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Proximal composition, fatty acid profile, omegas and lipid quality in the tambaqui (*Colossoma macropomum* Cuvier, 1818) (Serrasalmidae) in "flatted cut"

*Composição centesimal, perfil de ácidos graxos, ômegas e qualidade lipídica no tambaqui (**Colossoma macropomum** Cuvier, 1818) (Serrasalmidae) em "corte espalmado"*

Jucilene Cavali[1,2], Reginaldo da Silva Francisco[1,2*], Jerônimo Vieira Dantas Filho[2], Rute Bianchini Pontuschka[2], Tiago Lucena da Silva[1], Rodrigo Vieira Alves Amaral[2]

ABTRACT: The aimed of this study was to determine proximal composition, fatty acid profile, omegas and lipid quality in the tambaqui (*Colossoma macropomum*) in "flatted cut", produced and commercializeded by Rondônia state, Brazil. Three pieces of flatted tambaqui were collected from 40 fish weighing 1.10 ± 0.10 kg. Proximal composition were determined by AOAC Official method 969.23 and 968.08. The fatty acids were grouped to calculate ratio ∑PUFAs/∑SFAs and proportion ∑PUFAs (*n*-6/*n*-3), atherogenicity index (AI) were calculated, thrombogenicity index (TI), and ratio between hypocholesterolemic and hypercholesterolemic fatty acids (HH). Were found 1.06 g/100g of mineral matter, 17.64 g/100g of crude protein, 5.74 g/100g of lipids, 75 .54 g/100g of moisture and 122.22 kcal/100g of caloric value. Lipid composition 39.425% of SFAs, 43.518% of MUFAs and 17.057% of PUFAs. It also presented ∑PUFAs/∑SFAs ratios of 2.31 and ∑PUFAs (*n*-6/*n*-3) of 3.78. As AI of 0.44, TI of 0.92 and HH of 2.02. Tambaqui meat of 1.10 ± 0.10 kg in flatted cut contains good proximal contents, with high protein content and excellent lipid content, being considered a low-fat meat, with low moisture content and low caloric value and rich in minerals. It can also be considered a good source of MUFAs and PUFAs, especially *n*-3 and *n*-6, with high nutritional value, in addition to essential fatty acids, ALA, AA, DHA and EPA, which were crucial to provide good levels of lipid quality.

KEYWORDS: Essential fatty acids; lipid quality indeces; omegas; juvenile tambaqui.

RESUMO: O objetivo deste estudo foi determinar a composição centesimal, perfil de ácidos graxos, ômegas e qualidade lipídica no tambaqui (*Colossoma macropomum*) "em corte espalmado", produzido e comercializado pelo estado de Rondônia, Brasil. Foram coletadas três amostras de 40 exemplares de tambaqui espalmado de 1,10 ± 0,10 kg. A composição centesimal foi determinada pelos métodos AOAC 969,23 e 968,08. Os ácidos graxos foram agrupados para calcular a razão ∑PUFAs/∑SFAs e a proporção ∑PUFAs (*n*-6/*n*-3), índice de aterogenicidade (IA), índice de trombogenicidade (IT) e razão entre ácidos graxos hipocolesterolêmico e hipercolesterolêmico (HH). Foram encontrados 1,06 g/100g de matéria mineral, 17,64 g/100g de proteína bruta, 5,74 g/100g de lipídios, 75,54 g/100g de umidade e 122,22 kcal/100g de valor calórico. Composição lipídica de 39,425% de SFAs, 43.518% de MUFAs e 12,057% de PUFAs. O corte também apresentou razões ∑PUFAs/∑SFAs de 2,31 e ∑PUFAs (*n*-6/ *n* -3) de 3,78. E também, AI de 0,44, TI de 0,92 e HH de 2,02. A carne de tambaqui de 1,10 ± 0,10 kg em corte espalmado contém bons teores centesimais, com alto teor proteico e excelente teor de lipídios, sendo considerada uma carne semi-gorda, com baixo teor de umidade e baixo valor calórico e rico em minerais. Também pode ser considerada uma boa fonte de MUFAs e PUFAs, principalmente *n*-3 e *n*-6, com alto valor nutricional, além de ácidos graxos essenciais, ALA, AA, DHA e EPA, que foram fundamentais para fornecer bons níveis de qualidade lipídica.

PALAVRAS-CHAVE: Ácidos graxos essenciais; índices de qualidade lipídica; ômegas; tambaqui juvenil.

