

Evaluation of the Chemical Composition of Fish Species Captured in the lower Stretch of Itapecuru River, Maranhão, Brazil.

Heliene Leite Ribeiro Porto^{1*}, Antonio Carlos Leal de Castro¹, Victor Elias Mouchrek Filho² and Gandhi Rádís-Baptista³

¹Department of Oceanography and Limnology, Center for Health Sciences, Federal University of Maranhão, São Luís, Maranhão, Brazil.

²Department of Chemical Technology, Center for Science and Technology, Federal University of Maranhão, São Luís, Maranhão, Brazil.

³Laboratory of Biochemistry and Biotechnology, Institute of Marine Sciences, Federal University of Ceará, Fortaleza, CE, Brazil.

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This study aimed to investigate the chemical composition of muscle tissues from seven species of fish, which were captured from the lower section of the Itapecuru river, comprising the municipalities of Santa Rita and Rosario and the coastal area of Golfão Maranhão during the period of June 2012 to May 2013. The species selected for the experiment were: *Plagioscion squamosissimus*, *Geophagus surinamensis*, *Curimata* sp., *Prochilodus lacustris*, *Schizodon dissimilis*, *Ageneiosus ucayalensis* and *Hypostomus plecostomus*, which showed significant abundance and high commercial value. Representative samples were collected without distinction of size and sex and only species with good organoleptic conditions were selected. Analysis of the muscle of each species was performed in triplicate to assess the moisture content, total fat, ash and energy value. The average results of proximate analysis revealed the following variations: moisture 73.7% to 79.2%, total lipids 0.2% to 6.8%, protein 18.6% to 23.0%, ash 0.8% to 1.8% and the energy value of 77 to 136 kcal / 100g. The species *G. surinamensis* showed a higher moisture content and ash and a lower energy value, indicating the highest mineral content between the studied species. The *A. ucayalensis* species had, on average, higher levels of total lipids and energy, while the *P. lacustris* species showed a higher percentage of proteins. The results confirm the importance of knowing the protein value of species that can serve different dietary purposes of local people.

Keywords: Fish, Itapecuru river, Nutritional quality, Caloric value, Brazil.

INTRODUCTION

Human populations include fish as a main part of their daily diet, a fact that has become more relevant in developing countries, whose dietary pattern reveals a large dependency on staple foods, and fish is the main source, accounting in 2010, for about 19.6% of animal protein consumption (FAO, 2014). In addition to being recognized as a source of direct income of the Brazilian population, the fish is a very important food in the diet of individuals for its wealth of nutrients.

Martin *et al.* (2000) and Vila Nova *et al.* (2005) pointed out that fish is of high nutritional value due to its high protein content, excellent quality of lipids (omega 3 and 6 series) and low levels of total fat, saturated fats and cholesterol. It also incorporates high levels of polyunsaturated fatty acids, important for the promotion and maintenance of health and minerals like calcium, phosphorus, sodium, potassium and magnesium (Chandrashekar and Deosthale, 1993; Ismail and Ikram, 2004; Larson *et al.*, 2004; Arannilewa *et al.*, 2005; Harris, 2005).

According to the World Health Organization (WHO), the fish provides the healthiest animal protein and the Brazilians have arrived at consuming 14.5 kg per inhabitant / year, exceeding the recommended minimum consumption of fish, which is 12 kg per inhabitant / year or approximately 250 g of fish per week. Admittedly, the fish stands out for having in its composition high quality protein, retinol, vitamins D and E, iodine and selenium. Evidence increasingly associates their consumption to greater brain development and learning in children, also improving eye health, and protection against cardiovascular disease and some cancers.

The fats and fatty acids of fish are highly beneficial and difficult to obtain from other food sources (FAO, 2013). Acceptance of fishery products by consumers depend on various attributes of food quality, among which stand out the safety, nutrition, taste, texture, color and appearance, and the adequacy of raw material to processing and preservation (Cunha and Spers, 2010). The relative importance of any of

*Corresponding Author: Heliene Leite Ribeiro Porto. Department of Oceanography and Limnology, Center for Health Sciences, Federal University of Maranhão, São Luís, Maranhão, Brazil. Email: heliene.porto@ufma.br

these features depends on the particular material and its intended use (Haard, 1992). Information on the chemical and nutritional composition derived fishery products are important and badly needed for nutritionists, biologists and researchers who work with food, assisting in the formulation of diets, nutritional classification and supporting the food industries, research conservation and fish processing.

