PROXIMATE AND MICRONUTRIENT COMPOSITION OF BAYAD (*BAGRUS BAJAD*) AND UPSIDE-DOWN CATFISH (*SYNODONTIS RESUPINATUS*) FROM LAKE ALAU, NIGERIA

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Received *May 12, 2020;* ***Revised*** *June 4, 2020;* ***Accepted*** *June 06, 2020*

ABSTRACT

The knowledge of biochemical composition of muscles of fish helps in evaluating not only their nutritive value but also in quality assessment for optimum utilization. Therefore, the proximate composition and microelement contents in the muscle of bayad (Bagrus bajad) and upside-down catfish (Synodontis resupinatus) captured from Lake Alau were assessed. Ten fresh samples of each species (390.00 ± 46.25 g) obtained from fishers' were filleted and analysed for proximate and mineral compositions following standard procedures. Moisture (80.04 ± 3.48 g 100 g^{-1}), crude protein (15.64 ± 1.13 g 100 g^{-1}) and ash content (1.81 ± 0.31 g 100 g^{-1}) of bayad were significantly higher ($p<0.05$) than those of upside-down catfish. Carbohydrate (66.89 ± 1.28 %) and crude fat (2.03 ± 0.30 %) of upside-down catfish were significantly higher than that of bayad ($p<0.05$). Highest level of magnesium (0.54 ± 0.11 mg kg^{-1}), sodium (0.06 ± 0.03 mg kg^{-1}) and phosphate (0.67 ± 0.10 mg kg^{-1}) were found in bayad while upside-down catfish had superior calcium (0.48 ± 0.23 mg kg^{-1}) content. Furthermore, zinc (0.71 ± 0.15 mg kg^{-1}), nickel (0.62 ± 0.08 mg kg^{-1}) and chromium (0.11 ± 0.02 mg kg^{-1}) contents were higher in bayad while copper (0.17 ± 0.07 mg kg^{-1}), cadmium (0.07 ± 0.02 mg kg^{-1}), lead (0.09 ± 0.02 mg kg^{-1}) and iron (0.40 ± 0.16 mg kg^{-1}) contents were significantly lower ($p<0.05$) in value when compared with upside-down catfish. Conclusively, these two fish species are rich in nutrients and can impact positively on human health.

Keywords: Fish muscle, *Bagrus bajad, Synodontis resupinatus,* Nutritional composition, Minerals, Lake Alau

INTRODUCTION

Fish and fish products are known worldwide as a very important diet because of their high nutritive quality and impacts on human health. Fish is among the healthiest foods available for man, and undoubtedly occupies one of the highest places on the food list of Nigerians (Olanrewaju *et al*., 2015). It plays an important role in fighting hunger and malnutrition especially among the rural populace in developing world. Fish food also performs an important role in advancing the healthy development of infants, growing children and expectant mothers due to its superior nutritional quality and easy digestibility. However, fish meat being considered as a delicacy have varying nutritive value which depends on species, fishing ground, fishing season, age and sex of the individual and reproductive status (Barua and Chakraborty, 2011).

The bayad (*Bagrus bajad* Forsskål, 1775) and upside-down catfish (*Synodontis resupinatus* Boulenger, 1904) occur in most

freshwater bodies of Africa where they constitute a significant component of the catches. The bayad (Family: Bagridae) has a maximum size of about 11.2 metres with a maximum weight of 12.5 kilograms, but is reputed to reach 100 kg (FishBase, 2007). It is a benthic omnivorous feeder (bottom feeder) as they proved the presence of detritus (bottom deposit) in addition to the other food items inside the alimentary tract (Reed *et al*., 1967). Bayad is an important food fish commonly sold as food due to its good eating flesh. FishBase (2007) reported that bayad meat was highly acceptable to consumers, indicating a promising potential market for consumption of its meat. It is one of the most economically valuable species inhabits the lakes and rivers in Africa. The upside-down catfish (Family: Mochokidae) occur throughout most of the freshwaters of the Sub-Saharan Africa and the Nile River (Vigliotta, 2008). It is one of the dominant and endemic species of Nigeria inland waters commercially exploited for human consumption. *S. resupinatus* is a highly valued food fish and contribute significant proportion to the fishery of the Rivers. The species lives in streams and lakes, and feeds on plankton, plants and detritus (Olaosebikan and Lalèyè, 2010). It is also served as delicacy for many low-income earners as they are cherished for their taste and affordable price (Reed *et al*., 1967).