INTRODUCTION

Fish meat is rich in proteins, minerals and lipids, providing nutritional advantages for human consumption (RODRIGUES et al., 2017). Clinical and epidemiological studies suggest that populations that regularly consume meat or fish oil are less likely to be affected by cardiovascular problems (JOB et al.,

[1]Universidade Federal do Acre (UFAC), Rio Branco, AC, Brazil
[2]Universidade Federal de Rondônia (UNIR), Rolim de Moura, RO, Brazil
*Corresponding author: reginaldofco2011@hotmail.com
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2015). In addition, fish has high levels of monounsaturated (MUFAs) and polyunsaturated (PUFAs) fatty acids of the *n*-6 and *n*-3 series (PETENUCI et al., 2019; SOKAMTE et al., 2020). Furthermore, lipids have energetic, structural, hormonal, biochemical functions, among others (JUSTI et al., 2005). In humans, the PUFAs docosahexaenoic (DHA) and eicosapentaenoic (EPA) fatty acids have strong antiarrhythmic action in the heart and powerful antithrombotic action (MARTIN et al., 2006), linoleic (AA) and α-linolenic acids (ALA) are necessary to maintain membranes under normal conditions cells, brain functions and transmission of nerve impulses (NUNES et al., 2012). These fatty acids also participate in the transfer of atmospheric oxygen to the blood plasma, in the synthesis of hemoglobin and in cell division, being called essential because they are not synthesized by the body. In other words, the regular consumption of fish can provide healthier living conditions due to the presence of polyunsaturated fatty acids essential to the human diet (HAUTRIVE et al., 2012).

In 2020, the Brazilian fish farm reached a production of 802,930 tons. Data from the Association of Fish Farmers of Brazil (PEIXE BR, 2021) expressed that the segment grew 5.9% compared to 2019, with the Nile tilapia (*Oreochromis niloticus*) being the main cultivated species, representing 60.6% of the entire Brazilian fish production. However, native species produced a production of 278,671 tons, that is, 34.7% (PEIXE BR, 2021). It should be noted that the Rondônia state, in turn, stands out as the largest producer of native species, such as tambaqui (*Colossoma macropomum* CUVIER, 1818) (Serrasalmidae), with production in 2020 of 65,500 tons, while the Amazonas state occupied the fifth position with only 20,500 tons, Amazonas state is the largest consumer market for cultivated tambaqui in Brazil and the city of Manaus is the main consumer city of fish in the Rondônia state (MAMEDE, 2017; MEANTE; DÓRIA, 2017).

Tambaqui is of the main sources of animal protein for the Amazon population and an important source of fatty acids, such as PUFAs like the ones mentioned EPA and DHA, proteins and minerals (LIMA et al., 2018). It has characteristics such as easy digestibility, due to high biological value proteins (BATALHA et al., 2017). As they efficiently provide energy and essential fatty acids, lipids are important components of the diet. However, the content and availability of fatty acids vary between fish species, depending on age and inclusion rates in the diet (PARTHASARATHY; JOSEPH, 2011). However, in general, the fish product of greatest interest to the industry is its meat, which is often processed and offered in cuts such as fillet without the presence of intramuscular bones, to meet the demands of the current consumer market.

Therefore, seeking lighter specimens, that is, with a shorter production cycle, and also for weight categories that can meet the demand for fish in the off-season market in the city of Manaus, AM - Brazil, makes the demand and consumption of tambaqui to 1.10 ± 0.10 kg are leveraged. And, new products arouse interest for new fish farms. A commercial cut that meets this demand is the flatted tambaqui. However, there is still little information about the tambaqui flatted, and that is why this study supports producers in the adoption of correct decisions to reduce possible vulnerabilities in the market and/or fish production chain. Among the various options for supplying the consumer, the flatted tambaqui has gained prominence. In the Rondônia state, this cut in the weight category to 1.10 ± 0.10 kg is commonly elaborated, from the tambaqui without head or not, but cut longitudinally in two united bands until the caudal fin, but with removal of the vertebral column. Therefore, without band separation (BRASIL, 2020).

Given the above, the aimed of this study was to determine proximal composition, fatty acid profile, omegas and lipid quality in tambaqui (*Colossoma macropomum* CUVIER, 1818) in “flatted cut”, produced and commercialized by Rondônia state, Brazil.

MATERIAL AND METHODS

Bioethical considerations

The research was conducted by the Universidade Federal de Rondônia (UNIR) and approved by the Ethics Committee on Animal Use, from the Department of Veterinary Medicine at UNIR (CEUA/UNIR), under protocol number 002/2017. Sample collections to 1.10 ± 0.10 kg weight class of flatted tambaqui were carried out from January to October 2018 in a fish processing unit registered in the Brazilian System of Inspection of Animal Products (SISBI-POA), located in the Vale do Paraíso municipality, RO - Brazil. However, data from other weight classes in other commercial cuts were obtained in the study by Dantas Filho et al. (2021). However, the data survey and assessment of commercial feasibility were carried out from January to July 2021.

Commercial diet

The commercial extruded rations containing 28 % crude protein at a feed rate of 1.8 % of body weight were supplied to the juveniles tambaqui (*C. macropomum*). Feeding was performed twice a day at 10 am and 5 pm for 130 days (Table 1). It is important to point out that it is important to present the information on the guarantee levels of the rations provided by the fish farms, the fish suppliers to the refrigeration unit. In order to demonstrate that businesses adopt a standardized diet. Therefore, there is no dietary difference to cause variations in the fatty acid profile results.

