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Research Article

Anatomical Standardization and Nomenclature of Commercial Cuts of Round Fish Processed in Agro-industries of Rondônia state, Brazil

Padronização anatômica e nomenclatura dos cortes comerciais de peixes redondos processados em Agroindústrias de Rondônia, Brasil

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ABSTRACT

This study aimed to standardize the anatomical nomenclature and labeling of commercial cuts of tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*) filleted in agro-industries in Rondônia state, Brazil. The applied and descriptive research involved mapping the cuts, analyzing their anatomy, yield, and lipid profiles in accordance with current regulations. The results revealed significant nutritional variations among the commercial cuts. For tambaqui (1.8–2.4 kg), the band cut showed the highest content of polyunsaturated fatty acids (PUFAs) (19.05 g 100g^{-1}), while the rib cut was the richest in omega-3 (*n*-3) fatty acids (12.87 g 100g^{-1}). For pirarucu (11–14 kg), mechanically separated meat (MSM) was the most nutrient-dense cut, with the highest levels of PUFAs (28.02 g 100g^{-1}), *n*-3 (12.92 g 100g^{-1}), and docosahexaenoic acid (DHA) (4.41 g 100g^{-1}). A standardization proposal was developed and validated using the Delphi technique with industry experts. In conclusion, the anatomical standardization of the cuts ensures commercial consistency, compliance with regulations, and improved consumer identification by highlighting the distinct culinary applications and nutritional values of each cut, thereby adding value to the Amazonian aquaculture chain.

KEYWORDS: Anatomical cuts. Aquaculture. Fish industry.

RESUMO

Este estudo teve como objetivo padronizar a nomenclatura anatômica e a rotulagem dos cortes comerciais de tambaqui (*Colossoma macropomum*) e pirarucu (*Arapaima gigas*) filetados em agroindústrias de Rondônia, Brasil. A pesquisa aplicada e descritiva envolveu o mapeamento dos cortes, analisando sua anatomia, rendimento e perfis lipídicos de acordo com as regulamentações vigentes. Os resultados revelaram variações nutricionais significativas entre os cortes comerciais. Para o tambaqui (1,8–2,4 kg), o corte em banda apresentou o maior teor de ácidos graxos poli-insaturados (PUFAs) (19,05 g 100g^{-1}), enquanto o corte costela foi o mais rico em ácidos graxos ômega-3 (*n*-3) (12,87 g 100g^{-1}). Para o pirarucu (11–14 kg), a carne mecanicamente separada (CMS) foi o corte mais denso em nutrientes, com os maiores teores de PUFAs (28,02 g 100g^{-1}), *n*-3 (12,92 g/100g) e ácido docosahexaenoico (DHA) (4,41 g 100g^{-1}). Uma proposta de padronização foi desenvolvida e validada usando a técnica Delphi com especialistas do setor. Em conclusão, a padronização anatômica dos cortes garante a consistência comercial, o cumprimento das normas e melhora a identificação pelo consumidor, destacando as distintas aplicações culinárias e valores nutricionais de cada corte, agregando assim valor à cadeia aquícola amazônica.

PALAVRAS-CHAVE: Cortes anatômicos. Piscicultura. Indústria do Pescado.

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INTRODUCTION

Rondônia is Brazil's largest producer of farmed native fish, with a total output of 56.9 thousand tons in 2024 (PEIXE BR 2025) and leads in tambaqui (*Colossoma macropomum*) production. Despite this prominence, the sector has experienced a severe cumulative decline of 57% over the past nine years (PEIXE BR 2025). This downturn is attributed to a weak production chain organization, domestic market saturation, and an 81% rise in input costs. Additional obstacles include a lack of marketing strategies and parasitic infestations that compromise fish quality (CAVALI & DANTAS FILHO 2024). These challenges highlight critical vulnerabilities within the state's primary aquaculture sector.

The industry in Rondônia is predominantly based on family farming, especially in Ji-Paraná and neighboring municipalities (e.g., Urupá, Alta Floresta D'Oeste, Machadinho do Oeste), as defined by Federal Law No. 11.326/2006. The sector is supported by regulations like the State Fish Farming Law No. 5.280/2022, which establishes guidelines for environmental licensing. Tambaqui dominates production (86%), followed by jatuarana (*Brycon* spp., 6%), pintado (*Pseudoplatystoma corruscans*, 4%), and pirarucu (*Arapaima gigas*, 2%).

A significant milestone was achieved in 2023 when fish farming in Rondônia received a Geographical Indication (Indication of Origin) from the National Institute of Industrial Property (INPI) for tambaqui from Vale do Jamari (CAVALI & DANTAS FILHO 2024). However, this recognition contrasts sharply with the lack of standardization in fish processing, which remains a major barrier to exporting round fish species. The absence of a unified nomenclature for cuts and co-products creates confusion in the market, complicates regulatory compliance, and hinders the sector's growth by limiting efficient communication between producers, industries, and consumers (CARDOSO et al. 2023, TERADA-NASCIMENTO et al. 2024).