Bayad and upside-down catfish are ecologically similar species, as they live in the same aqueous layer as filter feeders (Olaosebikan and Lalèyè, 2010). Fish takes in a wide range of foodstuffs from which it obtains the required nutrients for its proper growth and development (Barua and Chakraborty, 2011). However, inland water bodies currently face lots of pressure leading to pollution which could undermine the quality of fisheries resources. Authman *et al*. (2015) pointed out that fish nutritional quality in most inland waterbodies has been compromised due to heavy metal bioaccumulation which has deleterious effect on human health upon consumption.

The chemical composition of many freshwater fish species in Nigeria has been extensively investigated (Ayanda *et al*., 2019). Specifically, several studies have been performed on bayad and up-side down catfish populations in Nigerian inland waters, in order to assess the nutritive value of the meat (Kefas *et al*., 2014; Alhassan *et al*., 2018; Elaigwu, 2019), and contamination by heavy metals (Effiong and Fakunle, 2012). In contrast, scanty information exists on *B. bajad* and *S. respinatus* populations from Lake Alau, Maiduguri, Nigeria. Hence, the present study was undertaken to determine and compare results of the proximate and macro element composition of *B. bajad* and *S. resupinatus* from Lake Alau, Maiduguri, Nigeria.

MATERIALS AND METHODS

Ten healthy adult each of *B. bajad* and *S. resupinatus* (390.00 ± 46.25 g) were collected from fishers' landings in Lake Alau (Lat. 11°39'84" – 11°40'02"N and long. 13°39'92" – 13°40'12"E) for three months (September to November 2019). Samples were collected fresh and refrigerated below 4°C, then were transported to Analytical Laboratory, NAFDAC Office, Maiduguri, Borno State. Thereafter, they were defrosted, eviscerated, filleted manually and thoroughly washed. Later minced, homogenized, packaged, labeled and stored in the refrigerator for analysis. The proximate composition and mineral content were analyzed based on standard procedures of AOAC (2005). The moisture content of the fillet of the fish was determined by oven drying at 105 ºC, ash by incineration of 2 g of each sample in a muffle furnace at 600 ºC for 2 hours, crude protein by the Micro-Kjeldahl method then (N x 6.25), crude fat was extracted with n-hexane in a Soxhlet extractor, while available carbohydrate was calculated by difference. The mineral content (calcium, potassium and sodium) were determined using flame photometric method (Jenway Digital Flame Photometer: PFP7 Model) (AOAC, 2005). Phosphorus was estimated using Vanadomolybdate colorimetric method while other microelements such as manganese, magnesium, iron, lead, zinc, cadmium, chromium, mercury, nickel and copper were determined using Atomic Absorption Spectrophotometric method (AOAC, 2005). All assays were done in triplicates.

Data Analysis: Data generated were analysed descriptively using SPSS 20.0 statistical software (SPSS Inc., Chicago, IL, USA). Student's t-test were used to compare parameters between the two species. All the statistical analyses were considered at significance level of 5% ($p<0.05$).

RESULTS

The result of proximate composition of *B. bajad* and *S. resupinatus* from Lake Alau were as shown in Table 1.

