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Biochemical Compositions in the Carcasses of Some Small-Sized Indigenous Fin-Fish Species (SIS)

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ABSTRACT

A total of 24 samples of 8 small-sized indigenous finfish species (SIS) from Ajiwa Irrigation dam were collected for biometric evaluation. The samples comprised 4 families and were analyzed for proximate compositions (muscle protein, moisture, lipid, ash and gross energy) as well as macro-nutrient compositions using standard procedures. The finfishes sampled ranged in size from 0.90-4.30 cm in length and 1.20-9.53 g in weight. The carcasses of these finfishes contained 17.1±0.15% muscle protein in *Sarotherodon galileus* and 22.05±0.08% muscle protein in *Mormyrus rume.* Moisture content ranged from 74.44±1.36% in *Schilbe mystus* to 78.67±0.2% in *Clarias gariepinus* while the values for total lipids ranged from 3.26±0.03% in *S. galileus* to 15.32±0.05% in *Clarias anguillaris.* The minimum and maximum mean values of ash found in *M. rume and C. anguillaris* were 2.25±0.02% and 3.71±0.12%, respectively. *S. galileus* recorded the lowest energy value (4.48±0.06 kcal/g) while *S. mystus* recorded the highest value (6.21±0.35 kcal/g). The average values of elements present in the flesh of the finfishes were as follows: Calcium (Ca) (41.2 mg/100g and 58.7 mg/100g), Phosphorous (P) (20.0 mg/100g and 27.0 mg/100g), Magnesium (Mg) (12.2 mg/100g and 16.7 mg/100g) and Sodium (Na) (5.1 mg/100g and 5.6 mg/100g). The results showed that Ca was the most abundant macro element present in the fish samples. Additionally, the results indicated that these indigenous finfishes, which are regularly consumed in the routine diets of rural dwellers in the surrounding communities of the Ajiwa irrigation dam have high nutrient values and are ideal for human and domesticated animal consumption despite their small sizes. This study provides current and baseline information on a broad range of species, which will assist nutritionists and the public in making informed decisions regarding the consumption of these species.

INTRODUCTION

Fishes are known generally to exhibit diversity in size, shape, biology and in the habitats, they occupy (Akinjogunla & Shu'ibu, 2022). Growth activity depends on sexual category, stages of development and ecological factors such as salinity, water temperature parameters and food (Akinjogunla & Moruf, 2019). Many rural communities in Nigeria are surrounded by different sizes of water bodies and so, most of the dwellers depends on the resources from them for their survival. Edible aquatic fauna species like catfishes, tilapias, oysters, shrimps, prawns, crabs, etc. are cheap sources of protein (Akinjogunla et al., 2017, 2021; Udoinyang et al., 2022). These indigenous species of fish are valuable and easily available source of food rich in protein, vitamin and minerals, not commonly available in other foods (Hossain et al., 1999). In a country with a population suffering from malnutrition and protein deficiency, consumption of these fish species may have positive effects in improving the health of the nation.

Fish may be the singular inexpensive source of animal protein for poor family units in municipal or semi-urban regions (Onyia et al., 2010). Small sized fish provide food and nutrition, subsistence and supplemental income to the great majority of people in the rural areas, particularly the poor and disadvantaged. There is considerable demand for these indigenous fishes both in rural and urban markets as low-income earners are not able to afford costly finfishes in terms of sizes.

Considering the importance of these indigenous finfishes and yet, no documented literatures on these species from Nigeria based on their sizes, this study was undertaken to evaluate the nutritional values of the small sized indigenous finfishes available to the communities assessing the Ajiwa irrigation dam for fishing activities.

MATERIAL AND METHODS

Study Area

Ajiwa irrigation dam with latitude 12°54'69"-12°57'58" N and longitude and 7°42'53"-7°47'50" E is situated at Batagarawa Local Government Area of Katsina State, Northern part of Nigeria (Akinjogunla & Shu'aibu, 2022).

Sampling

A total of 24 fish samples of 8 different small sized indigenous fish species were collected from the local farmers at the bank of the dam using cast nets for harvesting. Identifications of the species collected were done using the fisheries guidebook by Olaosebikan & Raji (2004). Biometric data (length and weight) of individual fishes were recorded using standard measuring ruler calibrated in centimeters and a sensitive digital weighing balance calibrated in gram, respectively. The fish were collected in a bowl, cleaned in water and ground whole because of their tiny (small) sizes by using a local mortar and pastel so as not lose any significant parts of the fish. The carcasses were kept in a deep freezer in air tight container for bio-chemical analysis.