Processing, sampling and design

Were 40 specimens of the tambaqui (*C. macropomum*) used in a “flatted cut”. This commercial cut flatted tambaqui made from Rondônia, in the weight category to 1.10 ± 0.10 kg (Figure 1). It is therefore from the headless tambaqui or not, but cut longitudinally into two united bands up to the caudal fin, but with removal of the vertebral column. Therefore, without band separation (BRASIL, 2020). When the fish arrived at the industry, they were weighed and identified, which accompanied the fish boxes along with the residues until the end of the production line. The second step was performed on the evisceration table, with the procedure of removing the head by sectioning at the level of the junction with the spine, desquamation and removal of the viscera and weighing. Then, the third step was carried out with collect of 4 cm of samples at three different points in "flat cut" and then homogenized by means of a lyophilizer in order to obtain greater representativeness in the chemical composition analyzes (proximal and lipid) (Figure 1).

Table 1. Guarantee levels of the feed provided to juveniles tambaqui (*C. macropomum*) cultivated in excavated tanks from Rondônia state, Brazil.

Feed composition[1]	Content (g/kg)	Feed composition[1]	Content (g/kg)
Calcium (min.g)	10.0	Vitamin B_{12} (mg)	4.2
Cálcium (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	Manganse (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.

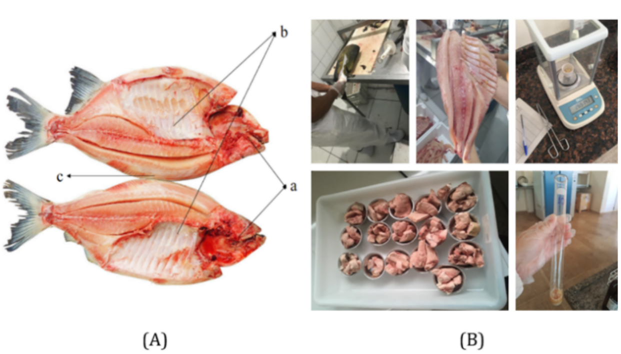

Figure 1. Processing, sampling and design, (A) Exemplary of the tambaqui (*C. macropomum*) to 1.10 ± 0.10 kg in "flatted cut", commercialized by Rondônia state, Brazil. (a) Example of unheaded cut, (b) cut longitudinally in two united bands up to the caudal fin, (c) with removal of the spinal column; (B) Samples of the flatted tambaqui were collected, separated and weighed. Then, they were homogenized and, later on, the samples were collected and sent for chemical composition analysis.

Proximal composition assessment

Samples were first lyophilized to later obtain the content of dry matter, mineral matter, crude protein and total lipids (DETMANN et al., 2012). To evaluate the lipids, 3.5 g of the lyophilized sample was used and the lipids were extracted using ethanol and chloroform (BRUM et al., 2009). For the quantification of macrominerals, an extract was obtained from the complete digestion of the sample in sulfuric acid at high temperature (350-375°C).

The microminerals were analyzed from extracts of samples from acid digestions under controlled temperatures, with nitric acid (120° C) and perchloric acid (180-190° C). To perform the measurements, an atomic absorption spectrometer model AA 12/1475 was used. The minerals Na^+, K^+, Total iron (Fe^{2+} + Fe^{3+}), Ca^{2+} and Mg^{2+} were determined by the AOAC Official method 969.23 and 968.08 methods according to the methodology described by Cook (2012). The sum of the amounts of calories from the proteins and lipids of the flat slice of tambaqui was obtained through theoretical calculation, with the final nutritional value expressed in kcal/100g of the sample.

Fatty acid profile assessment and lipid quality indices

Total lipids were extracted by the method of Bligh and Dyer (1959) and fatty acid methyl esters were prepared by methylation of triacylglycerols, as described in method 5509 of the International Organization for Standardization (ISO, 1978). The fatty acid methyl esters were analyzed using a 14-A gas chromatograph (Shimadzu, Japan), equipped with a flame ionization detector and a fused silica capillary column (50 m long, 0.25 mm internal diameter and 0 .20 µm Carbowax 20M). The fluxes of ultrapure gases (White Martins) were 1.2 mL/min for carrier gas (H_2); 30 mL/min for the auxiliary gas (make-up) (N_2); 30 and 300 mL/min for the flame gases, H_2 and synthetic air, respectively. The sample split ratio (split) was 1/100 (JUSTI et al., 2005). Column temperature was programmed at a rate of 2° C/min, from 150 to 240° C. Injector and detector temperatures were 220 and 245° C, respectively. Just as, Justi et al. (2005), the peak areas were determined by means of the CG-300 Integrator-Processor (CG scientific instruments) and the identification of the peaks was performed by comparison with the retention times of patterns (Sigma, USA).

The fatty acid profile data were grouped to calculate the ∑PUFAs/∑SFAs ratio and the ratio ∑PUFAs (*n*-6/*n*-3) following the guidelines of the World Health Organization (WHO). The nutritional quality of the lipid fraction was also calculated from the fatty acid profile through the indices of atherogenicity index (AI) = [(12:0 + 4 x 14:0+ 16:0)]/Σ*MUFAs* + Σ*n*-6+Σ*n*-3, thrombogenicity index (TI) = (14:0 + 16:0 + 18:0)/[(0,5 x Σ*MUFAs*)+(0,5 x Σ*n*-6)+(3 x Σ*n*-3)+(Σ*n*-3/*n*-6)] (Ulbricht; Southgate, 1991) and the ratio between hypocholesterolemic and hypercholesterolemic fatty acids (HH) = (18:1 *n*-9 + 18:2 *n*-6 + 20:4 *n*-6 + 18:3 *n*-3 + 20:5 *n*-3 + 22:5 *n*-3 + 22:6 *n*-6)/(14:0 + 16:0) (SANTOS-SILVA et al., 2002).

