

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

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 °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

34 world and they are related to deficiency of nutrients. Acute nutrient deficiency case in Nigeria
35 was 38% as reported in the Nepal Demographic and Health survey Fact Sheet (NDHS)
36 [10]. It is crucial for studies to come up regularly in order to gain relevant information on the
37 nutrient content levels in fish species commonly eaten by the poor across the nations of
38 Africa and Asia.

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40 Based on the levels required for adequate utilization, inorganic elements are divided into two
41 these include the macro or the micro elements [11]. The macro-elements are required in
42 levels higher than 100mg/g while micro-elements are required in small amount less than
43 100mg/g [12]. Macro-elements are collection of inorganic elements such as: phosphorus,
44 calcium, chloride and sodium etc. Among these elements, calcium is required for
45 penetrability of membrane, effective muscle activity and proper transfer of nerve signals [12].
46 The significance of minerals in the body metabolism and growth of living organisms cannot
47 be overemphasized as it builds up skeletal and colloidal systems, ensures acid-base
48 equilibrium of the body, and makes up the components of several enzymes and hormones
49 [13]. The roles of minerals in biological and chemical processes of living organisms, fish
50 inclusive, have been documented. To evaluate requisite minerals, based on their minimum
51 requirement in food consumption, information on foods, water and mineral element are
52 paramount [13]. Micro nutrient found in fish include vitamins A, B, and D, together with
53 manganese, calcium, selenium and phosphorus, these support its nutritious value as an
54 excellent source of animal proteins for both human and animal consumption [14]. Data on
55 nutrients levels of fishes especially in freshwater has become expedient to most field of food
56 technology. Maia *et al.* [15] affirmed that variations exist between freshwater and marine fish
57 species in relation to their mineral composition. Also, such differences extends to individuals
58 that belong to a species, as a result of variation in age, habitat, gender and seasonality. The
59 availability of nutrients in freshwater fishes are grouped on the basis of their distinct
60 geographical areas, climate, species and genders [16] and relationship, could be discovered
61 via the method of fish processing adopted [17]. It is crucial that fish and its products are
62 monitored on regular basis to ensure it met requisite international standard of food analyses
63 and essential nutrients, in order to balance up for the deficiency and minimize the death in
64 babies cause by malnutrition in food [19]. This study evaluated the proximate composition,
65 mineral elements and vitamins contents of *Schilbe mystus*, *Bagrus bayad*, *Oreochromis*
66 *niloticus*, *Clarias anguillaris* and *Petrocephalus bane bane* from Tiga Reservoir, in order to
67 ascertain the nutrient potentials of each fish species which could be used as nutrient sources
68 in human and animal foods.

70 2. MATERIALS AND METHODS

72 2.1 Sample collection and digestion

73 Samples of five fish species namely *Schilbe mystus*, *Bagrus bayad*, *Oreochromis niloticus*,
74 *Clarias anguillaris* and *Petrocephalus bane bane* were obtained monthly from Rano landing
75 site of Tiga reservoir from August to October, 2015. Rano settlement is found at longitudes
76 8° 18' to 8° 35' E and latitudes of 11° 18' to 11° 27' N. Each fish was identified using fish
77 identification keys of Olaosebikan and Aminu [20]. Thereafter, the samples were separately
78 beheaded, degutted and cleaned with distilled water before been oven-dried to a constant
79 weight at 105 °C in the laboratory. Scale removal was performed on *Oreochromis niloticus*
80 before it was beheaded and degutted. Oven-dried samples were grinded to powdery form in
81 preparation for digestion. The powdery form of each sample of the fish species was digested
82 strictly in accordance with the method described by Kumar *et al.* [21].

