ORIGINAL ARTICLE

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Mineral composition in commercial cuts of *Colossoma macropomum* (Cuvier, 1818) and *Arapaima gigas* (Schinz, 1822) in ideal weight class for commercialization

Composição mineral em cortes comerciais de Colossoma macropomum *(Cuvier, 1818) e* Arapaima gigas *(Schinz, 1822) na classe de peso ideal para comercialização*

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ABSTRACT: The aimed of this study was to evaluate the mineral composition in commercial cuts of tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*). Were compared to the minimum values of daily consumption of minerals recommended by the World Health Organization (WHO). The experimental design was completely randomized, with processing performed in triplicate. Data were submitted to ANOVA. If ANOVA appeared statistically significant (α=0.05), the means were compared by Tukey's Test. There was a difference (p<0.05) between commercial cuts of the tambaqui for different minerals. Tambaqui ribs and band presented the highest values of total iron 1.08 ± 0.12 mg/100g compared to other commercial cuts. The mineral elements Na^+, K^+, Ca^{2+} and Mg^{2+} expressed the highest values for the tambaqui steak, 301.00 ± 80.58, 457.00 ± 129.33, 36.00 ± 4.36 and 46.90 ± 4.68 mg/100g, respectively. There was a difference (p<0.05) between commercial cuts of the pirarucu for different minerals. The mineral elements Total Iron, Na^+, K^+ and Ca^{2+} expressed the highest values for pirarucu loin, 0.80 ± 0.07, 406.00 ± 117.50, 529.30 ± 130.58 and 32.00 ± 5.12 mg/100g, respectively. However, Mg^{2+} expressed a higher value for pirarucu tail fillet 37.10 ± 4.99 mg/100g. The tambaqui steak and pirarucu loin were the cuts that best met the minimum needs for mineral supply.

KEYWORDS: Aquaculture; Brazilian Amazon; Mineral matter; Mineral supply.

RESUMO: O objetivo do estudo foi avaliar a composição mineral em cortes comerciais de tambaqui (*Colossoma macropomum*) e pirarucu (*Arapaima gigas*). Foram comparados aos valores mínimos de consumo diário de minerais recomendados pela Organização Mundial da Saúde (OMS). O delineamento experimental foi inteiramente casualizado, com processamento realizado em triplicata. Os dados foram submetidos à ANOVA. Caso a ANOVA parecesse estatisticamente significativa (α=0,05), as médias foram comparadas pelo Teste de Tukey. Houve diferença (p<0,05) entre cortes comerciais de tambaqui para os diferentes minerais. A costela e a banda de tambaqui apresentaram os maiores valores de ferro total 1,08 ± 0,12 mg/100g em relação aos demais cortes comerciais. Os elementos minerais Na^+, K^+, Ca^{2+} e Mg^{2+} expressaram os maiores valores para posta de tambaqui, 301,00 ± 80,58, 457,00 ± 129,33, 36,00 ± 4,36 e 46,90 ± 4,68 mg/100g, respectivamente. Houve diferença (p<0,05) entre cortes comerciais de pirarucu para diferentes minerais. Os elementos minerais Ferro Total, Na^+, K^+ e Ca^{2+} expressaram os maiores valores para o lombo de pirarucu, 0,80 ± 0,07, 406,00 ± 117,50, 529,30 ± 130,58 e 32,00 ± 5,12 mg/100g, respectivamente. No entanto, o Mg^{2+} expressou maior valor para filé da cauda de pirarucu 37,10 ± 4,99 mg/100g. Em destaque, a posta de tambaqui e o lombo de pirarucu foram os cortes que mais atenderam às necessidades mínimas de suprimento mineral.

PALAVRAS-CHAVE: Aquicultura; Amazônia Brasileira; Matéria mineral; Suprimento mineral.

INTRODUCTION

Minerals are inorganic substances, as living beings do not produce them, but they are very important for the proper functioning of the human organism participating in many metabolic processes, and the lack of them can cause many health problems, such as undernutrition and even death (FELTES et al., 2010; JIM et al., 2017). The mineral salts that most contribute to the functioning of the human organism are the mineral elements iron, calcium, phosphorus, iodine, magnesium, zinc, potassium, selenium, sodium, fluorine, among others (Reinicke et al., 2019; Oliveira et al., 2020).