This lack of standardization directly impacts processing, marketing, and legislation. The variety of names for identical cuts—exemplified by the award-winning tambaqui rib, which is marketed under ten different names (GOTARDI 2023) - impedes the implementation of consistent practices as outlined in the RIISPOA (Regulation for Industrial and Sanitary Inspection of Products of Animal Origin). This inconsistency restricts market access, undermines consumer trust, and prevents the sector from fully capitalizing on its potential.

Therefore, an initiative to standardize the anatomical nomenclature and processing flow is urgently needed. Such an effort would not only enhance competitiveness and add value to Amazonian species but also promote significant social benefits, including improved food safety, the adoption of more sustainable practices by streamlining processing and reducing waste, and fostering regional development by strengthening the entire production chain.

Given this scenario, the objective of this study is to standardize the anatomical nomenclature and labeling of commercial cuts of round fish processed in agro-industries in Rondônia state, aiming for marketing consistency, compliance with RIISPOA regulations, and improved consumer identification.

MATERIALS AND METHODS

The study was developed with the support of the Rondônia Foundation for the Support of Scientific and Technological Actions and Research (FAPERO) and was approved by the Ethics Committee on Animal Use (IACUC) of the Universidade Federal de Rondônia (UNIR), under protocol No. 012/2021 (Annex A) – Project "Biosafety, Health, and Nutritional Quality of Fish." For the development of interviews with managers of fish processing units, the study was authorized by the Research Ethics Committee (CEP) of the UNIR, under authorization protocol CAAE No. 60744322.5.0000.5300 and certificate No. 077412/2022 (Annex B) – Project "Sanitary Characterization of Fish Farming in Rondônia."

Preliminary Considerations

The Figure 1 illustrates a flowchart titled "Material and Methods", representing the methodological steps of the study. It begins with the study design, definition of the study area, and species selection. Next, data collection is conducted, requiring ethical approvals: the Animal Ethics Committee (IACUC), and the Research Ethics Committee (CEP). After data collection, the process continues with data analysis and characterization of the lipid profile. The results are then synthesized into a proposal for standardization. The flow concludes with a target icon, symbolizing the achievement of the study's objectives. This sequence demonstrates a structured and ethically approved approach to conducting the research.

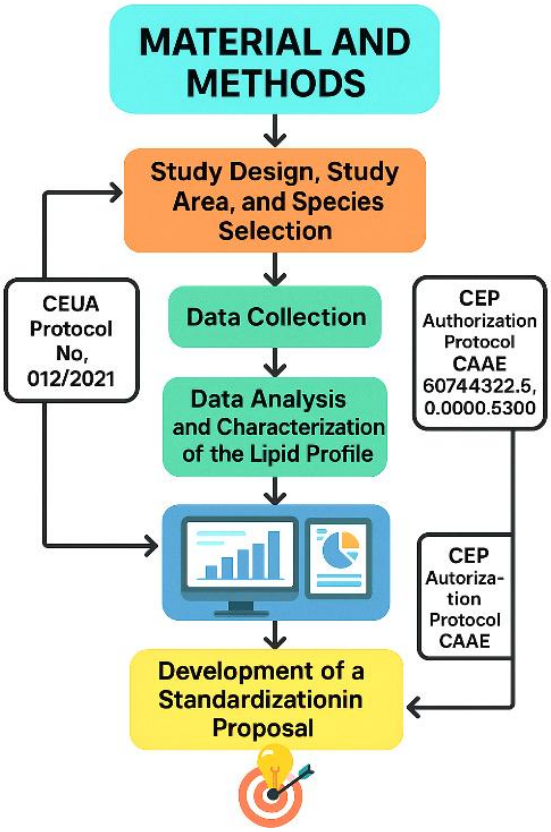


Figura 1. Flowchart of Methodological Steps and Ethical Procedures.

Study Design, Study Area, and Species Selection

The study will be conducted as an applied and descriptive research, using both qualitative and quantitative approaches (LAKATOS & MARCONI 2017). A survey and data analysis will be conducted on the commercial cuts of round fish processed in agro-industries in the state of Rondônia, aiming at anatomical standardization, labeling, and product nomenclature.

The research was carried out in fish processing agro-industries located in different municipalities of Rondônia state, Brazil. Mapping was supported by data from the Agrosilvopastoral State Sanitary Defense Agency of Rondônia (RONDÔNIA IDARON 2023) and the State Secretariat of Agriculture (SEAGRI-RO). The two most commonly filleted native fish species in Rondônia were considered: tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*) (DANTAS FILHO et al. (2022 a). The selection was based on local production data and market demand.