Despite the diversity of fish and the commercial potential of many native species, Brazil is still very lacking in data related to its chemical composition and the effect of storage under freezing in the constitution of fish flesh. Factors affecting the chemical composition are numerous, and some are intrinsic in nature such as genetic, morphological and physiological factors as well as other related environmental quality of the area where they live.

Thus, research in this field of expertise, with detailed study of the nutritional composition of these regional fish through analytical techniques available, are of great importance because they provide essential information for the fish processing industry and intensive fish farming, as well as, and perhaps more importantly, for healthcare professionals in the nutritional management of fish, with a view to a proper dietary guidance, and seek real alternatives that can adequately meet the nutritional needs of individuals, and further stimulate consumption of regional species. Thus, in view of the importance food and the lack of information on the nutritional value of these regional fish, proceeded up the present study the chemical composition of the fish.

MATERIAL AND METHODS

Material

The data that formed the basis for this study came from quarterly collections, carried out between the months of June / 2012 and May / 2013 in three different stations located in the lower stretch of the River Itapecuru between the ITALUÍS water catchment system and the mouth at the municipality of Rosario, as spatial distribution as shown in Figure 1. The species identification was made based on the work of: Eigenmanne Eigenmann (1890), Regan (1904), Fowler (1941), Fernández-Yépez (1968), Britski (1972), Mees (1974), Isbrücker (1979), Britski *et al* (1988), Vari (1988), Santos *et al* (1984, 2004), Piorski *et al* (1998, 2007), Mérona *et al* (2010). Taxonomic update was made by access to the Fishbase Project (Froese and Pauly, 2009).

Of specimens captured, seven species-individuals were selected for muscle tissue removal, using as criteria the capture volume and marketing potential. Samples considered had the best organoleptic conditions independent of the size of species and sex. The following taxa were selected: *Plagioscion squamosissimus*, *Geophagus surinamensis*, *Curimata* sp., *Prochilodus lacustris*, *Schizodon dissimilis*, *Ageneiosus ucayalensis* and *Hypostomus plecostomus*, and their morphometric measurements of total length (cm), total weight (g) and identified sex were taken.

Some individuals of each species were filleted, disregarding sex, anatomical differences and physiological characteristics. Then pulled out a portion of the lateral-medial region (abdominal muscles filet), skinless and boneless representative of the edible part of each sample. Subsequently, the muscle tissue was placed in properly labeled plastic bags and transported in coolers with ice, to the Quality Control Laboratory of Food and Water, Department of

Chemical Technology the UFMA, which were frozen at -17°C to date performing nutritional analyzes.

Determining the chemical composition

After homogenization, the following determinations were obtained using physico-chemical methods for food analysis of the Instituto Adolfo Lutz (IAL, 2008):

Humidity: determined by weight loss in oven set at 105 °C.

Ash: obtained by igniting a known amount of the sample in furnace at 550° C, to constant weight.

Protein: determined by the Kjeldhal method, which is used in the determination of total nitrogen. To convert the result into crude protein, the factor 6.25 was used.

Total lipids: extracted using the Soxhlet method.

The total **caloric value** was calculated from the calorie corresponding coefficients for proteins and lipids, 4 and 9 kcal / g respectively.

Statistical analysis

To compare the chemical and nutritional composition between species, we used a one-factor analysis of variance, after attaining the homogeneity of assumptions and normality of the data with the use of the Levene test. When the results of analysis of variance (ANOVA) indicated the presence of significant differences ($p < 0.05$), the posteriori Tukey test was used to identify the differences between the means, adopting a 0.05 significance level.

In cases where the ANOVA assumptions were not met, we used the non-parametric method of Kruskal-Wallis (Conover, 1990), accompanied by the nonparametric Mann-Whitney U test to compare possible differences between means. Multivariate analysis using the ordination technique of principal components (PCA) was used to verify the association between the sampled species and the concentration of nutrients, based on the variance-covariance matrix.

The statistical evaluations were performed using the STATISTICA computer package, version 7.0 (Stat Soft Corp., USA) and Palaeontological Statistics (PAST), version 17.2 (Hammer *et al*, 2001).