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The world has suffered and will suffer from the lack of adequate food to guarantee food security for the population. However, fish is a source of nutrients widely available in the world, especially in tropical regions (Cavali et al., 2020). Furthermore, to having proteins and lipids in levels of interest to the food industry, their meat has a good part of the essential minerals for humans (LIMA et al., 2018; Dantas Filho et al., 2021). The several factors influence the proximal composition of fish meat, such as species, age, size, sex, time of year and cut; however, generally, the muscle contains about 20 % crude protein, 0.4 to 1.5 % minerals, 75% moisture and provides 97.12 kcal/100g or 406.36 kJ/100g (Ribeiro et al., 2018).

Cultivated fish is very useful as a food source, due to its nutritional value, easy digestibility, diversity of flavors and balanced chemical composition due to high biological value proteins (Batalha et al., 2017). For this reason, several regions of the world have been cultivating freshwater fish for food production (FAO, 2018). Among countries with potential, Brazil has a prominent role, especially due to its water availability, favorable climate and natural occurrence of aquatic species that make zootechnical and market interests compatible (BRAZIL, 2017). However, fish consumption in Brazil is still low compared to Asian countries, although consumption has increased from 9 to 12 kg per capita in the last 10 years (FAO, 2018). But, in some regions of the Amazon, for example, fish consumption reaches 150 kg *per capita* (FAO, 2018). Rondônia state, in turn, is the largest producer of native fish in Brazil with emphasis on tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*), corresponding to a total of 65.5 million tonnes of fish produced in 2020 (Peixe BR, 2021).

The definition of nutritional values in commercial cuts of tambaqui (*Colossoma macropomum* Cuvier, 1818) and pirarucu (*Arapaima gigas* Schinz, 1822) commercialized in Rondônia state makes it possible to encourage consumption based on fish. In addition to that, the knowledge of the chemical composition provides subsidies for dietary decisions, in addition to the marketing incentive, adding commercial value, which directly reflects in trade and exports. Addressing the aspect of the elaboration of new products and by-products originating from fish justifies that, for constant consumption, it is essential that different forms of presentation are available to the consumer (Bordignon et al., 2012). In recent years, the demand for fish has intensified, and this is due to the dissemination of information related to its nutritional value and because its consumption is added to the health benefit of the population (Soares et al., 2012; Donadelli et al., 2019). Therefore, Rondônia state, through policies, should continue to encourage the production of fish native to the Amazon, such as the tambaqui and the pirarucu, so that they are widely commercialized in the Brazil, contributing to improving the population's diet and promoting public health.

In view of the above, the aimed of this study was to evaluate the mineral composition in commercial cuts of tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*) in the slaughter weight class (1.80 to 2.41 kg and 11.1 to 14.0 kg, respectively), commercialized in the Rondônia state, Western Brazilian Amazon. Then, the results will be compared to the minimum daily mineral consumption values recommended by the WHO. And also, it compared these mineral data with other species of fish and other animals.

MATERIAL AND METHODS

The study was conducted by the Universidade Federal de Rondônia (UNIR) and the analyzes were performed at the Water and Food Laboratory, Department of Chemistry, Universidade Estadual de Maringá (UEM). The research was developed with support from the Rondônia Research Support Foundation (FAPERO) and approved by the Ethics Committee on the Use of Animals (CEUA) with protocol number 02/2017. The sample collections were carried out from May 2017 to December 2018 in two processing industries located in Rondônia state, in the municipalities of Ariquemes and Vale do Paraíso, both registered in the Brazilian System for the Inspection of Animal Products (SISBI-POA).

Commercial diets

It is important to emphasize that the tambaqui (*C. macropomum*) sampled received standardized feed. Therefore, food was not a factor causing variation in the results of mineral composition.

That said, for feeding tambaqui, extruded commercial rations containing 28% crude protein at a feeding rate of 1.8% of body weight. Feeding was performed twice a day at 10 am and 5 pm for 130 days (Table 1).