Table 1: Proximate composition of *Bagrus bajad* and *Synodontis resupinatus* from Lake Alau

Proximate Component (%)	Species	
	Bagrus bajad	***Synodontis resupinatus***
Moisture	80.04 ± 3.48*	74.01 ± 4.54
Crude protein	15.64 ± 1.13*	10.23 ± 1.86
Carbohydrate	2.05 ± 0.74	9.12 ± 1.02*
Crude fat	0.43 ± 0.14	1.95 ± 0.82*
Ash	1.81 ± 0.31*	1.56 ± 0.58

**Significant at 5 % level (p<0.05)*

Mean values obtained for moisture content (80.04 ± 3.48 %), crude protein (15.64 ± 1.13 %) and ash content (1.81 ± 0.31 %) were significantly higher ($p<0.05$) in *B. bajad*. However, *S. resupinatus* showed markedly high carbohydrate (66.89 ± 1.28 %) and crude fat (2.03 ± 0.30 %) values as compared to *B. bajad.*

The result obtained for the different microelements in the muscle of *B. bajad* and *S. resupinatus* were as presented in Table 2. Significantly higher ($p<0.05$) level of magnesium (0.54 ± 0.11 mg kg^{-1}), sodium (0.06 ± 0.03 mg kg^{-1}), phosphate (0.67 ± 0.10 mg kg^{-1}), zinc (0.71 ± 0.15 mg kg^{-1}), nickel (0.62 ± 0.08 mg kg^{-1}) and chromium (0.11 ± 0.02 mg kg^{-1}) were found in *B. bajad*. However, calcium (0.48 ± 0.23 mg kg^{-1}), copper (0.36 ± 0.05 mg kg^{-1}), cadmium (1.11 ± 0.08 mg kg^{-1}), lead (0.43 ± 0.11 mg kg^{-1}) and iron (0.57 ± 0.12 mg kg^{-1}) content of *S. resupinatus* was significantly higher ($p<0.05$) than that the values obtained for *B. bajad*. Potassium and Manganese did not show any significant differences between the two fish species.

Table 2: Microelements' compositions of *Bagrus bajad* and *Synodontis resupinatus* from Lake Alau

Microelements (mg kg-1)	Species	
	Bagrus bajad	***Synodontis resupinatus***
Calcium (Ca)	0.19 ± 0.03	0.48 ± 0.23*
Magnesium (Mg)	0.54 ± 0.11*	0.01 ± 0.00
Potassium (K)	0.04 ± 0.02	0.03 ± 0.01
Sodium (Na)	0.06 ± 0.03*	0.01 ± 0.01
Phosphate (PO_4)	0.67 ± 0.10*	0.11 ± 0.03
Copper (Cu)	0.17 ± 0.07	0.36 ± 0.05*
Cadmium (Cd)	0.07 ± 0.02	1.11 ± 0.08*
Lead (Pb)	0.09 ± 0.02	0.43 ± 0.11*
Manganese (Mn)	0.04 ± 0.03	0.05 ± 0.03
Zinc (Zn)	0.71 ± 0.15*	0.01 ± 0.01
Iron (Fe)	0.40 ± 0.16	0.57 ± 0.12*
Nickel (Ni)	0.62 ± 0.08*	0.15 ± 0.05
Chromium (Cr)	0.11 ± 0.02*	0.02 ± 0.02
Mercury (Hg)	0.02 ± 0.01	ND

**Significant at 5 % level (p<0.05); ND not detected*

Potassium contents constituted 0.03 ± 0.01 mg kg^{-1} in *S. resupinatus* and 0.04 ± 0.02 mg kg^{-1} in *B. bajad*. The manganese contents were 0.04 ± 0.03 mg kg^{-1} in *B. bajad*, 0.05 ± 0.03 mg kg^{-1} in *S. resupinatus*. Mercury content was 0.02 ± 0.01 mg kg^{-1} in *B. bajad*, and not detected in *S. resupinatus*.

DISCUSSION

The nutritional characteristics of fish and fishery products are of vital interest to consumers and

have been established to vary with species and growing environment (Olanrewaju *et al*., 2016). Knowledge of fish biochemical composition is important for the quality and palatability of the fillet nutrients. In general, the proximate composition is well known as a proportion composition of basic elements such as protein, lipids, carbohydrate, minerals and water. Proximate composition variations between the investigated species in this study were statistically significant ($p<0.05$). However, moisture content, crude protein and crude ash were markedly higher in *B. bajad*. Also, the crude fat and carbohydrate content of *S. resupinatus* was remarkably higher than that measured in *B. bajad*. The range values obtained for proximate composition in this study was in consonance with standard recommended limits by FAO (2010), except crude protein in *S. resupinatus*.