Data Collection

Three fish processing units in Rondônia were visited, and their managers were interviewed: one located in the municipality of Ariquemes, one in Itapuã do Oeste, and another in Vale do Paraíso.

Initially, a characterization of commercial cuts was conducted to map and understand the local production scenario. This procedure was carried out through a survey of the types of round fish cuts available in the agro-industries of Rondônia, encompassing: the commercial name used; the cutting techniques employed; the anatomy of the cuts (identification of preserved bone and muscle structures); and the percentage yield of each cut relative to the total fish weight. These data, essential for diagnosing the lack of standardization, were obtained through structured interviews with the technical managers of the agro-industries and by direct observation of the processing (GIL 2019). This characterization is systematized in the next section, "Data Analysis and Characterization of the Lipid Profile."

Subsequently, the anatomical standardization phase was conducted, which is central to achieving consistency in marketing. The cuts were anatomically analyzed based on muscle morphology and arrangement, using references from comparative fish anatomy (BALDISSEROTTO 2013). The precise identification of bone structures was carried out through dissection and photographic imaging when necessary. This methodological rigor aimed to establish a clear and scientific anatomical nomenclature for each cut, serving as the basis for standardization.

Regarding labeling and commercial nomenclature, an analysis of the packaging was conducted in accordance with current legislation, with the explicit purpose of ensuring regulatory compliance. Mandatory information, terminology, and standardization were verified based on MAPA's Normative Instruction No. 22/2005 and ANVISA's RDC No. 727/2022, which regulate the identity and quality of fish products and general food labeling, respectively, in compliance with RIISPOA. Additionally, to align the nomenclature with international standards and facilitate consumer identification, a comparison was made with the international standards for fish cut nomenclature established by the FAO (2016). This triangulation between local practice, national legislation, and globais standards was essential to propose a standardization that is both regulatory compliant and intelligible to the market.

Data Analysis and characterization of the lipid profile

Qualitative data were analyzed using content analysis techniques, according to BARDIN (2011). Quantitative data, including weights, yields, and frequency of nomenclature use, were subjected to descriptive statistics (mean, standard deviation, and percentage distribution) using R software (R CORE TEAM 2022).

Statistical significance was assessedusing appropriate mean comparison tests. The characterization of the lipid profile of different commercial cuts of tambaqui and pirarucu was based on secondary data obtained from previously published studies by CAVALI et al. (2022a, 2022b, 2023) and DANTAS FILHO et al. (2022a,b), which conducted physicochemical and bromatological analyses on representative samples of the main cuts used in fish commercialization in the state of Rondônia, Brazil.

The samples analyzed in the referenced studies were obtained from farmed animals raised under commercial conditions, within the standard weight classes for the regional market: tambaqui (1.8 to 2.4 kg) and pirarucu (11 to 14 kg). The cuts they analyzed for tambaqui included: whole flatted (espalmado), fillet, rib, steak (posta), and band; and for pirarucu: mechanically separated meat (MSM), tenderloin (*fillet mignon*), tail fillet, loin, and mantle. Lipid analyses were conducted in the laboratory through total lipid extraction using the Bligh & Dyer method (1959), followed by transesterification to obtain fatty acid methyl esters (FAMEs). The separation and quantification of FAMEs were carried out using gas chromatography with flame ionization detection (GC-FID), employing a capillary column specific for lipids and international standard references for identification.

The parameters analyzed included the total content of monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), omega-6 (*n*-6), and omega-3 (*n*-3) fatty acids, as well as key individual fatty acids of nutritional and functional interest: docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), alpha-linolenic acid (ALA), and arachidonic acid (AA). The results were expressed in grams per 100 grams of edible tissue (g $100g^{-1}$).

The data were organized into comparative tables highlighting the variations in lipid profiles among the different commercial cuts, allowing the identification of fatty acid distribution patterns across anatomical regions of the fish. Descriptive analysis involved presenting the average lipid contents as reported in the original sources, with emphasis on the cuts that demonstrated the highest nutritional value. The comparative methodology adopted in this study allowed for identifying the relevance of specific cuts for targeted applications in the food industry and in the formulation of products with nutritional claims, especially those rich in essential *n*-3 fatty acids.

Development of a Standardization Proposal

Based on the results from the commercial cuts characterization stage, a proposal was developed for the anatomical standardization, labeling, and nomenclature of round fish cuts processed in Rondônia. To ensure the validity and applicability of the proposal, the Delphi technique was adopted, conducted in two successive rounds, following the methodological principles described by LINSTONE & TUROFF (2002). The process included participation from experts with recognized experience in fish processing technology and representatives of the local productive sector, who

contributed critical assessments and suggestions to improve the proposal. The convergence of opinions obtained at the end of the rounds gave robustness and legitimacy to the proposed model.