Table 1. Guarantee levels of the feed provided to tambaqui (*C. macropomum*) cultivated in the Western Brazilian Amazon.

Feed composition[1]	Content (g/kg)	Feed composition[1]	Content (g/kg)
Calcium (min.g)	10.0	Vitamin B_{12} (mg)	4.2
Calcium (max. g)	40.0	Vitamin B_2 (mg)	3.5
Ethereal extract (g)	25.0	Vitamin B_6 (mg)	2.0
Phosphorus (g)	6.0	Vitamin D_3 (mg)	4.200.0
Crude protein (g)	90.0	Vitamin E (UI)	52.0
Mineral matter (g)	150.0	Vitamin K_3 (mg)	2.1
Crude protein (g)	280.0	Vitamin C (mg)	300.0
Moisture (g)	90.0	Copper (mg)	5.0
Pantothenic acid (mg)	3.5	Iron (mg)	30
Biotin (mg)	0.05	Iodine (mg)	0.2
BHT (mg)	70.0	Niacin (mg)	10.5
Choline (mg)	290.0	Manganese (mg)	6.0
Vitamin A (UI)	14.000	Zinc (mg)	17.0
Vitamin B_1 (mg)	2.0	Selenium (mg)	0.06

[1]Percentage of dry matter.

For feeding pirarucu (*A. gigas*), extruded commercial rations containing 36% crude protein at a feeding rate of 1.0% of body weight. Feeding was performed twice a day at 10 am and 5:00 pm for 130 days (Table 2).

Sampling and processing

40 specimens of tambaqui (*C. macropomum*) with slaughter class body weight 1.80 to 2.41 kg were processed and data were obtained from 10 fish per commercial cut, which were tambaqui fillet, ribs, steak and band. To emphasize that three samples of meat were removed by commercial cut, more details later.

And also, 40 specimens of pirarucu (*A. gigas*) with slaughter class body weight 11.1 to 14.0 kg were processed and data were obtained from 10 fish per commercial cut, which were pirarucu fillet mignon, tail fillet, loin and deboned. To emphasize that three samples of meat were removed by commercial cut, more details later. Clarify that the weight classes (for tambaqui and pirarucu) were considered ideal for commercialization by (NUNES, 2019; DANTAS FILHO et al., 2021).

The sampled fish were selected from previously characterized fish farms, excluding lots from production systems that adopted production management very different from that adopted in fish farms, such as reports of parasite infestations, deaths from high stocking densities, undernutrition, among others. The animals were removed from the tanks through a fishing net, and then went through the stunning process, the tambaqui by thermal shock and the pirarucu by concussion. Then the fish were euthanized by exsanguination by section of the carotid veins, according to procedures adopted by the slaughterhouses. In the processing industry the fish were washed, gutted and processed in commercial cuts according to market demand.

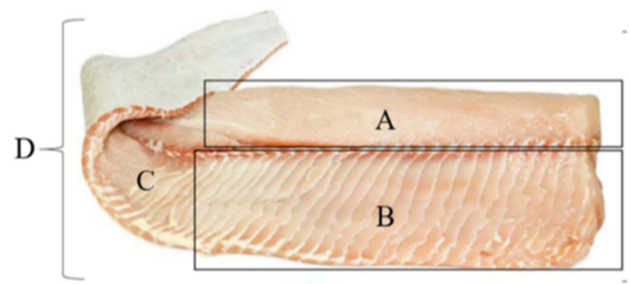
The initial stage of tambaqui processing was carried out on the evisceration table. The euthanized fish were destined for the fillet and ribs cuts (Figure 1 A and B), were preceded by the removal of the spine on the evisceration table followed by the removal of the intramuscular spines and separation of the respective cuts. The steak is the commercial cut of the tambaqui in transverse direction to the vertebral column (Figura 1 C). The tambaqui is sliced with a band-saw vertically in relation to the processing table. For the band cut (Figure 1 D) the head was kept, with only the spines and fins removed.