Biochemical Compositions

Fish muscles were also collected separately from fishes of each species to determine muscle protein content. Triplicate samples of each fish species were used to determine the proximate (Moisture, muscle protein, total lipid, Ash) compositions and energy value. Standards methods as described by Association Official Analytical Chemist (AOAC, 2006) were used for proximate analysis. The energy value was determined indirectly by using Rubner's coefficients for aquatic organisms (9.45 kcal/g to total lipids, 5.65 kcal/g to muscle proteins and 4.10 kcal/g to carbohydrate and expressed in kJ/g wet mass) as described by Eder & Lewis (2005). The element contents were determined following the methods of AOAC (2006) by dissolving the ash obtained from the sample in standard flask with distilled de-ionized water and adding few drops of concentrated hydrochloric acid. The fusion was warmed and vaporized on Bochy water bath and filtered using a filter paper. The aliquot parts were taken for evaluations of calcium, phosphorus, magnesium and sodium.

Data Analysis

Results collected from each analysis were subjected to computation using Prism version 5.03 statistical

software programs to calculate the mean and standard deviation (SD) followed by two tailed T-test.

RESULTS

The biometric data (scientific name, local names, average length and average weight) of 24 samples of 8 small indigenous finfish species in Ajiwa irrigation dam are shown in Table 1. The average body size in total length ranged between 0.90±0.10 cm in *S. galileus and* 4.30±1.06 cm in *C. gariepinus* while the average body weight was between the values of 1. 20±0.06 g in *S. galileus* and 9.53±3.72 g in *C. gariepinus.* The fish species collected for this study are at the post juvenile stage of growth which are not usually the sizes available for sales in the market.

The proximate compositions of the carcasses of the indigenous finfishes found in Ajiwa Irrigation dam are presented in Table 2. The results indicated that the range of muscle protein content among the species examined were between 16. 63±0.12% in *C. gariepinus* and 22. .05±0.08% in *M. rume*. The carcass's moisture content ranged between 74.44±1.36% in *S. mystus* and 78.67±0.2% *in C. gariepinus*. The highest value found for total lipid content was 15.32±0.05 in the carcass of *C. anguillaris* while the lowest value of 3.26±0.03% was found in the carcass of *S. galileus.* The highest values for ash content were 3.71±0.12% (*C. anguillaris*), slightly followed by 3.15±0.02% (*M. senegalensis*) while *S. galileus* came third in line with a value of 3.12±0.12%. The gross energy content of the finfishes' carcasses varied between 4.48±0.06 kcal/g in *S. galileus* and 6.21±0.35 kcal/g in *S. mystus* on composition wet weight basis. The Mormyridae (*M. rume)* has the relatively highest value recorded for muscle proteins while the Claridae (*C. gariepinus* and C. *anguillaris*) had the highest values for moisture content, total lipid and ash contents.

The mean element contents (Ca, P, Mg and Na) of the small sized indigenous finfish species are shown in Table 3. Ca has the highest mineral content ranging from 41.2 to 58.7 mg/100g, followed by P ranging from 20.0 to 27.0 mg/100g, Mg ranging from 12.2 to 16.7mg/100g while Na mean values were less than 6 mg/100g but greater than 4 mg/100g. The results showed that the most abundant macro element present in the fish samples was Ca. The Cichlids (*O. niloticus* (Linnaeus, 1758; *S. galileus* (Linnaeus, 1758); *C. zilli* (Gervais,1848) have the highest values recorded for Ca and Mg while the Mormyrids (*M. rume* (Valenciennes, 1847) *and M. senegalensis*) was recorded for contenting the highest value for P and Na, respectively.

The range of Ca was from 41.2 to 58.7mg/100g. The highest Ca content was found in *C. zilli* while the least value was found in C. *anguillaris*. Ca content in the family Cichlidae (*O. niloticus*; *S. galileus*; *C. zilli*) was observed to have similar values of greater than 50 mg/100g (> 50 mg/100g). The lowest recorded values of P and Mg were found in *M. senegalensis* with values of 20.0±0.5 mg/100g and 12.2±0.17 mg/100g, respectively. On the other hand, the highest value for

Table 1. Average length and weight of various indigenous finfishes used in this study