RESULTS

Flatted tambaqui (*C. macropomum*) to 1.10 ± 0.10 kg, presented 1.06 g/100g of mineral matter, 17.64 g/100g of crude protein, 5.74 g/100g of lipids, 75 .54 g/100g of moisture and 122.22 kcal/100g of caloric value.

Were found in the lipid composition 39.425% of saturated fatty acids (SFAs), 43.518% of monounsaturated fatty acids (MUFAs) and 17.057% of polyunsaturated fatty acids (PUFAs). Highlight the detection of fatty acids, 0.277 ± 0.001 of 18:3 *n*-3 (ALA), 0.634 ± 0.004 of 20:4 *n*-6 (AA), 0.927 ± 0.056 of 20:5 *n*-3 (EPA) and 0.526 ± 0.006 of 22:6 *n*-3 (DHA) (Table 2).

Sums of omegas were found, 3.565 ∑PUFAs (*n*-3), 13.485 ∑PUFAs (*n*-6), 6.717 ∑PUFAs (*n*-7) and 36.491 ∑PUFAs (*n*-9) (Table 2). It also presented ∑PUFAs/∑SFAs ratios of 2.31 and ∑PUFAs (*n*-6/*n*-3) of 3.78. As well as a

Table 2. Fatty acids profile in tambaqui (*C. macropomum*) of 1.1 ± 0.10 kg in "flatted cut", commercialized by Rondônia state, Brazil (*n*=40).

Fatty acids	IUPAC Nomenclature	Values (%)
SFAs		
12:00	Dodecanoic acid	1.254 ± 0.006
13:00	Tridecanoic acid	0.132 ± 0.001
14:00	Tetradecanoic acid	0.405 ± 0.015
15:00	Pentadecanoic acid	0.053 ± 0.020
16:00	Hexadecanoic acid	24.038 ± 0.001
17:00	Heptadecanoic acid	0.152 ± 0.001
18:00	Octadecanoic acid	11.821 ± 0.002
20:00	Eicosanoic acid	0.275 ± 0.004
21:00	Heneicosanoic acid	1.188 ± 0.004
22:0	Docosanoic acid	0.064 ± 0.001
24:0	Tetracosanoic acid	0.046 ± 0.001
	∑SFAs	39.425
MUFAs		
16:1 *n*-7	9-Hexadecenoic acid	4.135 ± 0.004
16:1 *n*-9	7-Hexadecenoic acid	0.806 ± 0.020
17:1	8-Heptadecenoic acid	0.760 ± 0.030
18:1 *n*-7	11-Octadecenoic acid	2.582 ± 0.001
18:1 *n*-9	9-Octadecenoic acid	35.833 ± 0.003
20:1 *n*-9	11-Eicosenoic acid	0.117 ± 0.001
22:1 *n*-9	13-Docosenoic acid	0.195 ± 0.004
24:1 *n*-9	15-Tetracosenoic acid	0.090 ± 0.002
	∑MUFAs	43.518
PUFAs		
18:2 *n*-6	9,12-Octadecadienoic acid	10.421 ± 0.005
18:3 *n*-6	6,9,12-Octadecatrienoic acid	0.482 ± 0.001
18:3 *n*-3 (ALA)	(α-) Linolenic acid	0.277 ± 0.001
20:2 *n*-6	11,14-Eicosadienoic acid	0.260 ± 0.001
20:4 *n*-6 (AA)	5,8,11,14-Eicosatetraenoic acid	0.634 ± 0.004
20:3 *n*-6	8,11,14-Eicosatrienoic acid	0.955 ± 0.005
20:5 *n*-3 (EPA)	5,8,11,14,17-Eicosapentaenoic acid	0.927 ± 0.056
20:3 *n*-3	11,14,17-Eicosatrienoic acid	1.835 ± 0.001
22:2 *n*-6	13,16-Docosadienoic acid	0.740 ± 0.001
22:6 *n*-3 (DHA)	4,7,10,13,16,19-Docosahexaenoic acid	0.526 ± 0.006
	∑PUFAs	17,057

Results expressed as percentage (%) of total fatty acids. Saturation: saturated fatty acids (SFAs), monounsaturated (MUFAs) and polyunsaturated (PUFAs).

ratio of atherogenicity index (AI) of 0.44 and thrombogenicity index (TI) of 0.92 and ratios between hypocholesterolemic and hypercholesterolemic fatty acids (HH) of 2.02 (Table 3).