The species in this study had high moisture content which was in agreement with 78.32 % in *B. bajad* from Shagari earth Dam, Sokoto, Nigeria (Alhassan *et al.,* 2018). The result indicates that water is a major constituent of the fish body, and high moisture contents have been similarly reported in freshwater species (Abdullahi, 2001). Ayanda *et al*. (2019) pointed out that high moisture content plays important roles in metabolic reactions and help to easily solubilize certain elements. The result was also similar to Oboh *et al*. (2019) who reported higher moisture content of 79.00 ± 2.35 % and 78.87 ± 0.66 % for *Synodontis nigrita* and *Tilapia mariae*, respectively. Several other authors such as Alfa *et al*. (2014) and Ayanda *et al*. (2019) equally reported high moisture content in fresh fishes from Nigerian inland waters. Proteins which are the major structural component of muscle and body tissue of fish and represent an excellent source of essential amino acids (Tacon, 1987). According to FAO (2010), the crude protein values of freshwater fish ranges between 15 – 28 %. The values obtained for *B. bajad* (15.64 ± 1.13 %) were found to be within this range but the mean value in *S. resupinatus* (10.23 ± 1.86 %) was below the recommended range. Similar variation in the crude protein value (15.35 ± 0.22 %) of *B. docmak* was reported by Teame *et al*. (2016). The same trends of high crude protein values were reported by Kefas *et al*. (2014) in *Synodontis clarias* and Alhassan *et al.* (2018) in *B. bajad*. The result however implies that *B. bajad* is a high-quality protein fish unlike *S. resupinatus*. This could not be as a result of environment but may be due to food availability and absorption capability and conversion potentials of essential nutrients from their diets (Tadesse, 2010).

Carbohydrate content of *B. bajad* and *S. resupinatus* were estimated to be 2.05 ± 0.74 % and 9.12 ± 1.02 %, respectively. However, the carbohydrate values in this study were within the normal range (2 – 5 %) recommended for good quality fish (FAO, 2010). The carbohydrate values of the two fish species were within the ranges reported in *B. bajad* (1.20 %) by Alhassan *et al.* (2018) and *B. docmak* (2.64 ± 0.15 %) by (Teame *et al*., 2016). However, *S. resupinatus* had superior carbohydrate value compared with value obtained for *Schilbe mystus* and *Heterotis niloticus* from Lake Alau (Olanrewaju *et al*., 2016). This species could be a high-quality carbohydrate source for providing energy to the cells. Also, by implication, the discrepancy in glycogen content of fish muscles may be linked to diet, sexual condition and probably season of the year. Fat is one of the most important nutrients present in fish and its composition help to describe the nutritional status of particular organisms (Aberoumad and Pourshafi, 2010). The mean crude fat level (0.43 ± 0.14 – 1.95 ± 0.82 %) recorded for *B. bajad* and *S. resupinatus* were on the low range, which indicates that both species belong to the category of low fat (i.e. below 2 % - lean fish) classified by Ackman (1989). Similar sequel was also recorded in *B. bajad* (1.64 %) (Alhassan *et al.,* 2018), but lower than the levels reported for *B. docmak* (4.32 ± 0.16 %) (Teame *et al*., 2016) and *S. clarias* (10.30 ± 0.81 %) (Kefas *et al*., 2014). According to Rakocevic *et al*. (2018), the difference in the value of crude fat level in the fish species may be due to the availability of food and physiological status of the fish. Rakocevic *et al*. (2018) however corroborated that fat content in fish species varies with climate, season, available food and physiological status of fish. Nair and Mathew (2001) reported that the ash content measures the total mineral content in the tissue, which helps in body development and growth. Crude ash estimates had the highest concentration in *B. bajad* (1.81 ± 0.31 %) and lowest in *S. resupinatus* (1.56 ± 0.58 %). This result concurs with the findings of Teame *et al*., (2016) and Alhassan *et al.* (2018) who reported