S/N	Species	Local Name (Hausa)*	Average Body Length (cm)±SD	Average Body Weight (g)±SD
1	*Schilbe mystu s* (Linnaeus, 1758)	Balo	1.76±0.22	3.36±2.81
2	*Marcusenius senegalensis*	Farinwata Data	1.27±0.49	3.64±0.08
3	*M. rume* (Valenciennes, 1847)	Milligi	2.43±0.89	6:84±0.29
4	*Oreochromis niloticus* (Linnaeus, 1758)	Karfasa	2.80±1.06	4.83±0.93
5	*S. galileus* (Linnaeus, 1758)	Gargaza	0.90±0.10	1.20±0.06
6	*Coptodon zilli* (Gervais, 1848)	Karfasa	2.13±3.62	5.79±4.37
7	*C. gariepinus* (Burchell, 1822)	Tarwada	4.30±1.06	9.53±3.72
8	*C. anguillaris* (Linnaeus, 1758)	Kuluni	3.43±0.57	9.19±4.49

Note: *adapted from Akinjogunla & Shu'aibu (2022)

Table 2. Proximate analysis of various indigenous finfishes' carcasses available in Ajiwa Irrigation Dam, Katsina State, Nigeria

S/N	Species	Muscle Protein*	Moisture Content*	Total Lipid*	Ash*	Energy Value (kcal/g)
1	*S. mystus*	18.14±0.61	74.44±1.36	7.25±0.79	2.77±1.52	6.21±0.35
2	*M. senegalensis*	18.17±0.58	78.09±0.35	4.27±0.17	3.15±0.02	5.1±0.02
3	*M. rume*	22.05±0.08	78.12±0.03	3.56±0.06	2.25±0.02	5.25±0.17
4	*O. niloticus*	17.02±0.10	75.59±0.05	4.86±0.06	3.03±3.54	6.03±0.08
5	*S. galileus*	17.1±0.15	78.41±0.22	3.26±0.03	3.12±0.12	4.48±0.06
6	*C. zilli*	17.61±0.02	74.68±2.0	4.85±0.10	2.82±0.39	6.03±0.04
7	*C. gariepinus*	18.63±0.12	78.67±0.2	14.54±0.23	2.35±0.15	5.03±0.02
8	*C. anguillaris*	18.69±0.03	75.52±1.07	15.32±0.05	3.71±0.12	5.43±0.10

Note: *Composition wet weight (CWW) basis in %; Values in mean±SD

Table 3. Carcass's element contents (mg/100g) of various small sized indigenous finfish available in Ajiwa Irrigation Dam (% wet matter basis)

S/N	Species	Mineral (mg/100g)			
		Ca	*P*	*Mg*	*Na*
1	*S. mystus*	42.3±0.58	23.6±0.3	13.0±.17	5.6±0.16
2	*M. senegalensis*	47.1±0.51	20.0±0.5	12.2±0.17	5.6±0.2
3	*M. rume*	48.03±0.15	27.0±0.23	13.0±0.26	5.13±0.02
4	*O. niloticus*	56.9±0.25	24.1±0.15	15.3±0.21	5.14±.002
5	*S. galileus*	55.3±0.58	23.9±0.21	16.7±0.62	5.20±0.3
6	*C. zilli*	58.7±0.35	23.7±0.2	16.1±0.36	5.30±0.5
7	*C. gariepinus*	44.5±0.50	21.1±0.17	14.2±0.29	5.1±0.01
8	*C. anguillaris*	41.2±0.29	22.2±0.46	14.1±0.017	5.23±0.2

Note: Values in mean±SD

Na was recorded in *M. senegalensis* with a value of 5.6±0.2 mg/100g. Interestingly, the highest values for P and Mg were found in the carcasses of *M. rume and S. galileus*, respectively. *M. rume* had a Phosphorus value of 27.0±0.23 mg/100g, while *S. galileus* had a Mg value of 16.7±0.62 mg/100g. Furthermore, the study revealed that the most abundant macro element presents in the carcasses of the small sized indigenous finfishes followed a specific order. Calcium (Ca) was found to be the most abundant, followed by Phosphorus (P), Magnesium (Mg) and Sodium (Na).

DISCUSSION

Biometric evaluation of aquatic organisms is one of the benchmarks used to generate justifiable biological information on the organisms. The small sized indigenous finfish species (SIS) collected for this study were within the size ranges of 0.90-4.30 cm (in length) and 1.20-9.53 g (in weight). Even though the harvesting of small sized fishes (fin/shell) are discouraged for fishery management and sustainability, we cannot deny the facts that these small sizes of finfishes are landed on the banks of many fishing sites, jetties and fish markets in Nigeria and more often than not, end up as regular stables for some individuals either as a result of wrong use of mesh sizes by the fisher folks, illiteracy/ ignorance or overfishing of the adult sized fish species, leaving only the small sized species for subsequent harvesting if no re-stocking is done.

