PROTEIN, ENERGY AND MICRONUTRIENT OF FIVE DIFFERENT FISHES FROM TIGA RESERVOIR, NIGERIA

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ABSTRACT

This study evaluated the proximate, mineral elements, and vitamins composition of oven-dried *Schilbe mystus*, *Bagrus bayad*, *Oreochromis niloticus*, *Clarias anguillaris* and *Petrocephalus bane bane* from Tiga Reservoir. The fishes were obtained from landing site of Tiga reservoir at Rano, they were beheaded, degutted and cleaned with distilled water and oven-dried to a constant weight at 105 ^{O}C. Grinded form of samples were used for wet digestion and the contents were analyzed according to standard methods at the Biochemistry laboratory, University of Jos, The proximate content of the fishes varied significantly ($p<0.05$), with mean values of 4.79 - 9.52 g/100g moisture content, 42.20 - 57.71 g/100g crude protein, 0.90 - 12.51 g/100g ash content, 3.41 - 9.93 g/100g ether extract, 0.62 - 5.08 g/100g crude fibre, 12.28 - 42.70 g/100g nitrogen free extract and 90.48 - 95.21 g/100g dry matter. Based on the FAO/WHO recommended nutrient intakes (RNIs), calcium, magnesium, iron and zinc were found in appreciable amount. The vitamin content of the fishes were above the WHO recommended limits, peak values of vitamins B1 (33.88 mg/l), B6 (15.83 mg/l), B12 (3.04 mg/l), were observed in *P. bane bane* alone. Whereas, *C. anguillaris*, *O. niloticus* and *S. mystus* contained the highest values of vitamins A (15.87 mg/l), C (1.22 mg/l) and E (4.22 mg/l) respectively. It has shown that all the fishes could be utilized as sources of protein, mineral elements and vitamins for human and animal foods

Keywords: Fish species, freshwater, protein, nutrient, proximate composition

1. INTRODUCTION

In most Nigerian homes fish has become a noticeable meal on daily basis, as it could be eaten fresh or smoked form without any religious, age, educational and social discrimination [1]. The Nigerian fisheries subsector plays a vital role, as it accounts for 50% of total animal protein consumed by larger percentage of the populace [2]. Fishes are highly favoured against other animal protein sources due to its relatively low levels of collagen and cholesterol in the flesh, appealing flesh flavor [3] and better essential nutrient composition [4]. The major constituents of fish carcass include protein, fat, moisture and mineral elements [5]. Parts of proximate analysis from fish flesh comprises of ash, lipids, protein, crude fibre and nitrogen free extract, this assessment is implemented on fishes in order to guarantee their definite and nutrients standards [6]. Fish is similar to other animals as it possess enough quantity of the amino acids, for instance lysine which is limiting in cereals. Therefore, fish could be a better source of protein in order to meet up the requisite protein profile in common staple food of starch source [7]. Africans are identified to have high appetite for tuber and cereal food. Fish has become a dependable source of dietary protein as up to 15 to 20% were used to fill that void of limitations in food protein [8]. In Africa for instance, over 60% of babies less than five years of age died annually of complication from Protein-Energy Malnutrition [9]. Health threatening issues abound in most poor nations of the world and they are related to deficiency of nutrients. Acute nutrient deficiency case in Nigeria was 38% as reported in the Nepal Demographic and Health survey Fact Sheet (NDHS) [10].It is crucial for studies to come up regularly in order to gain relevant information on the nutrient content levels in fish species commonly eaten by the poor across the nations of Africa and Asia.