DISCUSSION

Analyzing the results obtained (Table 2 and 3), it is observed that the average lipid values allow classifying the flatted tambaqui as low fat, a category in which fish have fat content (between 3 and 8%), being included in the group of fish of good nutritional quality (STANSBY, 1962). Nhavoto et al. (2018), in juveniles tambaqui (*C. macropomum*), with an average weight of 380g, obtained 78.35% moisture, 18.44% crude protein, 2.46% lipids and 0.72% minerals, these results differ slightly from those found in the flatted cut in this study. For Arbelaéz-Rojas et al. (2002), consumer acceptance is closely related to the lipid content, as they improve palatability and provide a more pleasant flavor to the meat, being rich in PUFAs. Lipids can also negatively influence meat quality, this is due to *post-mortem* degradative changes, which occur more quickly in fish with higher lipid concentrations. This fact can lead to a reduction in shelf life (CARTONILHO; JESUS, 2011).

The lipid content (5.74%) presents a considerable difference in relation to the results of Nhavoto et al. (2018), with 2.46%, which even though studying with juvenile tambaqui found lower lipid content, is also superior to the results obtained by Andrade et al. (2010), with 2.66% and Andreghetto et al. (2020), with 3.79% of lipids in juveniles tambaqui. Bello and Rivas (1992) describe that juveniles tambaqui tend to have a lower fat content, being classified as lean fish and, as it gains weight, this content tends to increase and then it will move to the fat class. Sales and Maia (2013), in 2.5 kg tambaquis, found values between 6.5 and 6.8% of lipids, demonstrating the variations between different weight classes of the same species. Dantas Filho et al. (2021), in tambaquis with different weights, obtained those

Table 3. Total omegas and lipid quality in tambaqui (*C. macropomum*) of 1.1 ± 0.10 kg in "flatted cut", commercialized by Rondônia state, Brazil (*n*=40).

Indexes	Formulas	Values
Omegas	*ΣPUFAs* (*n*-3)	3.565
	ΣPUFAs (*n*-6)	13.485
	ΣPUFAs (*n*-7)	6.717
	ΣPUFAs (*n*-9)	36.491
	ΣPUFAs/ΣSFAs	2.31
	ΣPUFAs (*n*-6/*n*-3)	3.78
Lipid quality	AI	0.44
	TI	0.92
	HH	2.02

Saturation: saturated fatty acids (SFAs), monounsaturated (MUFAs) and polyunsaturated (PUFAs); Atherogenicity index (AI), Thrombogenicity index (TI) and ratio between hypocholesterolemic and hypercholesterolemic fatty acids (HH).

for the lipid content in tambaquis weighing less than 1.2 kg: in the fillet 5.74%, in the ribs 3.25%, in the steak 4.32% and in the band 4 .54%. However, for tambaquis weighing over 2.0 kg, there were increasing oscillations in which for filet 8.5 to 10.94%, ribs 4.91 to 10.42%, serving 4.81 to 9.99% and band 6.77 to 10.98%. These fluctuations in lipid composition are related to several factors, namely, handling, feeding and growth, and the greater the weight of the animals at slaughter, the greater the lipid content, in addition to the cultivation environment, in which fish cultivated in excavated tanks tend to present higher lipid concentration compared to fish raised in streams (ARBELÁEZ-ROJAS et al., 2002; LIMA et al., 2018).

Arbeláez-Rojas et al. (2002), in juveniles tambaqui cultivated in supply weir of streams and excavated ponds, found a lipid content of 1.4% in streams and 2.41% in excavated ponds, demonstrating that the cultivation environment significantly interferes with the lipid composition of the fish, the concentration is greater when fish have less need to move in the environment. The moisture content (75.54%) is similar to those of Cartonilho and Jesus (2011), for tenderloin (77.49%) and steak (77.65%) of 1.54 kg tambaqui. Regarding the data found by Pereira Júnior et al. (2013), in the tambaqui muscle of 41.1 g with 72.8% moisture and to the results of Andreghetto et al. (2020), in tambaqui 6.16g with 74.97% moisture, however, it differs from the values obtained by Andrade et al. (2010), in tambaqui from 500 to 1000g, with 79.42% moisture. It is important to remember that in fish the moisture content has an opposite relationship to the lipid concentration, with moisture decreasing as the fish develops and consequently the lipid content increases (ADAMES et al., 2014), this fact can be observed in research like that of Goes et al. (2015), where fish weighing between 100 and 200g had 77.1% moisture and 3.18% lipids and fish weighing between 301 and 400 g had 73.59% moisture and 7.73% lipids and Dantas Filho et al. (2021) in tambaquis smaller than 1.2kg found a lipid content of 4.54% and moisture of 75.78% and in tambaquis from 2.41 to 3.5 kg they obtained 10.46% of lipids and 64.59 % moisture.