RESULTS AND DISCUSSION

Proximate analysis and statistical evaluation

Table 1 shows the data of the chemical composition of the seven fish species (*P. squamosissimus*, *G. surinamensis*, *Curimata* sp., *P. lacustris*, *S. dissimilis*, *A. ucayalensis* and *H. plecostomus*) and confirms the statement Maia *et al.* (1999) that although fish composition is well established as its predominant constituents, the ratio between them is very variable.

The results indicate that the average moisture content ranges from 77.3 to 79.2 g / 100 g, and the highest value was found in species *G. surinamensis* and lowest in species *A. ucayalensis* (Table 1). Moisture as a major component of the edible portion of fish was also observed by Yeannes and Almandos (2003) and Wang *et al.* (2005), confirmed water as the main component of the fish muscle, followed by protein and fat (Badolato *et al*, 1994).

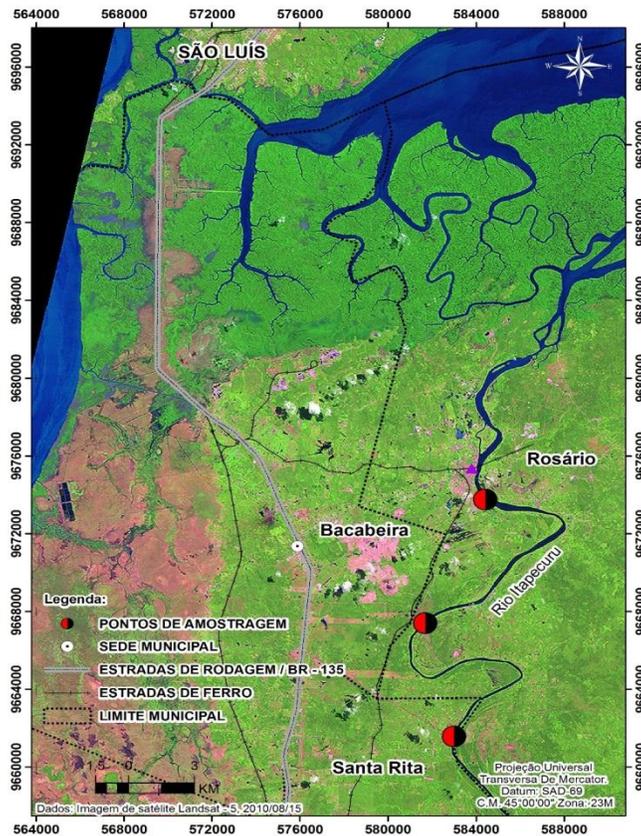


Figure 1. Map of locations of samples of fish in the lower stretch of the Itapecuru River.

Table 1. Chemical composition and caloric value (mean ± standard deviation) of muscle tissue fillet of seven species of fish captured in the lower stretch of the Itapecuru River - Maranhão - Brazil.

Species	Humidity (g/100g)	Lipid (g/100g)	Proteins (g/100g)	*Ashes (g/100g)	*Energy value (kcal/100g)
	Média ± Desvio	Média ± Desvio	Média ± Desvio	Média ± Desvio	Média ± Desvio
<i>P. squamosissimus</i> ^a	77.6 ± 1.04 ^{cf}	0.5 ± 0.46 ^{bf}	20.6 ± 1.23 ^{cd}	1.3 ± 0.26 ^f	87 ± 5.39 ^{cdf}
<i>Curimata sp.</i> ^b	77.6 ± 0.56 ^{cf}	1.4 ± 0.44 ^{defg}	20 ± 0.38 ^c	1.2 ± 0.21 ^f	92 ± 3.96 ^{cdef}
<i>P. lacustris</i> ^c	75 ± 2.16 ^{deg}	0.8 ± 0.16 ^{efg}	23 ± 1.41 ^{def}	1.2 ± 0.16 ^f	100 ± 1.25 ^{defg}
<i>G. surinamensis</i> ^d	79.2 ± 1.57 ^f	0.4 ± 0.16 ^f	18.6 ± 0.99 ^g	1.8 ± 0.81 ^f	77 ± 4.60 ^{fg}
<i>S. dissimilis</i> ^e	79 ± 0.93 ^f	0.2 ± 0.07 ^f	19.7 ± 0.65 ^g	1.1 ± 0.13 ^f	81 ± 2.24 ^{fg}
<i>A. ucayalensis</i> ^f	73.7 ± 0.78 ^g	6.8 ± 0.21 ^g	19 ± 0.67 ^g	0.8 ± 0.05 ^g	136 ± 1.05 ^g
<i>H. plecostomus</i> ^g	77.3 ± 0.82	0.2 ± 0.05	21.5 ± 0.96	1.1 ± 0.11	89 ± 3.35

a, b, c, d, e, f, g = species identification that showed significant differences between them (p < 0.05), for each of the concentrations of chemical composition and calorific value.