Based on the levels required for adequate utilization, inorganic elements are divided into two these include the macro or the micro elements [11]. The macro-elements are required in levels higher than 100mg/g while micro-elements are required in small amount less than 100mg/g [12]. Macro-elements are collection of inorganic elements such as: phosphorus, calcium, chloride and sodium etc. Among these elements, calcium is required for penetrability of membrane, effective muscle activity and proper transfer of nerve signals [12]. The significance of minerals in the body metabolism and growth of living organisms cannot be overemphasized as it builds up skeletal and colloidal systems, ensures acid-base equilibrium of the body, and makes up the components of several enzymes and hormones [13]. The roles of minerals in biological and chemical processes of living organisms, fish inclusive, have been documented. To evaluate requisite minerals, based on their minimum requirement in food consumption, information on foods, water and mineral element are paramount [13]. Micro nutrient found in fish include vitamins A, B, and D, together with manganese, calcium, selenium and phosphorus, these support its nutritious value as an excellent source of animal proteins for both human and animal consumption [14]. Data on nutrients levels of fishes especially in freshwater has become expedient to most field of food technology. Maia *et al*. [15] affirmed that variations exist between freshwater and marine fish species in relation to their mineral composition. Also, such differences extends to individuals that belong to a species, as a result of variation in age, habitat, gender and seasonality. The availability of nutrients in freshwater fishes are grouped on the basis of their distinct geographical areas, climate, species and genders [16] and relationship, could be discovered via the method of fish processing adopted [17]. It is crucial that fish and its products are monitored on regular basis to ensure it met requisite international standard of food analyses and essential nutrients, in order to balance up for the deficiency and minimize the death in babies cause by malnutrition in food [19]. This study evaluated the proximate composition, mineral elements and vitamins contents of *Schilbe mystus*, *Bagrus bayad*, *Oreochromis niloticus*, *Clarias anguillaris* and *Petrocephalus bane bane* from Tiga Reservoir, in order to ascertain the nutrient potentials of each fish species which could be used as nutrient sources in human and animal foods.

2. MATERIALS AND METHODS

2.1 Sample collection and digestion

Samples of five fish species namely *Schilbe mystus*, *Bagrus bayad*, *Oreochromis niloticus*, *Clarias anguillaris* and *Petrocephalus bane bane* were obtained monthly from Rano landing site of Tiga reservoir from August to October, 2015. Rano settlement is found at longitudes 8° 18' to 8° 35' E and latitudes of 11° 18' to 11° 27' N. Each fish was identified using fish identification keys of Olaosebikan and Aminu [20]. Thereafter, the samples were separately beheaded, degutted and cleaned with distilled water before been oven-dried to a constant weight at 105 ^{O}C in the laboratory. Scale removal was performed on *Oreochromis niloticus* before it was beheaded and degutted. Oven-dried samples were grinded to powdery form in preparation for digestion. The powdery form of each sample of the fish species was digested strictly in accordance with the method described by Kumar *et al*. [21].

2.2 Chemical analyses

The resulting supernatant solution from the digested samples were used for the proximate analysis. This was carried out in three replicates in accordance with the procedure of AOAC

[22], in the Biochemistry laboratory, University of Jos, Nigeria. Also the digested samples were used to determine the mineral content using atomic absorption spectrophotometer (AAS 50B, Australia). Vitamin contents of the samples were spectrophotometrically determined as follows: vitamin B complex was assessed using the procedure of Brubacher *et al*. [23]; vitamin A was measured with the method of Rutkowski *et al*. [24]; vitamin C was determined using the procedure of Rutkowski *et al.* [25] while vitamin E was measured with the method of Rutkowski *et al*. [26].

2.3 Calculation and statistical analyses

The calorific value of crude protein, crude lipid and nitrogen free extract (NFE) were calculated using the standard conversion factors [27].

a - crude protein = protein (g/100g) x 5.5 kcal/g (1)

b – crude lipid = amount of lipid (g/100g) x 9.5 kcal/g (2)

c – NFE = carbohydrate (g/100g) x 4.1 kcal/g (3)

Total Calorific Value = a+b+c. (4)

Statistical Package for Social Science (SPSS) version 20 was used for the statistical analyses. Data for proximate composition, mineral elements and vitamins were subjected to analysis of variance (ANOVA) while Duncan Multiple Range Test (DMRT) was used to separate means at 5% significant level [28].

3. RESULTS AND DISCUSSION

The values of the proximate assessment varied significantly ($p<0.05$) and showed that crude protein of sampled fishes ranged from 30.42±0.57 to 58.89±0.03 g/100g, and are presented in Table 1. This was a pointer to consumers that the fishes were rich source of protein. The fishes examined were found to possessed high crude protein with a slight differences among them. This could be linked to individual fish innate ability to take in and assimilate nutrients from its feed and immediate locality and subsequently convert such to protein [29]. The crude protein and ash contents values were both highest in *P. bane bane* 58.89 ± 0.03 g/100g and 12.99 ± 0.04 g/100g respectively thus, confirmed this fish nutrient endowment as protein and mineral rich source. While the least values of crude protein and ash contents 30.42 ± 0.57 g/100g and 0.47 ± 0.02 g/100g were found in *O. niloticus* and *B. bayad*. The crude protein content of *Clarias anguillaris* (37.01 g/100g) was a bit lower than the value of (41.28 g/100g) reported by Muhammad *et a*l. [30]. Similarly, Elagba Mohammed *et al*. [31], recorded a higher crude protein content of 77.00 g/100g and 78.00 g/100g for *B. bayad* and *O. niloticus*. The protein content of different fishes varies in relation to time of the year, consequent of reproduction, presence of diet and migration [32] On the basis of biochemical and physiological assessment of organisms, protein has been widely accepted as a crucial instrument for its contribution to body development, function and repairs [33]