The initial stage of pirarucu processing was performed on the evisceration table, with the procedure of removing the skin with scales, removing the head and the viscera. In definition, the loin (Figura 2 A) is located in the upper part of the deboned cut, the fillet mignon (Figura 2 B) is the largest meat part that covers the ribs and the tail fillet (Figura 2 C) is located in the caudal portion of the deboned cut (Figure 2 D).

Three samples were taken from different regions of the commercial cuts for the two fish species. However, the 3 samples were homogenized to obtain greater representation and facilitated referral to the specialized laboratory in Maringá - PR, Brazil.

Source: Dantas Filho et al., 2021.

Figure 1. Representation of commercial cuts of tambaqui (*C. macropomum*) produced in processing industries in the Western Brazilian Amazon. (A) Fillet; (B) Ribs; (C) Steak; (D) Band.



Source: Dantas Filho et al., 2021.

Figure 2. Representation of commercial cuts of pirarucu (*A. gigas*) produced in processing industries in the Western Brazilian Amazon. (A) Loin; (B) Fillet mignon; (C) Tail fillet; (D) Deboned.

Table 2. Guarantee levels of the feed provided to pirarucu (*A. gigas*) cultivated in the Western Brazilian Amazon.

Feed composition	Content (g/kg)	Feed composition	Content (g/kg)
Dry matter (g)	910.0	Ethereal extract (mim,g)	80.0
Crude protein (min.,g)	360.0	Calcium (max.,g)	35.0
Fibrous matter (máx.,g)	95.0	Calcium (min.,g)	20.0
Mineral matter (max.,g)[1]	15.0	Phosphorus (min.,g)	15.0

[1]Amount of nutrient per kg, for crude protein ration (36%). Pantothenic acid (min) - 3.00 mg; Biotin (min) - 50 mg; Choline (min) - 290 mg; Vitamin A (min) - 28,000 IU; Vitamin B_1 (min) - 2.00 mg; Vitamin B_{12}(min) - 4.00 mg; Vitamin B_2 (min) –3.00 mg; Vitamin B_6 (min) - 2.00 mg; Vitamin D_3 (min) –5,000 IU; Vitamin E (min) –45.00 IU; Vitamin K_3 (min) - 2.00 mg; Vitamin C (min) - 500 mg; Copper (min) - 10.00 mg; Iron (min) - 90 mg; Iodine (min) - 0.40 mg; Niacin (min) - 50.00 mg; Manganese (min) - 10.00 mg; Zinc (min) - 180 mg; Selenium (min) - 0.60 mg.

Specifically, the extraction of the 3 samples by commercial cut, this extraction was performed by removing 4 cm^2 of meat always on the right side of the cut. It is important to emphasize that these samples were properly identified and stored at -18°C for later forwarding to the specialized laboratory.

Mineral composition assesment

For the quantification of the macrominerals, an extract was obtained from the complete digestion of the sample in sulfuric acid and high temperature (350 - 375° C). The microminerals were analyzed from extracts from samples of acid digestions under controlled temperatures, with nitric acid (120° C) and perchloric acid (180 - 190° C), Total iron (Fe^{2+} + Fe^{3+}) (Ruiz-de-Cenzano et al., 2013). To perform the measurements, a model AA 12/1475 atomic absorption spectrometer was used. The minerals Na^+ and K^+ were determined by the AOAC Official method 969.23 and the minerals Total iron, Ca^{2+} and Mg^{2+} were determined by the AOAC Official method 968.08 according to the methodology described by Cook et al. (2020).

Comparison analysis and data survey

After obtaining the mineral composition results, the data will be compared to the minimum daily mineral consumption values recommended (for men and women – total iron). The comparison analysis will be performed by calculating the percentage of daily supply (Vdsm %) in relation to the recommendations of average daily consumption (mg / day) of minerals (recommended by WHO).

Vdsm= Vmf/Vmr x 100

Where: Vdsm = Percentage of daily mineral supply value; mineral value found (in 100g); minimum mineral value for daily consumption (recommended by WHO)

Source: Dantas Filho, 2020.