The results found are acceptable and compatible with data from several studies, which showed fluctuations in different growing ages, and in tambaqui fingerlings the moisture content of the fillet varies around 65% (MENDONÇA et al., 2011), and from the juvenile stage to the adult stage, these values range from 70 to 80% (SALES; MAIA, 2013; LIMA et al., 2018; OLIVEIRA et al., 2020). This fluctuation in moisture content also occurs in other species such as pacu (*Piaractus mesopotamicus*) (RAMOS et al., 2008; CORTEZ et al., 2010), carp mrigal (*Cirrhinus mrigala*) (AHMED et al., 2015), Nile tilapia (*Oreochromis niloticus*) (CORTEZ et al., 2010; SALES; MAIA, 2012; COLPINI et al., 2017), and piauçu (*Leporinus microcephalus*) (Lanzarin et al., 2017), which tend to oscillate between from 60 to 80%.

Regarding the crude protein content (17.64%), according to the scientific literature, they are considered plausible values since the crude protein content for tambaqui is around 20% (CHAGAS et al., 2005). Corroborating these data is the research by Andrade et al. (2010), in 500g tambaqui with 16.74% crude protein, Andreghetto et al. (2020), in juveniles tambaqui with 19.45% crude protein, Cartonilho and Jesus (2011), in 1.54 kg tambaquis found 19.80% crude protein in ribs, 19.63% in the tenderloin and 18.85% in the post, Pereira Júnior et al. (2013), using tambaqui with 41.1 g, obtained 13% crude protein. Nhavoto et al. (2018), in juvelines tambaqui from 355 to 400g they obtained 20% of protein, according to the mentioned authors, these results are due to the size of the fish and, as they are cultivated, they constantly supply protein-rich feed. Tambaqui fingerlings tend to have high protein concentrations in their meat, which may reach 45%, and in the juvenile and adult stage these levels decline and range from 15 to 23% (MENDONÇA et al., 2011; SALES; MAIA, 2013; COLPINI et al. al., 2017; LANZARIN et al., 2017; LIMA et al., 2018; OLIVEIRA et al., 2020). According to Lima et al. (2018), these variations are strictly related to factors such as the quality of the food provided, species, cultivation environment, stage of gonad maturation, in addition to age and analyzed body part.

Regarding minerals, the average values of minerals found in this study were around 1.06%, similar to those of Cartonilho and Jesus (2011), who found 1.14% in the loin and 1.12% in the ribs of tambaqui. Tambaqui fingerlings have high mineral contents ranging from 10 to 15% and as they grow these contents tend to decrease, in the juvenile stage these contents fall to 0.7 to 2.7%, remaining throughout the adult stage (MENDONÇA et al., 2011; SALES; MAIA, 2013; LIMA et al., 2018; OLIVEIRA et al., 2020). Researches with different species of fish expressed results similar to those obtained in this study, Mafra et al. (2016), in fillets of red piranha (*Pygocentrus nattereri*) 1.12% minerals, Adames et al. (2014), 1.18% in barbado (*Pinirampus pirinampu),* Ramos Filho et al. (2010), and Vila-Nova et al. (2005), in Nile tilapia (*Oreochromis niloticus*), with 0.97% and 1.04% respectively, Lanzarin et al. (2017), 1.16% in piauçu (*Leporinus macrocephalus*) and 0.99% in Amazonian catfish (*Pseudoplatystoma fasciatum* x *Leiarius marmoratus*), Colpini et al. (2017), with 1.19% in juveniles of Nile tilapia.

According to Njinkoue et al. (2016), these minerals play essential roles in the body, as constituents of prosthetic groups of proteins or ions dissolved in body fluids that regulate the activities of many enzymes and maintain the acid-base balance and osmotic pressure necessary for physiological homeostasis and lack of this can cause seizures, weakness, muscle paralysis, bone problems and memory loss (MAHAN et al., 2005). Lima et al. (2018), highlight that fish meat is considered a valuable source of calcium and phosphorus, it also presents reasonable values of sodium, potassium, manganese, copper, cobalt, zinc, iron and iodine, Duarte et al (2021), emphasizes that minerals play a key role in fish metabolism and their absence can cause biological dysfunction and reflect their content in muscle. The mineral composition in fish tissue varies according to some factors, namely, slaughter age, fish size, water quality, environment in which it is grown, muscle and/or body portion analyzed, in addition to the rations provided (DUARTE et al., 2021). Fish can accumulate high levels of mineral elements from the culture water through gill filtration, by the consumption of food and sediments, accumulating in the tissues, it should be noted that this accumulation varies according to the mineral concentration in the water, food and time of exhibition (Yilmaz et al., 2010). Thus, it is inferred that the mineral concentrations obtained in this research may be the result of factors arising from the bioavailability of these elements in the diet and water for the use of fish, contributing to a greater or lesser use and concentration in their meat (DUARTE et al., 2021).

Research around the world has shown that diets rich in lipids tend to affect the concentrations of minerals in the body of fish, causing a lower absorption of minerals such as calcium, resulting in greater renal and/or fecal excretion (CORWIN, 2003). Induction of urinary calcium excretion when there are high concentrations of free fatty acids in plasma (BATALHA et al., 2017), considering such premises, a negative interaction between lipids and mineral deposition in muscle tissue is considered (DUARTE et al., 2021). It is important to highlight that the ingested amount of an element and the mineral *versus* mineral interactions that occur when they compete for the same absorption site because they have physicochemical similarities, and the excess of one will harm the use of the other (DUARTE et al., 2021). Potassium was the mineral found in the greatest amount (341.00mg/100g), a result similar to that obtained by Duarte et al. (2021), working with Nile tilapia submitted to diets supplemented with fish oil, a result also reported by O'Neill et al. (2017), when analyzing the mineral composition in six edible portions of the olho-de-boi (*Seriola lalandi*).