Table 1: Proximate analysis and calorific value of sampled fish species

Proximate (g/100g) Dry Matter	*Schilbe mystus*	*Bagrus Bayad*	*Oreochromis niloticus*	*Clarias anguillaris*	*Petrocephalus bane bane*
Moisture	4.47±0.03[a]	8.06±0.04[c]	10.12±0.08[d]	8.02±0.04[c]	5.09±0.04[b]

content					
Crude protein	53.85±0.04^{d}	52.70±0.03^{c}	30.42±0.57^{a}	37.01±0.04^{b}	58.89±0.03^{e}
Ash content	11.99±0.02^{c}	0.47±0.02^{a}	0.52±0.27^{a}	4.00±0.04^{b}	12.99±0.04^{d}
Ether extract	10.32±0.02^{e}	3.08±0.03^{b}	2.90±0.14^{a}	8.11±0.04^{d}	6.72±0.02^{c}
Crude fibre	3.35±0.02^{d}	0.55±0.04^{b}	1.51±0.04^{c}	0.19±0.03^{a}	5.31±0.05^{e}
Dry matter	95.51±0.03^{d}	91.94±0.04^{b}	89.88±0.08^{a}	91.98±0.04^{b}	94.91±0.04^{c}
Nitrogen free extract	20.50±0.08^{b}	43.20±0.01^{c}	64.64±0.20^{e}	50.68±0.01^{d}	16.09±0.09^{a}
Total calorific value (kcal/g)	478.265	496.23	459.884	488.388	453.704

Means ±S.D within a row followed by different superscripts are significantly different ($p<0.05$).

The ether extract are recognized for their capacity as high energy sources of nutrients and are found to store as much as double the energy gotten from protein and starch [34]. The highest ether extract content of 10.32 ± 0.02 g/100g was observed in *S. mystus*, followed by *C. anguillaries* (8.11 ± 0.04 g/100g), *P. bane bane* (6.72 ± 0.02 g/100g), *B. bayad* (3.08 ± 0.03 g/100g) and *O. niloticus* (2.90 ± 0.14 g/100g). The ether extract of the sampled fishes were found to have fell within the group of low fat to high fat fish [29]. The disparity of the ether extract noticed among the sampled fishes could be attributed to the deviations in diets, age, water temperature, and species [35]. The gross energy of the sampled fishes were the aggregated amount found in individual fish and are shown as (total calorific value). *B. bayad* had the highest total calorific value of 496.23 kcal/g. But, *P. bane bane* had the least value of total calorific value of 453.704 kcal/g. The range of energy found in the sampled fishes was an evident that they were all high energy source of nutrient. The high dry matter content observed across the examined fishes could be as a result of the carcass qualities, as exemplified by the high crude protein contents. This is in consonance with the findings of Steffens [36], which submitted that protein forms bulk of the dry matter in fish carcass with low moisture and higher fat level. The ash content level in *Clarias anguillaris* was relatively higher than what was reported by Effiong and Mohammed [32], which observed a range of 0.41 to 1.35 g/100g for *C. anguillaris*. This was also affirmed by Adeyeye [37], that the ash content level of a fish sample depicts its nutritional mineral composition.

The concentration of mineral elements of the sampled fishes are presented in Table 2. In all the fish species, the mineral elements concentration differed significantly ($p<0.05$), with the exception of cadmium and lead which were observed below detectable limits. The values of essential elements in organisms depend on the rate of absorption through the medium homeostatically, especially, during respiration and from food consumed [29][35]. Peak values of iron (1.625 mg/g), potassium (2.638 mg/g), calcium (4.578 mg/g) and phosphate (0.371 mg/g) were observed in *P. bane bane*. Since calcium was the mineral with the highest concentration across all the fishes, followed by potassium and magnesium, confirmed the richness of the sampled fishes in essential elements. The levels of calcium and potassium minerals in fishes determine its nutritional importance [38]. Effiong and Fakunle [39], reported similar high concentration of potassium (0.76 mg/g), calcium (2.86 mg/g) and magnesium (0.32 mg/g) in *O. niloticus*. Also, recorded by the same authors were the peak values of potassium (0.63 mg/g), calcium (2.83 mg/g) and magnesium (0.21 mg/g) in *B. bayad*. Similar trend was found in the works of Effiong and Mohammed [32], wherein 0.75 mg/g potassium, 2.88 mg/g calcium and 0.30 mg/g magnesium were observed in *C. anguillaris*.