Concerning the collection of data to compare the results with the mineral composition of other species of fish and other animals. The data collection is characterized as exploratory descriptive, qualitative, aiming at the analysis, comparison and cross-referencing of data between several scientific articles and literature related to the theme "Mineral composition of native Amazonian fish".

The searches, storage and analysis of data were carried out from August 2020 to February 2021. The bibliographic databases for carrying out the searches were Google Academic, Scielo, CAPES journals and institutional repositories. The criteria adopted for the searches were periodicals/scientific journals with a consolidated technical and editorial staff, and which have a focus and scope related to the theme. In addition, having a link with a higher education institution and qualis concept (2013-2016) at least B1 in the areas of assessment in Veterinary Medicine and Environmental Sciences.

The descriptors used were aquaculture, fish farming, commercial fish, native fish, fish meat and mineral profile; in Portuguese and English languages, with words and terms separated by the Boolean operators 'AND' and 'OR'.

Statistical design and analysis

The experimental design was completely randomized with four commercial cuts for both tambaqui and pirarucu, and the analyzes were carried out in triplicate for both species. Data were submitted to ANOVA to assess differences between commercial cuts in mineral compositions. If ANOVA appeared statistically significant (α=0.05), the means were compared by Tukey's Test. The software used to perform the statistical analyzes was the Genes Program made available by the Universidade Federal de Viçosa (UFV), version 13.3 (Cruz, 2013).

RESULTS AND DISCUSSION

There was a difference ($p<0.05$) between commercial cuts of the tambaqui (*C. macropomum*) for different minerals. Tambaqui ribs and band presented the highest values of total iron 1.08 ± 0.12 mg/100g compared to other commercial cuts. The mineral elements Na^+, K^+, Ca^{2+} and Mg^{2+} expressed the highest values for the tambaqui steak, 301.00 ± 80.58, 457.00 ± 129.33, 36.00 ± 4.36 and 46.90 ± 4.68 mg/100g, respectively (Table 3).

There was a difference ($p<0.05$) between commercial cuts of the pirarucu (*A. gigas*) for different minerals. The mineral elements Total Iron, Na^+, K^+ and Ca^{2+} expressed the highest values for pirarucu loin, 0.80 ± 0.07, 406.00 ± 117.50, 529.30 ± 130.58 and 32.00 ± 5.12 mg/100g, respectively. However,

Table 3. Mineral composition (mg/100g) in commercial cuts of tambaqui (*C. macropomum*) from the slaughter weight class (1.80 to 2.41 kg) commercialized in the Western Brazilian Amazon.

Commercial cuts	Total iron	Na^+	K^+	Ca^{2+}	Mg^{2+}
Fillet	0.48 ± 0.05^{ab}	270.90 ± 72.52^{ab}	306.00 ± 86.60^{ab}	17.40 ± 2.11^{b}	12.00 ± 1.20^{ab}
Ribs	1.08 ± 0.12^{a}	175.57 ± 47.00^{b}	295.00 ± 83.49^{b}	17.96 ± 2.17^{b}	11.24 ± 1.12^{b}
Steak	0.27 ± 0.03^{b}	301.00 ± 80.58^{a}	457.00 ± 129.33^{a}	36.00 ± 4.36^{a}	46.90 ± 4.68^{a}
Band	1.08 ± 0.12^{a}	175.50 ± 47.00^{b}	295.50 ± 83.49^{b}	17.96 ± 2.17^{b}	11.24 ± 1.12^{b}

If there are averages followed by different letters in columns (a, b) they are different from each other by Tukey's Test ($p<0.05$).

Mg^{2+} expressed a higher value for pirarucu tail fillet 37.10 ± 4.99 mg/100g (Table 3).

Based on the results of the data survey, Table 5 was found, showing the recommended values for the average daily consumption of minerals for adults (men and women) according to the WHO recommendations.

With regard to the supply of minerals in relation to the recommendations presented in Table 5, it is important to highlight the following significant results. Tambaqui ribs and pirarucu loin supply 13.5 and 6.0 and 10 and 4.44 %, respectively. This data is for total daily iron consumption requirements for adult men and women.

