firstly mentioned in the species breeding.

(2.89 ± 0.12). Calcium (Cmol/kg^{-1}) also showed no significant differences ($P > 0.05$), *C. gariepinus* (0.49 ± 0.04), *H. bidorsalis* (0.47 ± 0.03), hybrid (0.62 ± 0.35) and reciprocal hybrid (0.33 ± 0.04). For potassium (Cmol/kg^{-1}), the hybrid (33.65 ± 1.25) was significantly higher than *H. bidorsalis* (20.59 ± 0.01) ($P < 0.05$), while there was no difference ($P > 0.05$) in the *C. gariepinus* (25.14 ± 1.10) ($P > 0.05$), reciprocal hybrid (25.56 ± 1.47) and *H. bidorsalis*; and also there was no significant difference ($P >$

0.05) across the hybrids and *C. gariepinus*. Moreover, there was significant difference ($P < 0.05$) for sodium levels (Cmol/kg^{-1}) in the sample *C. gariepinus* (17.53 ± 0.96) and reciprocal hybrid (27.58 ± 4.07), while there was no difference between *H. bidorsalis* (20.65 ± 1.92) and hybrid (23.51 ± 2.11) ($P < 0.05$). *H. bidorsalis* and hybrid species showed no significant difference compared to *C. gariepinus* and reciprocal hybrid ($P > 0.05$).

Table 1: Moisture and mineral contents in African catfish species of *Claria gariepinus*, *Heterobranchus bidorsalis* and their hybrids

Parameters	<i>Clarias gariepinus</i>	<i>Heterobranchus bidorsalis</i>	Hybrid	Reciprocal Hybrid
Moisture content (%)	73.67 ± 2.08^a	77.67 ± 4.16^a	76.33 ± 12.74^a	77.33 ± 6.03^a
Zn (mg kg^{-1})	11.27 ± 1.71^a	18.68 ± 1.07^a	13.77 ± 4.68^a	17.76 ± 1.61^a
Fe (mg kg^{-1})	103.28 ± 2.87^a	105.76 ± 18.42^a	80.05 ± 28.63^a	50.50 ± 45.81^a
Cu (mg kg^{-1})	2.92 ± 0.06^a	1.48 ± 0.07^b	1.69 ± 0.50^b	1.36 ± 0.27^b
Mn (mg kg^{-1})	3.19 ± 0.24^a	2.16 ± 0.22^b	2.37 ± 0.2^{ab}	2.46 ± 0.54^{ab}
P (mg kg^{-1})	10342.82 ± 1680.65^a	18956.80 ± 6557.09^a	14319.87 ± 5187.63^a	11713.82 ± 969.45^a
Mg (mg kg^{-1})	2.35 ± 0.06^a	2.82 ± 0.08^a	2.66 ± 0.57^a	2.89 ± 0.12^a
Ca (Cmol kg^{-1})	0.49 ± 0.04^a	0.47 ± 0.03^a	0.62 ± 0.35^a	0.33 ± 0.04^a
K (Cmol kg^{-1})	25.14 ± 1.10^{ab}	20.59 ± 0.01^b	33.65 ± 1.25^a	25.56 ± 1.47^{ab}
Na (Cmol kg^{-1})	17.53 ± 0.96^b	20.65 ± 1.92^{ab}	23.51 ± 2.11^{ab}	27.58 ± 4.07^a

^{ab}Means within a row with different superscripts are significantly different ($P < 0.05$). General Linear Model procedure (SAS[®], 2003).

Clarias gariepinus = *Clarias gariepinus* × *Clarias gariepinus*; *Heterobranchus bidorsalis* = *Heterobranchus bidorsalis* × *Heterobranchus bidorsalis*; Hybrid = *Clarias gariepinus* × *Heterobranchus bidorsalis*; and Reciprocal hybrid progeny = *Heterobranchus bidorsalis* × *Clarias gariepinus*

DISCUSSION

Minerals are highly important and required for normal life biological and physiological processes. They are essential in the formation and maintenance of skeletal system, colloidal systems maintenance, acid-base equilibrium and regulation of compounds such as hormones and enzymes (Watanabe *et al.*, 1997). Moreover, the high level of water holding capacity of the fish species contributes to juiciness of fish product (Fauconneau and Laroche, 1996; Paredes and Baker, 1997), in addition to presence of the mineral composition. In this study, zinc presence in all the samples significantly revealed the same amount; and this depicts that relative value of the same mineral will be gained from any of the species if consumed. Zinc is a very important mineral that forms an integral component in the formation of many enzymes, including RNA and DNA polymerases (Rosa *et al.*, 2007). Moreover, it has been reported to play a crucial role in growth control (Chesters, 1991). The recommended dietary allowance (RDA) of zinc is 15 – 19 mg (HWN, 2005); hence, the *H. bidorsalis* and the reciprocal hybrid are better sources compared to other products.