Table 2: Concentration of mineral elements in the sampled fish species

Element (mg/g)	*Schilbe mystus*	*Bagrus Bayad*	*Oreochromis niloticus*	*Clarias anguillaris*	*Petrocephalus bane bane*	FAO/WHO RNIs (mg/day)
Chromium	0.005±0.0002^{a}	0.012±0.0002^{c}	0.014±0.0002^{d}	0.014±0.0002^{e}	0.010±0.0004^{b}	
Iron	0.502±0.0003^{c}	0.261±0.0004^{b}	0.115±0.0003^{a}	0.611±0.0003^{d}	1.625±0.0003^{e}	3.9 -20.7
Magnesium	1.160±0.0002^{e}	0.521±0.0003^{b}	0.312±0.0003^{a}	0.603±0.0004^{c}	1.104±0.0004^{d}	26 -260
Potassium	2.296±0.0003^{d}	0.916±0.0004^{a}	1.461±0.0003^{b}	1.907±0.0002^{c}	2.638±0.0003^{e}	
Calcium	4.511±0.0003^{d}	2.852±0.0004^{b}	2.417±0.0004^{a}	3.521±0.0004^{c}	4.578±0.0004^{e}	300 -1300
Zinc	0.064±0.0002^{a}	0.095±0.0003^{e}	0.082±0.0005^{c}	0.079±0.0002^{b}	0.090±0.0003^{d}	1.1 - 6.0
Manganese	0.025±0.0003^{a}	0.040±0.0003^{c}	0.073±0.0002^{d}	0.091±0.0002^{e}	0.036±0.0004^{b}	
Phosphate	0.360±0.0004^{e}	0.352±0.0002^{b}	0.371±0.0003^{d}	0.315±0.0003^{a}	0.371±0.0003^{d}	
Copper	0.034±0.0001^{c}	0.049±0.0004^{e}	0.042±0.0003^{d}	0.027±0.0001^{a}	0.031±0.0002^{b}	
Cadmium	ND	ND	ND	ND	ND	
Lead	ND	ND	ND	ND	ND	

Means ±S.D within a row following by different alphabets are significantly different ($p<0.05$), ND (Not Detected). RNIs: Recommended nutrient intakes

The importance of mineral elements in animals has been reported in several studies. In most animals especially fishes, calcium is required for growth and repairs of teeth, bones, muscles, nails and/or scales [40], adequate calcium concentration in the body cells is crucial for the production of cellular cement substances and clotting of blood. The consumption of potassium at every stage of life in man could ensure proper control of blood pressure, heart ailment like stroke, amount of blood fat and kidney function [41].In addition, it maintain proper activities of the muscle and nervous system, as well as the body sugar level, body fluid pH and brain supply of oxygen [29] Magnesium is required in the body for bone formation, regeneration of cells, maintenance of protein and fatty acid, increase activity of vitamin B, muscle flexibility, enhanced blood clotting and production of energy [29]. The peak value of magnesium (1.160 mg/g) was found in *S. mystus.* Generally, nutrients of animal origin are known to be poor means of magnesium. The order of occurrence of the macro-elements (calcium > potassium > magnesium > phosphorus) observed in this study was similar to the one found by Effiong and Fakunle [39] in *B. bayad* and *O. niloticus*. The micro-elements includes those nutrients found in small amount in the body of organism and are require for its proper function. But, they may become harmful to organism when their presence in the body are beyond its needs. *B. bayad* contained the highest values of minerals such as zinc (0.095 mg/g) and copper (0.049 mg/g) respectively. Both *O. niloticus* and *C. anguillaris* had the highest chromium content (0.014 mg/g). The trend of micro-elements was (iron>zinc>manganese>copper>chromium) and was supported by the works of Ako and Salihu [42]. The same similarity was established in the findings of Nurulla *et al*. [43] and Ghosh *et a*l. [44], wherein a decreasing order: iron > zinc > manganese > cobalt > copper was observed. Zinc is essential for the control of diabetic case identified with ineffectiveness of insulin [45]. Whereas, Iron has been very significant as a major component of haemoglobin [46].