Tambaqui steak and pirarucu loin supply 15.0 and 20.6 %, respectively, of the need for daily Na^{+} consumption. Tambaqui steak and pirarucu loin supply 13.0 and 15.1 %, respectively, of the need for daily K^{+} consumption. Tambaqui steak and pirarucu loin supply 3.6 and 3.2 %, respectively, of the need for daily Ca^{2+} consumption. And finally, tambaqui steak and pirarucu tail fillet supply 11.7 and 9.3 %, respectively, of the need for daily Mg^{2+} consumption (Table 6). Therefore, tambaqui steak and pirarucu loin were the cuts that most met the minimum mineral supply needs.

According to Ordinance No. 27 of January 13, 1998, which classifies food as a source or rich in certain nutrients (BRASIL, 1998), was a function of to the minimum daily supply values, the commercial cuts of tambaqui steak and pirarucu loin are rich in iron, sodium and potassium. Tambaqui steak and pirarucu tail fillet are rich in magnesium. The other commercial cuts of both tambaqui and pirarucu are considered as a source of iron, sodium, calcium and magnesium.

The Table 7 summarizes the minerals found in the fillet of Nile tilapia (*Oreochromis niloticus*), Salmon (*Salmo salar*), Pirapitinga (*Piaractus brachypomus*), Cavala (*Trachurus murphyi*), Skipjack tuna (*Katsuwonus pelamis*), Pangasius (*Pangasius hypophthalmus*), African catfish (*Clarias gariepinus*), Cachara (*Pseudoplatystoma fasciatum*) and Trout (*Salmo trutta*).

Regarding the data on the mineral composition of fillets of other fish species, we highlight, Ostrich and Nile tilapia expressed the highest values of total iron 4.17 and 3.83 mg/100g. Pangasius and African catfish expressed the highest values of Na^{+} 387.50 and 308.00 mg/100g. Nile tilapia and Pangasius expressed the highest values of K^{+} 378.33 and 335.60 mg/100g. African catfish and Pirapitinga expressed the highest values of Ca^{2+} 40.10 and 21.10 mg/100g. Pirapitinga and trout expressed the highest values of Mg^{2+} 25.77 and 23.00 mg/100g, respectively. Concerning mineral composition data from other animal species, Beef steak and Bovine rump expressed the highest values of total iron 5.80 and 3.31 mg/100g. Chicken upperleg and Bovine liver expressed the highest values of Na^{+} 90.67 and 84.00 mg/100g. Chicken upperleg and Ground beef expressed the highest values of K^{+} 301.00 and 300.00 mg/100g. Bovine liver and Ground beef expressed the highest values of Ca^{2+} 8.00 and 8.00 mg/100g. Bovine rump and Pork shank expressed the highest values of Mg^{2+} 49.33 and 36.67 mg/100g, respectively (Table 7).

In comparison with the mineral content presented in the tambaqui cuts, it was found that although the fillet and the tambaqui steak had lower total iron values than the fish summarized in Table 7, tambaqui ribs and band expressed similar values Salmon fillet, Pirapitinga, Skipjack tuna and Pangasius. However, they expressed lower total iron values than Nile tilapia, Cachara, Cavala and Trout. Tambaqui fillet, ribs and band expressed lower Na^{+} values in relation to the fish presented in Table 7, with the exception of Pirapitinga 96.30 mg/100g, Skipjack tuna 87.33 mg/100g and Cavala 130 mg/100g. However, tambaqui steak expressed a higher Na^{+} value, with the exception of Pangasius 387.50 mg/100g and African catfish 308.00 mg/100g.

All commercial tambaqui cuts presented higher K^{+} values than the fish species compiled in Table 7, with the exception of Nile tilapia and Pangasius 378 mg/100g and 335.60 mg/100g, respectively, because tambaqui ribs and band expressed K^{+} values lower than the fillet of these fish. Tambaqui cuts expressed

Table 5. Recommendations for daily consumption (mg/day) of minerals for adults (men and women).

Minerals	Daily intake (mg/day)[1]
Total iron	8.0 – 18.0[2]
Na^{+}	2000.0
K^{+}	3510.0
Ca^{2+}	1000.0
Mg^{2+}	400.0

[1]Minimum daily consumption; [2] Minimum daily total iron intake of 8.0 mg for men and 18.0 mg for adult women.
Source: WHO.