84 2.2 Chemical analyses

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

87 [22], in the Biochemistry laboratory, University of Jos, Nigeria. Also the digested samples
 88 were used to determine the mineral content using atomic absorption spectrophotometer
 89 (AAS 50B, Australia). Vitamin contents of the samples were spectrophotometrically
 90 determined as follows: vitamin B complex was assessed using the procedure of Brubacher
 91 *et al.* [23]; vitamin A was measured with the method of Rutkowski *et al.* [24]; vitamin C was
 92 determined using the procedure of Rutkowski *et al.* [25] while vitamin E was measured with
 93 the method of Rutkowski *et al.* [26].

94 95 **2.3 Calculation and statistical analyses**

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

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

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

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

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

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

106 107 108 **3. RESULTS AND DISCUSSION**

109 The values of the proximate assessment varied significantly ($p < 0.05$) and showed that crude
 110 protein of sampled fishes ranged from 30.42 ± 0.57 to 58.89 ± 0.03 g/100g, and are presented
 111 in Table 1. This was a pointer to consumers that the fishes were rich source of protein. The
 112 fishes examined were found to possessed high crude protein with a slight differences among
 113 them. This could be linked to individual fish innate ability to take in and assimilate nutrients
 114 from its feed and immediate locality and subsequently convert such to protein [29]. The
 115 crude protein and ash contents values were both highest in *P. bane bane* 58.89 ± 0.03
 116 g/100g and 12.99 ± 0.04 g/100g respectively thus, confirmed this fish nutrient endowment as
 117 protein and mineral rich source. While the least values of crude protein and ash contents
 118 30.42 ± 0.57 g/100g and 0.47 ± 0.02 g/100g were found in *O. niloticus* and *B. bayad*. The
 119 crude protein content of *Clarias anguillaris* (37.01 g/100g) was a bit lower than the value of
 120 (41.28 g/100g) reported by Muhammad *et al.* [30]. Similarly, Elagba Mohammed *et al.* [31],
 121 recorded a higher crude protein content of 77.00 g/100g and 78.00 g/100g for *B. bayad* and
 122 *O. niloticus*. The protein content of different fishes varies in relation to time of the year,
 123 consequent of reproduction, presence of diet and migration [32] On the basis of biochemical
 124 and physiological assessment of organisms, protein has been widely accepted as a crucial
 125 instrument for its contribution to body development, function and repairs [33]

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

Proximate (g/100g) Dry Matter	<i>Schilbe mystus</i>	<i>Bagrus Bayad</i>	<i>Oreochromis niloticus</i>	<i>Clarias anguillaris</i>	<i>Petrocephalus bane bane</i>
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).

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131 The ether extract are recognized for their capacity as high energy sources of nutrients and
132 are found to store as much as double the energy gotten from protein and starch [34]. The
133 highest ether extract content of 10.32 ± 0.02 g/100g was observed in *S. mystus*, followed by
134 *C. anguillaries* (8.11 ± 0.04 g/100g), *P. bane bane* (6.72 ± 0.02 g/100g), *B. bayad* (3.08 ±
135 0.03 g/100g) and *O. niloticus* (2.90 ± 0.14 g/100g). The ether extract of the sampled fishes
136 were found to have fell within the group of low fat to high fat fish [29]. The disparity of the
137 ether extract noticed among the sampled fishes could be attributed to the deviations in diets,
138 age, water temperature, and species [35]. The gross energy of the sampled fishes were the
139 aggregated amount found in individual fish and are shown as (total calorific value). *B. bayad*
140 had the highest total calorific value of 496.23 kcal/g. But, *P. bane bane* had the least value of
141 total calorific value of 453.704 kcal/g. The range of energy found in the sampled fishes was
142 an evident that they were all high energy source of nutrient. The high dry matter content
143 observed across the examined fishes could be as a result of the carcass qualities, as
144 exemplified by the high crude protein contents. This is in consonance with the findings of
145 Steffens [36], which submitted that protein forms bulk of the dry matter in fish carcass with
146 low moisture and higher fat level. The ash content level in *Clarias anguillaris* was relatively
147 higher than what was reported by Effiong and Mohammed [32], which observed a range of
148 0.41 to 1.35 g/100g for *C. anguillaris*. This was also affirmed by Adeyeye [37], that the ash
149 content level of a fish sample depicts its nutritional mineral composition.