Iron is one of the essential micronutrients that carries oxygen and also forms part of the oxygen-carrying proteins (Rosa *et al.*, 2007). FAO (2014) reported that more than 30% (~ 2 billion) of the world's population are suffering from iron deficiency; therefore good dietary source of iron content is necessary. The RDA of Fe is 15 mg (HWN, 2005), and this study has revealed that all the studied catfish products are very good sources of iron. Feeds from animal sources (fish meal and meat meal) have shown to be very rich in iron and contain 400 – 800 mg kg^{-1} and this is comparable to plant sources such as oil seeds and cereals containing 100 – 200 mg kg^{-1} and 30 – 60 mg kg^{-1} respectively (Watanabe *et al.*, 1997).

Copper is a trace element that is required as a component of many enzymes (Rosa *et al.*, 2007). It is an essential mineral that is important in the enzyme activities such as cytochrome oxidase, superoxide dismutase, lysyl oxidase, dopamine hydroxylase and tyrosinase (Watanabe *et al.*, 1997). The RDA of Cu is 1.5 – 3 mg (HWN, 2005); showing that the studied catfish species are good sources of this mineral. The study further revealed that, consumer will get good content of copper from the *C. gariepinus* species

compared to other catfish samples. Its requirement depends on the physiological condition of the animal, the copper content of the water (if it is aquatic animal) and the levels of the metabolic antagonists of this mineral such as zinc, iron, cadmium and molybdenum (Watanabe *et al.*, 1997).

Manganese is an essential mineral in growth and development especially in the formation of bone and cartilage, and glucose metabolism. It is also important in the normal functioning of the brain and in the lipid and carbohydrate metabolism. Majorly it serves as, (i) cofactor for enzymes that form metal-enzyme complexes; and (ii) an essential part of metalloenzymes, (Clark *et al.*, 1987). The RDA is 2–5 mg (HWN, 2005), and this further revealed that the catfish species of present study are all good sources of this mineral element. The deficiency leads to reduction in food intake, loss of equilibrium and poor growth and development (Ishac and Dollar, 1968; Ogino and Yang, 1980). In addition, its deficiency was reported to have great negative effect on the gonads of common carp and the hatchability of the eggs of brook trout and rainbow trout (Takeuchi *et al.*, 1981; Satoh *et al.*, 1987; Lall, 1989).

Phosphorus is a very important mineral that has been recommended for the treatment of arthritis, stress and tooth or gum disorders (Fang, 2000); though its availability is been reduced by processing methods. The RDA is 1000 mg (HWN, 2005). There should be balanced ratio between phosphorus and some minerals such as calcium, zinc and manganese, otherwise there may problems. Its excess leads to loss of equilibrium in the ratio of calcium to phosphorus, thereby affecting growth and development, and availability of zinc and manganese. Rosa *et al.* (2007) reported direct relationship between fat and phosphorus content in a fish, therefore fatty fishes contain higher values of phosphorus than the lean ones.

The exchangeable cations of magnesium, calcium and potassium have been proved to reduce blood pressure, thereby help to reduce the risk of hypertension and stroke (Paolisso and Barbagallo, 1997; Reddy and Katan, 2004; Nutinf, 2005); hence increased dietary intake is recommended. The RDA for calcium is 1200 mg (HWN, 2005), and this is ~ 6 cmol which indicates that studied catfish species are poor sources of calcium element. The RDA for magnesium and potassium is 400 mg and 3500 mg (~9 Cmol) respectively (HWN, 2005). Potassium has additional importance in the prevention of osteoporosis by maintaining the bone mineral density (New *et al.*, 2000). The present studied species are all good sources of these exchangeable cations except in calcium content. Moreover, among the exchangeable cations, sodium is the main element that is

responsible for the balancing of the acid to base relationship and that also helps in the transmission of the nerve impulses. According to HWN (2005), the daily intake of sodium should be less than 2400mg; while it may be cause hypertension if the level of Na:K is higher than 1.5 (Nutinf, 2005). All the present species have good proportion of Na/K levels and predisposes to no risk of hypertension.

CONCLUSION

The present study revealed that African catfish species are good sources of minerals that are indispensable for normal body system growth and development. The catfish products showed good composition of the highly essential nutrients that prevent diseases, promote good health, needed for survival of vulnerable groups such as infants, children, pregnant and nursing women. Therefore, mineral contents should be the underlying determinants for the choice of assured quality food products among other factors such as taste, size, freshness and other related external appearances in order to improve consumers' nutrition status.

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