* = Significant result for test of homogeneity of variances-application of non-parametric test of Kruskal-Wallis.

Although there is no scientific record with information about the nutritional value of fish species present in Itapecuru river, the chemical composition in muscle tissue of different species of fish surveyed in other freshwater environments showed variation of moisture content in the range of 64.0% to 90.0% (Sanchez et al, 1990; Hart and Fisher, 1997; Andrade et al, 2009; Spitz et al, 2010).

With regard to the concentration of lipid, the species investigated showed values ranging from 0.2 to 6.8 g / 100g, with a higher concentration in the muscle tissue of *A. ucayalensis*, then *Curimata sp* which showed a fat content of 1.4% of the total composition, while the other species showed even less significant values (Table 1 and Figure 2).

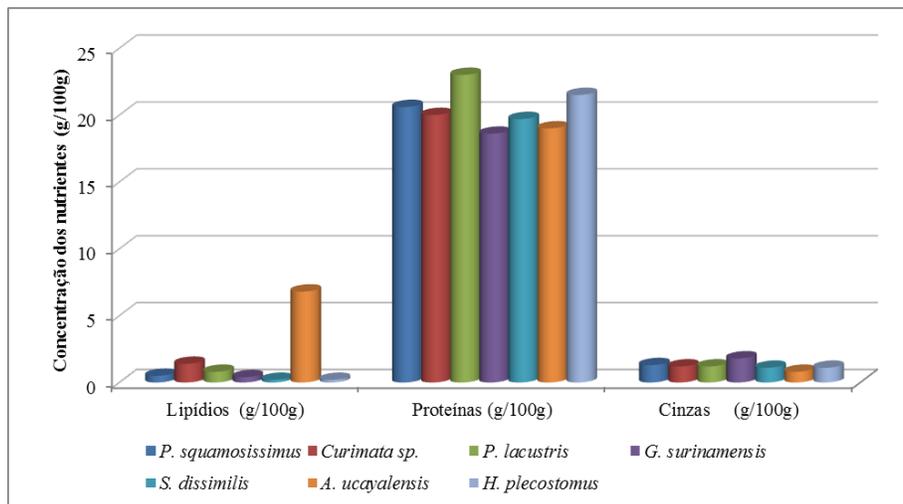


Figure 2. Average Levels of lipids, proteins and ash fish species captured in the Itapecuru River

Lourenço *et al* (2001) reported lipid traits for the species *P. squamosissimus* captured by artisanal fishing on the Tocantins River in the state of Pará, lotic environment of nature, like the Itapecuru River, where 0.5% of content was found for the same species (Table 1 and Figure 2).

These results were lower when compared to reports of Sales and Sales (1990); Sanchez *et al* (1990); Guinazi *et al* (2006); Ramos Filho *et al* (2008); Caula *et al* (2008); Souza *et al* (2013), all in search of the chemical composition of freshwater species. The relative superiority in the concentration of lipids in the studies cited above is probably due to the nature of the confined environment (dams, dam or breeding) suggesting a greater availability of nutrients.

The protein content in the species *H. plecostomus* and *P. lacustris* showed values of 21.5% and 23%, respectively, especially compared with other species caught in Itapecuru River, which ranged from 18.6 to 20.6% (Table 1 and Figure 2). These values are presented above those reported by Sales and Sales (1990) for the species *P. squamosissimus* (18.1%), *Curimata sp* (18%) and *Prochilodus cearensis* (18.5%), by Lawrence *et al* (2001) for *P. squamosissimus* (15.6%) on the Tocantins River in Pará and Caula *et al* (2008) studying the chemical composition also of the species *Prochilodus cearensis* (18.7%) in the state of Ceará.

These results show not only the assertion by Badolato *et al* (1994), that protein is the second component with the highest contribution to the fish muscle, as well as the fishes investigated in the Itapecuru river are classified as rich protein content species. Stansby (1961) considers fish to be fatty or oily when it contains a content above 15% lipids, medium or semi-fat when between 5 and 15% and lean when its fat content is below 5%. The same occurred with the protein, which Stansby and Olcott (1968) consider low level when the fish present with less than 15% and high content, ranging from 15 to 20%.