150 The concentration of mineral elements of the sampled fishes are presented in Table 2. In all
151 the fish species, the mineral elements concentration differed significantly (p<0.05), with the
152 exception of cadmium and lead which were observed below detectable limits. The values of
153 essential elements in organisms depend on the rate of absorption through the medium
154 homeostatically, especially, during respiration and from food consumed [29][35]. Peak
155 values of iron (1.625 mg/g), potassium (2.638 mg/g), calcium (4.578 mg/g) and phosphate
156 (0.371 mg/g) were observed in *P. bane bane*. Since calcium was the mineral with the highest
157 concentration across all the fishes, followed by potassium and magnesium, confirmed the
158 richness of the sampled fishes in essential elements. The levels of calcium and potassium
159 minerals in fishes determine its nutritional importance [38]. Effiong and Fakunle [39],
160 reported similar high concentration of potassium (0.76 mg/g), calcium (2.86 mg/g) and
161 magnesium (0.32 mg/g) in *O. niloticus*. Also, recorded by the same authors were the peak
162 values of potassium (0.63 mg/g), calcium (2.83 mg/g) and magnesium (0.21 mg/g) in *B.*
163 *bayad*. Similar trend was found in the works of Effiong and Mohammed [32], wherein 0.75
164 mg/g potassium, 2.88 mg/g calcium and 0.30 mg/g magnesium were observed in *C.*
165 *anguillaris*.

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

Element (mg/g)	<i>Schilbe mystus</i>	<i>Bagrus Bayad</i>	<i>Oreochromis niloticus</i>	<i>Clarias anguillaris</i>	<i>Petrocephalus bane bane</i>	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	

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

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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 maintains 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 include those nutrients found in small amount in the body of organism and are required 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 al.* [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 B₁ (33.880 ± 0.229 mg/l), B₆ (15.830 ± 0.246 mg/l) and B₁₂ (3.043 ± 0.212 mg/l). Followed by *B. bayad* which contained the highest values of vitamins B₂ (10.440 ± 0.071 mg/l) and B₃ (2.077 ± 0.031 mg/l). Other fishes such as *C.*

202 *anguillaris*, *O. niloticus* and *S. mystus* contained the highest levels of vitamins A ($15.873 \pm$
 203 0.181 mg/l), C (1.223 ± 0.448 mg/l) and E (4.220 ± 0.135 mg/l) respectively. In comparison
 204 with WHO reference values [47], all the fishes contained vitamins above the reference
 205 values for vitamins, except for vitamins C and B₃ which had values below their WHO
 206 reference values. Differences in the vitamin content of the examined fishes was expected
 207 considering their innate characteristics. This was in addition to variations in habitat,
 208 geographical location, seasonality and physiological status [48]. Two fat soluble vitamins,
 209 vitamins A and E, found in high amounts in *C. anguillaris* corroborates the submission of
 210 Ersoy and Ozeren [49], which reported high concentrations of both vitamins in *C. gariepinus*.
 211 Also, water soluble vitamins, vitamins B₁, B₂, B₃, B₆, B₁₂ and C, were reported by the same
 212 author, although different from the findings of this study where *P. bane bane* had the highest
 213 level of vitamin B₁, B₆ and B₁₂, while the highest concentrations of vitamins B₂ and B₃ were
 214 observed in *B. bayad*.
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216 Table 3: Vitamin content of the sampled fish species and WHO vitamins reference values

Vitamin (mg/l)	<i>Schilbe mystus</i>	<i>Bagrus Bayad</i>	<i>Oreochromis niloticus</i>	<i>Clarias anguillaris</i>	<i>Petrocephalus bane bane</i>	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

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

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220 4. CONCLUSION

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

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239 This is original research paper

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241 **COMPETING INTERESTS**

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243 I declare that there were no competing interests.

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246 **ETHICAL APPROVAL (WHERE EVER APPLICABLE)**

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

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