0.88 ± 0.08% and 1.90% for *B. Docmak* and *B. bajad*, respectively. However, the ash content was comparatively lower than 15.48 ± 0.81 % and 5.74 ± 0.36 % obtained in *B. Bajad* and *S. nigrita* by Kefas *et al*. (2014) and Oboh *et al*. (2019), respectively. The results obtained for ash in the two species is an indication of moderately high mineral contents, which rarely exceeds 1 – 2 percent of the edible portion (FAO, 2010).

Mineral elements variations between the investigated species in this study were statistically significant ($p<0.05$). However, most of the studied parameters were significantly higher in *B. bajad*. The mineral contents for the two species examined were within the FAO (2010) standard, except for sodium in *S. resupinatus* (0.01 ± 0.01 mg kg^{-1}) which were observed to be below the FAO standard. Magnesium and phosphate were found to dominate other microelements in the two species, which supported their richness in essential elements. According to Ayanda *et al*. (2019), the microelements in fish can improve physical and mental health, as well as reduce the risk of diseases upon consumption. These results are in consonance with the observations of Effiong and Fakunle (2012) in *B. bajad* from Lake Kainji, Nigeria. Contrarily, Alhassan *et al.* (2018) and Elaigwu *et al*. (2019) reported higher microelements concentration in *B. bajad* from Shagari Earth Dam and Tiga Reservoir, respectively. Kefas *et al*. (2014) also, report higher calcium (1.53 ± 0.54 mg kg^{-1}) and magnesium (9.83 ± 0.54 mg kg^{-1}) concentrations for *S. clarias*. The differences may be due to feed and feeding habits of the fish (El-Zaeem *et al*., 2012).

As pointed out by Uysal *et al*. (2009), fish muscle is generally considered a tissue with little potential for bioaccumulation of metal.

Microelement content in fish muscle tissues is self-regulated and very important for cell functions at biological, chemical and molecular levels. However, trace element levels in fish muscle can vary because of certain biological conditions, such as species, sex, age, life history and feeding (Carpeme *et al*., 1999). The concentration of trace elements obtained in this study did not exceeded FAO/WHO (1991) permissible levels in aquatic species for human consumption. This result is within the range of the corresponding values described for *B. bajad* (Elaigwu *et al*., 2019; Alhassan *et al.,* 2018; Effiong and Fakunle, 2012). This value was however lower than values reported for *Bagrus docmak* (Teame *et al*., 2016). Also, Kefas *et al.* (2014) reported higher values of Fe 0.68 ± 0.54 mg kg^{-1} in *S. clarias* from Mubi, Nigeria. The concentration of Hg in *B. bajad* was similar to 0.02 ± 0.00 mg kg^{-1} reported by Ikape *et al*. (2018) for *Momyrus rume* from Lower River Benue, Nigeria. The similarities may be due to their matching feeding habits. As earlier reported by Güner *et al*. (1998), the most abundant microelement in the studied species were Zn and Fe.

Conclusion: The study demonstrated that the investigated species have good proximate and mineral properties. Although, *B. bajad* had higher nutritive value when compared with *S. resupinatus* of the same size and habitat, *S. resupinatus* possess high-quality carbohydrate and could serve as a nutrient base for high energy food in the food industry. Also, the trace elements were markedly different among the species but their concentrations did not exceed permissible levels in aquatic species. This study therefore reveals that these species are good nutritional source and can contribute to the health of human. The research has provided additional information on the proximate and mineral element composition of commercially important fish species from Lake Alau, Nigeria. It is recommended that further studies should be conducted on the amino and fatty acids quality of these species to provide adequate information on its nutritional quality.

ACKNOWLEDGEMENTS

We thank Mr. Ali Anthony (Federal College of Freshwater Fisheries Technology, Baga) for help in the field samples, and Mallam Ali Goniri (NAFDAC Office, Maiduguri) for laboratory assistance.

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