Thus, analyzing the mean values of lipid and protein samples investigated in this study, one can fit the species investigated in the class of lean and rich fish protein, except for the species *A. ucayalensis*. Furthermore, even considering the classification suggested by Stansby & Olcott in Stansby & Dassow (1967), which fall under low fish lipids (<5%) and high

protein content (15-20%) in category A, the samples analyzed from the Itapecuru river can be considered to be of excellent nutritional quality.

The results of the samples of this study agree, too, with a quotation from Stansby & Olcott (1968) in which the sum of the amounts of moisture and lipids in a study of proximate chemical composition in fish should be close to 80%.

The average levels for ashes are marked in Table 1 and Figure 2, revealing the species *A. ucayalensis* with the lowest ash content (0.8%) and *G. surinamensis* signaling species with the highest content (1.8%). The other species presented homogeneity as the average ash content, ranging from 1.1 to 1.3%. Aguiar (1996) found, for Amazon, ash content of 1.0% to *Schizodon sp* and *Prochilodus nigricans*, 1.2% for *Curimata sp*, all within the levels now presented, and from 1.8% to *Plagioscion sp*, which is consistent with the high ash content found in this study for the species *G. surinamensis* but much higher than that found for *P. squamosissimus* and also the *Plagioscion* genre.

The other findings were compatible also with those reported by other authors such as Sales and Sales (1990) also for *P. squamosissimus* and *Curimata sp* species (both 1.5%); Sanchez *et al* (1990) and Lourenço *et al* (2001) 1.12% and 1.1% respectively for the species *P. squamosissimus*; and even in reports of Guinazi *et al* (2006) studying freshwater species of Zona da Mata in the state of Minas Gerais; Ramos Filho *et al* (2008) for species in the Pantanal region of Mato Grosso do Sul; Caula *et al* (2008) reported ash content of freshwater species in the state of Ceará, including the *Prochilodus cearensis* species (0.8%); and Souza *et al* (2013) reported ash content of the species *Schizodon fasciatum* (0.3%) in the Amazon.

The total content of nutrients such as calcium, potassium, sodium, magnesium, iron, copper, cobalt, aluminum, sulfate, chloride, silicate, phosphate and others is indicated by ash content, and overall ash content in fish varies between 1 to 2% of the total chemical composition, which is strongly influenced by the type of food species (Viana *et al*, 2013). Thus, on the premise of these studies, *G. surinamensis* species showed higher ash content, indicating a higher mineral content.

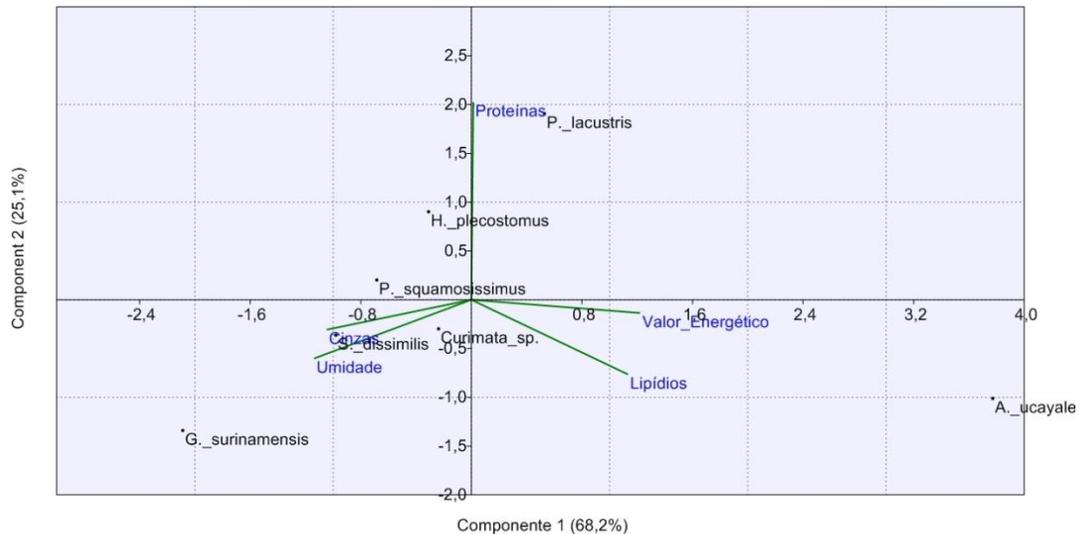


Figure 3. Resultant factorial Plan of Principal Component Analysis of the chemical composition of species caught in the lower stretch of the Itapecuru River.