Table 4. Mineral composition (mg/100g) in commercial cuts of pirarucu (*A. gigas*) in the slaughter weight class (11.1 to 14.0 kg) commercialized in the Western Brazilian Amazon.

Commercial cuts	Total iron	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}
Fillet mignon	0.21 ± 0.02^{b}	234.38 ± 67.83^{ab}	317.00 ± 78.20^{b}	14.41 ± 2.31^{b}	9.64 ± 1.30^{b}
Tail fillet	0.24 ± 0.02^{b}	236.75 ± 68.51^{ab}	348.20 ± 85.85^{ab}	25.80 ± 4.13^{ab}	37.10 ± 4.99^{a}
Loin	0.80 ± 0.07^{a}	406.00 ± 117.50^{a}	529.30 ± 130.58^{a}	32.00 ± 5.12^{a}	18.80 ± 2.53^{ab}
Deboned	0.37 ± 0.03^{b}	214.57 ± 62.09^{b}	315.36 ± 77.80^{b}	16.70 ± 2.67^{b}	10.40 ± 1.40^{b}

If there are averages followed by different letters in columns (a, b) they are different from each other by Tukey's Test ($p<0.05$).

amounts of Ca^{2+} higher than the fillet of Salmon 5.45 mg/100g, Cavala 14.44 mg/100g, Pangasius 2.44 mg/100g and Cachara 10.06 mg/100g. However, tambaqui steak expressed a higher value (36.00 mg/100g) of Ca^{2+} than all the fish summarized in Table 7. With the exception of Pangasius 12.08 mg/100g, all compiled fish have higher values of Mg^{2+} than the tambaqui fillet, ribs and band. However, the tambaqui steak (46.90 mg/100g) expressed a higher Mg^{2+} value.

It was found that the commercial cuts of pirarucu expressed lower values of total iron compared to fish fillets presented in Table 7. Except Pangasius and Cachara 387.50 and 308.00 mg/100g, respectively. All pirarucu commercial cuts expressed higher K^{+} values compared to all fish presented in Table 7. Except Nile tilapia 378 mg/100g. Pirarucu tail fillet presented higher values of Mg^{2+} 37.10 mg/100g than all the fish presented in Table 7. However, except Cachara 10.06 mg/100g, the fish in Table 7 expressed higher values of Mg^{2+} to pirarucu fillet mignon, loin and deboned.

Regarding the comparison of mineral composition with other animal species, tambaqui steak and pirarucu tail fillet expressed higher values of Mg^{2+} than the portions presented in Table 7. Except Bovine beef, with higher values 49.33 mg/100g.

Table 6. Percentage of daily supply (%) of commercial cuts (of 100g) of tambaqui (*C. macropomum*) and pirarucu (*A. gigas*) in function of to the recommendations of average daily consumption (mg/day) of the minerals iron, sodium, potassium, calcium and magnesium for adults (men and women).

Commercial tambaqui cuts					
	Total iron	**Na^{+}**	**K^{+}**	**Ca^{2+}**	**Mg^{2+}**
Fillet	6.0 – 2.67	13.6	8.7	1.7	3.0
Ribs	13.5 – 6.0	8.8	8.4	1.8	2.8
Steak	3.4 – 1.5	15.0	13.0	3.6	11.7
Band	13.5 – 6.0	8.8	8.4	1.8	2.8
Commercial pirarucu cuts					
Fillet mignon	2.63 – 1.17	11.7	9.0	1.4	2.4
Tail fillet	3.0 – 1.33	11.8	10.0	2.58	9.3
Loin	10.0 – 4.44	20.6	15.1	3.2	4.7
Deboned	4.63 – 2.06	10.7	9.0	1.7	2.6

Table 7. Mineral composition (mg/100g) in fillets of different species of fish and other animal species.