The concentration of muscle protein, moisture content, total lipid, ash, energy value, and minerals (Ca, P, Mg and Na) are extremely variable among the small sized indigenous species (SIS). Different species

of fish and even strain within a species vary significantly in the nutritional content of the carcass. According to several documented literatures (FAO/WHO, 1998; USDA, 2010; Bashir et al., 2012; Womeni et al., 2014; Udoinyang et al., 2022; Egun et al., 2023), fish meat comprises protein (16-21%), moisture (66-81%), lipids (0.2-25%) and ash (1.2 to 1.5%). The proximate composition of the analyzed small sized indigenous finfish's species in this study was within FAO's standard ranges except for the total ash content which is higher than the recommended value. In this research, the results of the proximate analysis of these SIS showed that the finfishes can all be categorized as high-protein (15-20%) while some are medium lipid species with 4 to 8% total lipid contents (*S. mystus, M. senegalensis, M. rume, O. niloticus, S. galileus and C. zilli)* and others (*C. gariepinus; C. anguillaris)* are classified as high lipid species (>8%).

The results obtained from this study shows that the muscle protein content of the species was relatively higher compared to documented reports from other authors who had worked on proximate compositions of fishes (both fin and shell-fish) in various Nigerian water bodies (Babalola & Akinsoyinu, 2009; Osibona et al., 2009; Adejonwo et al., 2010; Osibona, 2011; Abraham-Olukayode et al., 2013; Obande et al., 2013; Oramadike, 2015; Adejonwo, 2016; Davies & Jamabo, 2016; Akinjogunla et al., 2017) but collaborates and in similarity with reports from Okeyo et al. (2009), Olagunju et al. (2012), Effiong & Fakunle (2013), Kasozi et al. (2014) and Udoinyang et al. (2022). The high values obtained in the percentage of muscle protein contents in these SIS may be attributed to the fact that fishes are reliable source of protein while the differences in values obtained could be as a result of their adapted mode of feeding based on their present growth sizes, availability of their preferred diets in the environment and the conversion ability of these nutrients from their diets (Onyia et al., 2010).

It was also observed that the Cichlids (though herbivorous in nature) had the lowest mean values of muscle proteins (±17%), this could be that since the cichlids are prolific breeders, they must have converted their protein content levels towards reproduction instead of storing in their bodies. The high muscle protein contents in the Carnivorous species (Schibeidae, Mormyridae and Claridae) could be traced to their diets which comprise majorly smaller aquatic organisms like shrimps and crabs which have high protein contents in them.

The fish muscle contains high percentage of moisture (about 66-81%). Several reports have documented that, the data for the moisture content in an organism give useful knowledge on how to conserve the qualities of the organisms and also their vulnerability and sensitivity to fungi infection in addition to microbial spoilage and oxidative degradation of poly-saturated fatty acids (Adeyeye et al., 2013). Therefore, high moisture content in fish body decreases the quality of fishes over time. The mean value for the moisture content in this present study ranged between 74.44 and 78.67%. Since the moisture has an inverse relation with size of the fish, the fishes in the present study being small showed comparatively higher moisture content than that obtained by Adejonwo et al. (2010) who reported on *Tilapia guineensis* and *Tilapia melanotheron;* Osibona (2011) who worked on *Chrysichthys gariepinus, Tilapia zillii, Pseudotolithus. quinquarius* and *Pseudotolithus. typus*; Abraham-Olukayode et al. (2013) on *Pseudotolithus. elongatus*; Oramadike (2015) on *C. nigrodigitatus* and Adejonwo (2016) on *P. typus* and *Pseudotolithus. senegalesis*. The mean value ranges obtained for moisture content in this study are in similarity with reports from Woke et al. (2016) (73.67% on *Crassostrea gasar*) and Obande et al. (2013) (76.32% on fresh water snail) while the values were lower compared to the values of 85.65% reported by Udoinyang et al. (2022) who worked on the mudskippers (*Periopthalmus babarus*) from the Ibaka mangrove swamp in Calabar.

Lipids also represent a major source of energy and provide essential lipid nutrients that feature in our diets (Adebayo-Tayo et al., 2006). Like carbohydrates, lipids also have been documented to play a key role in determining the flavor, texture, mouthfeel, and appearance of foods (Shahidi & Hossain, 2022). The range of values of lipid obtained in this study (3.26-15.32%) for SIS were slightly different and relatively higher from the values of 0.86-1.05% documented by Adejonwo (2016), 2.16–2.21% reported by

Akinjogunla et al. (2017) and 2.29–3.05% by Udoinyang et al. (2022).