Regarding the caloric value found in the flatted tambaqui (122.22 kcal/100g), as it is related to the content of lipids and proteins, this value was as expected, since several studies have shown that the meat of commercial fish have a low caloric value, for example the results obtained by Caula et al. (2008), who obtained a caloric value for Jundiá (*Rhamdia quelen*) of 140.21 kcal/100g in fish weighing 301 to 400 g and Cartonilho and Jesus (2011), which they found in curimatã (*Prochilodus cearaensis*) fillet 108.4 kcal/100g and tambaqui steak with 96.54 kcal/100g. According to Caula et al. (2008), these values justify the fact that fish is considered a low-calorie food. Dantas Filho et al. (2021), studying the chemical composition of tambaqui in different weight classes, found a higher caloric value (186.98 kcal/100g) in tambaquis from 2.41 to 3.5 kg, according to the authors, such values occurred because these weights expressed higher lipid content (10.46%) and higher crude protein content (23.21%). According to Ordinance No. 27 of January 13, 1998 - Ministry of Health, which classifies foods as a source or rich in certain nutrients (BRASIL, 1998), according to the minimum daily supply values, the flat cut of tambaqui of 1 0.0 to 1.2 kg is rich in total iron, sodium and potassium and a source of calcium and magnesium.

Tables 2 and 3 presented the composition of fatty acids, which we have the presence of some of great interest such as α-linolenic acid (ALA), linoleic (AA), oleic, arachidonic, docosahexaenoic (DHA), eicosapentaenoic (EPA) and palmitoleic acid, with emphasis on PUFAs (*n*-3), associated with the prevention and treatment of many chronic diseases such as neurological, cancer, inflammatory diseases, obesity and diabetes mellitus (SANTOS et al., 2019). It is important to highlight the levels of eicosatetraenoic acid (0.634%), eicosatrienoic acid (1.835%) and octadecadienoic acid (10.421%), lipid quality indicators that help to accelerate the healing process and renewal of the body's defense cells (NUNES et al., 2012). It should be noted that the concentration of fatty acids in the flesh of the flatted tambaqui may be related to the lipid composition of its diet composed of rations rich in lipids to which they are constantly submitted, since tissue fatty acids can be modified by feeding management, increasing or decreasing their concentrations in the feeds provided (FRANCIS et al., 2006). Duarte et al. (2021), using diets enriched with fish residual oil in the tilapia feed, concluded that this addition influenced the composition of fatty acid contents, mainly *n*-3 and *n*-6, and mainly DHA.

Fish that inhabit colder regions have higher concentrations of *n*-3 and *n*-6 (up to seven times more) compared to fish that inhabit warmer regions, this is due to the feeding of these fish that are composed of plankton and algae (TOWERS et al., 2012). Watters et al. (2013), including *Schizochytrium* sp., a species of microalgae, and fish oil in Nile tilapia's diet considerably increased *n*-3 fatty acids in Nile tilapia fillets, Sarker et al. (2016a, 2016b), using *Schizochytrium* sp., in Nile tilapia feeding, observed that such inclusion improved the growth and fatty acid profile. Oliveira et al. (2020), highlight that the cultivation environment also interferes in the composition of fatty acids, and wild tambaquis tend to have higher concentrations of *n*-3, *n*-6 and *n*-9 when compared to cultivated tambaqui. Flatted tambaqui has a percentage of saturated fatty acids (39.62%), higher than pork fat (28%), beef (32.26%), ostrich (27.3%) and chicken (19.73%) (HAUTRIVE et al., 2012; LEITE et al., 2015). Morais et al. (2016), studying the chemical composition of exotic and native fish in reservoirs, described that the curimba has higher concentrations of saturated fatty acids with about 64.18% and unsaturated are on average 35.82%.

Flatted tambaqui expressed a percentage of MUFAs (43.518%) higher than the "generally medium" chicken (37.0%) and lower than the "generally medium" ostrich (45.7%), "generally medium" swine (52.2%) and "generally medium" beef (61.0%). And it expressed equivalent levels of PUFAs (17.057%) in relation to "generally medium" pork (20.26%) and higher than "generally medium" beef (5.9%) (HAUTRIVE et al., 2012; LEITE et al., 2015). Orban et al. (2008) and Chaijan et al. (2010), in pangasius (*Pangasius hypophthalmus*) and panga (*Pangasius boccourti*) fillets, found lower levels of PUFAs (12.45 and 14.80%) compared to flatted tambaqui. However, Martino et al. (2002) and Tanamati et al. (2009) found 18.10% in the Amazonian catfish fillet (*Pseudoplatystoma corruscans*) and 18% in yellow-pacu (*Piaractus mesopotamicus*) with similar values. Fallah et al. (2011) in trout (*Oncorhynchus mykiss*) found higher percentages of AGP (25%) than the flatted tambaqui and a lower percentage of MUFAs (28%), Njinkoue et al. (2016), comparing the fatty acid profiles of *Pseudotolithus typus* and *Pseudotolithus elongatus*, two widely consumed marine fish species on the west coast of Africa, found a higher percentage of PUFAs (50.93%) and lower MUFAs (33.4%) to the flatted tambaqui, Özogul et al. (2007) and Jensen et al. (2013) describe that freshwater fish have lower PUFAs indices than marine fish, especially EPA and DHA.