Protein and ash contents below the range observed in this study were found by Maia *et al* (1999) and UNICAMP (2006) for species *Prochilodus cearensis* and *P. squamosissimus*, respectively, proving once again that the levels of lipids and moisture reported were superior for both studies.

As for caloric value, they have shown the species *S. dissimilis*, *P. squamosissimus*, *H. plecostomus*, *Curimata* sp and *P. lacustris* with average values between 81-100 kcal / 100g weight, except getting to the species *G. surinamensis* 77 kcal and the species *A. ucayalensis* which presented the maximum of 136 kcal / 100g, the latter being the species with the highest content of lipids, among those studied.

Aguiar (1996) analyzing the chemical composition of the fruits, vegetables and fish from the Amazon, reported calorific value of 89 kcal / 100g for the genre *Plagioscion*, very close to that found in this study for *P. squamosissimus* species which was 87 kcal / 100g (Table 1). Already, Caula *et al* (2008) reported calorific value of 108 kcal / 100g to *Prochilodus cearensis* also very close to that found in this study for the species *P. lacustris* which was 100 kcal / 100g (Table 1).

Sales and Sales (1990) obtained energy values for *P. squamosissimus* (109 kcal / 100 g) and *Prochilodus cearensis* and *Curimata* sp (185 kcal / 100g both), in ponds and Souza *et al* (2013) reported for the species *Schizodon fasciatum*, in Amazon waters, energy value of around 125.43 kcal / 100g, so it's all much higher, compared to the values found in this study for *P. squamosissimus* (87 kcal / 100g), *Curimata* sp (92 kcal / 100g), *P. lacustris* (100kcal / 100g) and *S. dissimilis* (81 kcal / 100g), this difference in results are probably associated with the nature of the investigated environment, confirming what Stansby (1961) postulates when he states that the chemical composition does not vary only from species to species, but also between individuals of the same species, and Visentainer *et al* (2005) stating that the analytical data greatly vary according to the age, sex, diet, genetics, type and time of nesting, the productive stage, size, migration, and season as

well as environmental factors associated with variations in fish habitat.

None of the seven species presented levels of carbohydrates, evaluated by the difference of the levels obtained from 100%. Comparison of chemical composition and nutritional values among the species investigated showed significant differences ($p < 0.05$) between *Ageneiosus ucayalensis* species group consisting of: *P. squamosissimus*, *Curimata* sp, *G. surinamensis* and *S. dissimilis*, which were statistically similar in relation to moisture levels, lipids and proteins.

Regarding the multivariate analysis, it was observed that the *P. lacustris* species was associated with protein values through a direct and positive correlation, while the species *G. surinamensis* and *A. ucayalensis*, correlated negatively with the moisture content and lipids, respectively. The two main components of the analysis accounted for 93.3% of the total variability of the data indicating that the data set may be reduced and explained in two dimensions (Figure 3).

CONCLUSION

Humidity was the main component (73.0 to 81.5%) of the fish muscle investigated, followed by protein representing the second component with the highest contribution. The Species *Plagioscion squamosissimus*, *Geophagus surinamensis*, *Curimata* sp, *Prochilodus lacustris*, *Schizodon dissimilis* and *Hypostomus plecostomus* based on literature records were classified in category A - lean, while *Ageneiosus ucayalensis* species was classified in category B - semi-fat species, presenting the latter as a good source of lipids.

All species investigated were classified as rich protein content species, showing that they are good sources of protein, especially for *Prochilodus lacustris* species. The species *Geophagus surinamensis* showed higher ash content indicating greater content of minerals. From the nutritional

point of view, species were found with different characteristics in the same environment, such as high protein content and low calorific value, such as *Geophagus surinamensis*, *Schizodon dissimilis*, *Plagioscion squamosissimus*, *Hypostomus plecostomus* and *Curimata* sp., and others with high content of protein and energy value from 100 kcal/100g as was the case of the species *Prochilodus lacustris* and *Ageneiosus ucayalensis*. The species reported in this study are presented as high-quality food, and may serve different dietary purposes for the local population.

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