The ash content of all the fish species in present study ranged between 2.25%. (*M. rume*) and 3.71% (*C. anguillaris*). The values are slightly higher than the recommended values of 1.2-1.5% from FAO/WHO (1998), 1.98-2.23% from Akinjogunla et al. (2017) and 1.20-1.81% from Udoinyang et al. (2022) but lower than values (7.25-7.56%) reported by Kasozi et al. (2014) who worked on the fillets on *Alestes baremoze* based on sizes (< 1-2.5 kg).

The gross energy content of the analyzed small indigenous finfish species (SIS) in this study ranged between 4.48 and 6.21 kcal/g. The individual gross energy content of the SIS was similar to that reported by Alemu et al. (2013) for Nile tilapia (60.2 kcal/g) and Kasozi et al. (2014) who worked on *Alestes baremoze* (546.5-597.69 kcal/g) but lower than the values documented by Udoinyang et al. (2022). Although the values recorded for this study is higher compared to that of Akinjogunla et al. (2017) who reported the value of 114.02 kcal/g on *Crassostrea* species from the Lagos estuary.

All the fish samples examined contained appreciable concentrations of Ca, P, Mg and Na suggesting that these fishes could be used as good sources of elements. The highest values of these macro elements (Ca – 58.7 mg/100g; P – 27.0 mg/100g; Mg – 16.7 mg/100g and Na – 5.6 mg/100g) in the analyzed SIS shows that, though they are rich sources of Ca and P but have low deposits of Na. Concentration values of Ca was observed to dominate other element concentrations in all the samples. This tends to disagree with the work done by Moruf & Akinjogunla (2018) where the dominant element in the fish sampled was P while Onyia et al. (2010), Kasozi et al. (2014) and Udoinyang et al. (2022) all recorded Potassium (K) as the dominate element in their analyzed samples. The values of Ca dominating the macro elements in the sampled species is in agreement with the works of Andem & Ekpo (2014), Adejonwo (2016) and Akinjogunla et al. (2017). It could be inferred from the high concentration of Ca ions (Ca^+) in the tissues of the fish species that the water body from which the fishes were collected is rich in Ca^+.

The concentration of P in the fish samples studied graded and recorded as the second among the elements analyzed. Most of the small sized species (<10 cm) have large amount of Ca and P in their body and they can be eaten whole at once. Almost the entire store of Ca (99%) and most of the P (80%) in the body are in the form of bones, teeth and scales. In the present study, the Ca content ranged between 41.2 mg/100g and 58.7 mg/100g with the highest detected in the carcasses of the Cichlids (*O. niloticus* – 56.9 mg/100g, *S. galileus* – 55.3 mg/100g *and C. zilli* – 58.7 mg/100g) which might be due to their bony structures. The highest Ca content of 58.7 mg/100g observed for *C. zilli* in this present research is high when compared to values for beef (7 mg/100g) and egg (54 mg/100g) but lower than the value of 120 mg/100g obtained in milk or 129.18 mg/100g obtained in freshwater snail which are other good sources of Ca (Obande et al., 2013).

The variations observed in the levels of the nutrients analyzed in this study as compared to previously documented studies (Moronkola et al., 2011; Alemu et al., 2013; Andem & Ekpo, 2014; Kasozi et al., 2014; Woke et al., 2016; Akinjogunla et al., 2017, 2021; Moruf & Akinjogunla, 2018) could be attributed to the differences in the type of species, their food preference, feeding habits, sizes, sexes, type of habitats, availability and forms of the nutrients with the ability to convert the nutrients from the food in their environment.

In rural communities in developing countries like Nigeria and other undeveloped countries, where dairy and dairy products are way above the reach of the common man to be included in their diets, small fishes can be eaten since it contains important Ca and P for growth and bone development.

CONCLUSION

The study shed light on the elemental compositions of the carcasses of the SIS, revealing that they are good sources of essential nutrients and macro elements. Since the nutritional values of these small sized indigenous finfishes examined are now known

through this baseline research, nutritionists and the general public can now make informed decisions about the consumption of these species. However, it is important to understand the distribution and levels of these elements as they play crucial roles in various physiological processes. Further research can be conducted to explore the implication of these findings and their potential impact on the overall health and well-being of these fish species.

Compliance with Ethical Standards

Authors' Contributions

VFA: Manuscript design, Conducted the survey, Data analysis, Drafting, Reviewing and Editing.

BIU: Data analysis, Editing

All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon request.

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