Meat portions	Total iron	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	References
Fish species						
Nile tilapia *(Oreochromis niloticus)*	3.83	160.20	378.33	4.33	21.00	Jim et al. (2017)
Salmon *(Salmo salar)*	1.18	195.05	244.70	5.45	22.12	Atanasoff et al. (2013)
Pirapitinga *(Piaractus brachypomus)*	1.06	96.30	177.00	21.10	25.77	Murthy et al. (2015)
Cavala *(Trachurus murphyi)*	2.48	130.30	99.70	14.44	20.10	Bastías et al. (2017)
skipjack tuna (*Katsuwonus pelamis)*	0.99	87.33	83.00	16.40	18.70	Mahaliyana et al. (2015)
Pangasius (*Pangasius hypophthalmus*)	0.97	387.50	335.60	2.44	12.08	Orban et al. (2008)
African catfish (*Clarias gariepinus)*	1.44	308.00	181.70	40.10	18.40	Ersoy and Özeren (2009)
Cachara *(Pseudoplatystoma fasciatum*)	2.06	106.33	176.00	10.24	10.06	Perea et al. (2008)
Trout *(Salmo trutta)*	2.17	201.77	166.00	16.10	23.00	Perea et al. (2008)
Ostrich fillet (*Crassostrea gigas*)	4.17	77.33	192.33	7.73	34.00	Hautrivel et al. (2012)
Other animal species						
Bovine rump	3.31	76.00	251.00	5.43	49.33	Roça (2012)
Beef steak	5.80	61.00	355.00	4.00	24.00	Roça (2012)
Bovine liver	3.20	84.00	298.00	8.00	14.00	Roça (2012)
Ground beef	3.20	70.00	300.00	8.00	17.00	Roça (2012)
Pork shank	0.89	58.00	245.00	5.87	36.67	Hautrivel et al. (2012)
Chicken upperleg	0.76	90.67	301.00	5.23	35.33	Hautrivel et al. (2012)

Pirarucu loin had higher amounts of Mg^{2+} than the Bovine liver and Ground beef 14 and 17 mg/100g, respectively. It was found that despite the commercial cuts of tambaqui and pirarucu present total iron values lower than the Beef steak, Bovine liver and Ground beef from cattle, presented higher values of total iron in relation to the 100g portions of Pork shank 0.89 mg/100g and Chicken upperleg 0.76 mg/100g. Except tambaqui steak 0.27 mg/100g and pirarucu tail fillet and deboned 0.24 and 0.37 mg/100g, respectively.

As an alternative, fish bran and biological or chemical fish silage for the nutrition of fish, chicken and commercial swine can be mentioned. However, it is necessary to frequently monitor the microbiological safety of this food (VENTUROSO et al., 2016; DANTAS FILHO et al., 2019). Finally, it is important to emphasize, some studies that have not been successful in feeding animals with diets derived from fish processing, possibly were because they were unable to meet the organic needs of animals fed through the administration of acid silage from slaughter by-products (EYNG et al., 2010; BASTÍAS et al., 2017). However, Reinicke et al. (2019) and Donadelli et al. (2019) using cut residues from fish processing, they were able to provide acidic fish silage to domestic dogs due to the nutritional attributes of the fish intestines for silage production.

However, undoubtedly, fish intake benefits human health, so much so that it can be said that the nutritional benefits from regular fish consumption reinforce the validity of investments and incentives through public policies to increase the availability and consumption of this food on the table Brazilians (Sartori; Amâncio, 2012; Cersósimo et al., 2015; Mielcarek et al., 2020; Valenti et al., 2021).

CONCLUSIONS

Commercial cuts of tambaqui (*C. macropomum*) and pirarucu (*A. gigas*) contain important mineral elements, total iron, Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}. Highlighted, tambaqui steak and pirarucu loin were the cuts that most met the minimum mineral supply needs for consumers. These same cuts express higher and/our similar mineral values compared to fillets of some species of fish and other cuts of animals, widely traded internationally at high prices.

Certainly, the meat of tropical fish tambaqui and pirarucu in their different commercial cuts favor the health of the consumer. Therefore, nutritional information, such as mineral values, are important for the processing and development of new products on the market. Thus, providing commercial security to different market niches.

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