The results of the vitamin content of the sampled fishes are presented in Table 3. *P. bane bane* had the highest levels of vitamins B_1 (33.880 ± 0.229 mg/l), B_6 (15.830 ± 0.246 mg/l) and B_{12} (3.043 ± 0.212 mg/l). Followed by *B. bayad* which contained the highest values of vitamins B_2 (10.440 ± 0.071 mg/l) and B_3 (2.077 ± 0.031 mg/l). Other fishes such as *C.*

anguillaris, *O. niloticus* and *S. mystus* contained the highest levels of vitamins A (15.873 ± 0.181 mg/l), C (1.223 ± 0.448 mg/l) and E (4.220 ± 0.135 mg/l) respectively. In comparison with WHO reference values [47], all the fishes contained vitamins above the reference values for vitamins, except for vitamins C and B_3 which had values below their WHO reference values. Differences in the vitamin content of the examined fishes was expected considering their innate characteristics. This was in addition to variations in habitat, geographical location, seasonality and physiological status [48]. Two fat soluble vitamins, vitamins A and E, found in high amounts in *C. anguillaris* corroborates the submission of Ersoy and Ozeren [49], which reported high concentrations of both vitamins in *C. gariepinus*. Also, water soluble vitamins, vitamins B_1, B_2, B_3, B_6, B_{12} and C, were reported by the same author, although different from the findings of this study where *P. bane bane* had the highest level of vitamin B_1, B_6 and $B_{12,}$ while the highest concentrations of vitamins B_2 and B_3 were observed in *B. bayad*.

Table 3: Vitamin content of the sampled fish species and WHO vitamins reference values

Vitamin (mg/l)	*Schilbe mystus*	*Bagrus Bayad*	*Oreochromis niloticus*	*Clarias anguillaris*	*Petrocephalus bane bane*	WHO Ref. Value
Vit. A	1.257±0.155^a	8.083±0.204^d	4.817±0.290^c	15.873±0.181^e	2.500±0.193^b	0.80
Vit. C	0.413±0.112^a	0.750±0.210^b	1.223±0.448^b	0.610±0.090^a	0.547±0.335^a	60.00
Vit. E	4.220±0.135^c	2.477±0.251^a	3.407±0.237^b	2.633±0.505^a	3.657±0.181^b	-
Vit. B_1	20.280±0.217^c	14.170±0.159^b	13.247±0.165^a	26.157±0.265^d	33.880±0.229^e	1.40
Vit. B_2	8.940±0.079^c	10.440±0.071^d	5.973±0.163^b	4.847±0.290^a	5.553±0.434^b	1.60
Vit. B_3	0.967±0.045^b	2.077±0.031^d	0.667±0.142^a	1.307±0.139^c	0.987±0.135^b	18.00
Vit. B_6	9.327±0.137^a	12.533±0.215^b	15.297±0.132^c	12.450±0.347^b	15.830±0.246^d	2.00
Vit. B_{12}	0.853±0.076^a	0.653±0.065^a	1.333±0.133^b	2.153±0.080^c	3.043±0.212^d	1.00

Means ±S.D within a row following by different alphabets are significantly different ($p<0.05$)

4. CONCLUSION

There are variations in the proximate composition, minerals and vitamins contents of the five freshwater fish species examined. Differences in their innate body features and food types among other factors may have accounted for the variations in these parameters. High dry matter coupled with low moisture, high crude protein, fat and mineral contents in the fish species lend credence to their importance as animal protein sources. Macro- and micro-nutrients found in the fish species primes them as sources of essential and trace minerals. The nutritional importance of the minerals present in the fish species confers additional quality on them. Vitamin constituents in quantities above the recommended limits also add more values to the fish species. Although there exist variations in all the parameters, nevertheless, all the fish species contained adequate levels of proximate and mineral nutrients as well as vitamins. Hence, they can all be utilized as nutrient base for human and animal consumption. Further studies on the nutrient composition of other freshwater fish species is recommended in order to reveal differences in the species and aquatic habitats.

TYPE OF MANUSCRIPT

This is original research paper

COMPETING INTERESTS

I declare that there were no competing interests.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

This study was considered and approved by the Senate of University of Agriculture Makurdi at its 270th meeting held on Thursday, 5th November, 2015. The approval number was: Ref: D/PGS/UAM/ADM/037. All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee"

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