Concerning the content of essential fatty acids EPA and DHA, Wing-Keong et al. (2003), Orban et al. (2008) and Li et al. (2009) and Tanamati et al. (2009) obtained for African catfish (*Clarias gariepinus*) (DHA 2.0%), pangasius (EPA 0.19% and DHA 0.083%) and American catfish (*Ictalurus punctatus*) (DHA 0.75%) lower values of EPA and DHA than the flat cut. According to Harris et al. (2009) it is recommended to consume between 250 to 500mg of EPA + DHA per day, as they are reported as essential fatty acids acting with inflammatory processes, increasing anti-inflammatory mediators, vasodilation and inhibition of platelet aggregation (ANTONELO et al., 2020), that is, the enzymatic action of these PUFAs in the modulation of the lipid profile from unsaturated to saturated during metabolism changes the efficiency of the consumed diet and the ingested profile, making the meat healthier (VIEIRA et al., 2015).

Flatted tambaqui presented a ∑PUFAs/SFAs index of 2.31, being classified according to the WHO as a remarkable nutritional quality, and values below 0.45 are considered unhealthy (WOOD; ENSER, 1996; WHO, 2005). The fatty acid profiles of ostrich, pork, beef and chicken presented values below 0.45 (HAUTRIVE et al., 2012), confirming that tambaqui meat is healthier than both meats. According to Martino et al. (2002), Lu et al. (2003) and Tanamati et al. (2009), describe that the spotted Amazonian catfish with 0.44, pangasius with 0.26 and the pacu with 0.35, had lower ∑PUFAs/SFAs index than the flatted tambaqui, in addition to not having nutritional quality in accordance with the prescriptions of the WHO.

Flatted tambaqui presented a ∑AGP ratio (*n*-6/*n*-3) of 3.78, which allows us to consider it of high nutritional quality as described by the WHO. According to Ramos Filho et al.

(2010) the PUFAs have a fundamental action in the body, the *n*-6 are pro-inflammatory, increase the production of cytokines with vasoconstrictor action and promote platelet aggregation, while the *n*-3 are anti-inflammatory, promote vasodilation and inhibition of aggregation platelet and are related to the prevention of hypertension, atherosclerosis, hypercholesterolemia, arthritis and other autoimmune and inflammatory diseases, as well as the most diverse cancers (RAMOS FILHO et al., 2010). According to the results obtained for fatty acids, it was possible to obtain an AI of 0.44 and a TI of 0.92, with high lipid quality (RODRIGUES et al., 2017; ZHANG et al., 2020). These indices are related to antiatherogenic acids, which assess fatty acids and their effects on lipoprotein metabolism. However, there are no recommended values for these indices. Thus, their reduction demonstrates a relationship of fatty acids more beneficial to human health, since they are related to the prevention of the onset of coronary heart disease (TURAN et al., 2007; BARROS et al., 2013).

And yet, on the HH index, it was found of 2.02, expressing high lipid quality, these acids are related to cholesterol metabolism. Bentes et al. (2009) emphasizes that the higher the HH, the more nutritionally adequate is the most recommended food to provide benefits to human health. Thus, it is emphasized that the consumption of fish meat is beneficial to human health, increasing the validity of investments and incentives to increase availability and consumption by the Brazilian population (SARTORI; AMANCIO, 2012). In addition, it is noteworthy that TI and AI are related to the potential to stimulate platelet aggregation. Therefore, values lower than those found in this research indicate a high amount of anti-atherogenic acids in a given fat or oil, with a correspondingly increased potential to prevent the emergence of coronary heart disease (ALMEIDA; SILVA, 2016). In contrast, a higher proportion of HH found in this research indicates greater nutritional adequacy (oil or fat) for human consumption because this index is related to cholesterol metabolism.

CONCLUSIONS

Tambaqui meat of 1.10 ± 0.10 kg in "flatted cut" contains good proximal contents, with high protein content and excellent lipid content, being considered a low-fat meat, with low moisture content and low caloric value and rich in minerals. It can also be considered a good source of MUFAs and PUFAs, especially *n*-3 and *n*-6, with high nutritional value, in addition to essential fatty acids, ALA, AA, DHA and EPA, which were crucial to provide good levels of lipid quality, PUFAs/SFAs, *n*-6/*n*-3, AI, TI and HH. Which points to a commercial cut nutritionally adequate for human health. Therefore, making known the proximal and lipid composition of a new product is important for the processing processes, development of new products on the market, as well as guiding the labeling of nutritional information, thus providing commercial security for different market niches.

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