RESULTS

This study details the main commercial cuts of tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*), emphasizing their anatomical origins, preparation, and nutritional value. For tambaqui, key cuts include the boneless fillet (Figure 2 I-A), valued for its firm texture and high *n*-3 content (12.27 g $100g^{-1}$); the cross-sectional steak (Figure 2 I-B) which retains skin and bones; the rib cut (Figure 2 I-C), rich in intramuscular *n*-3 fat (12.87 g $100g^{-1}$) for roasting; the butterfly cut (Figure 2 I-D), prepared for grilling; and the side cut (Figure 2 I-E), notable for its polyunsaturated fats (19.05 g $100g^{-1}$).

Pirarucu cuts include the premium, boneless *fillet mignon* (Figure 2 II-A) from the dorsal muscle; the firm tail fillet (Figure 2 II-B) with high alpha-linolenic acid (3.43 g $100g^{-1}$); the tender and versatile loin (Figure 2 II-C); and the robust blanket cut (Figure 2 II-D) for roasting. MSM from carcass remnants is also highlighted for its high protein and DHA content (4.41 g $100g^{-1}$).

The research concludes that significant differences in yield, texture, and lipid composition among these cuts directly influence their culinary applications and nutritional benefits. These variations underscore the critical importance of species-specific processing techniques to fully maximize their gastronomic and functional potential.

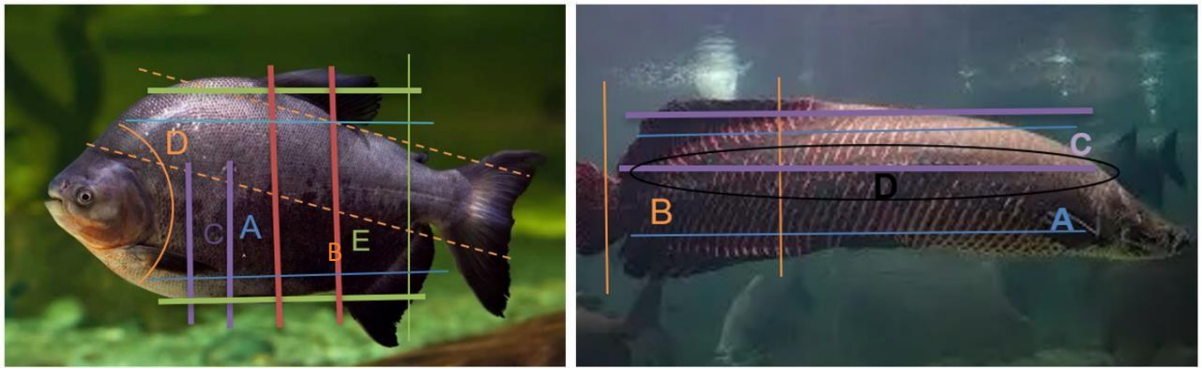


Figure 2. Representation of the main commercial cuts of tambaqui (*Colossoma macropomum*) (I) and pirarucu (Arapaima gigas) (II): (I-A) fillet; (I-B) steak; (I-C) rib (piece); (I-D) butterfly cut; (I-E) side cut; (II-A) *fillet mignon*; (II-B) tail fillet; (II-C) loin; (II-D) blanket cut; (II-E) mechanically separated meat (MSM).

Commercial Cuts of Tambaqui (*Colossoma macropomum*)

Fillet

The tambaqui fillet (Figure 3A) is a cut obtained from the lateral musculature of the fish, characterized by a high proportion of white muscle tissue and a low content of intramuscular bones, which makes it highly valued in culinary applications and the fish processing industry (BACELAR et al. 2023). The preparation of the fillet begins with

evisceration and cleaning of the fish, followed by head removal through a section between the occipital bone and the first cervical vertebra.

A dorsal incision is then made, following the lateral line and the contour of the spine to the tail region. The knife should slide closely along the bone structure to preserve as much muscle mass as possible. The fillet is then separated by carefully detaching the musculature from the backbone and ribs, paying close attention to the removal of intramuscular bones (Y-bones), which are typical of the species (SILVA et al. 2021, OLIVEIRA et al. 2025).

The fillet can be prepared with or without skin, depending on its commercial purpose. Skin removal is performed with the blade angled between the subcutaneous tissue and dermis to minimize muscle loss. The resulting cut has an elongated shape, uniform medium thickness, light pink color, and firm texture, representing the most premium portion of the fish. This type of cut is especially appreciated for its yield and high content of monounsaturated and polyunsaturated *n*-3 fatty acids, as shown in lipid profiles described by SOUSA et al. (2020), highlighting its functional and nutritional potential.

Steak

The tambaqui steak (Figure 3B) is a cross-sectional cut obtained from the trunk of the fish, encompassing both the epaxial (above the lateral line) and hypaxial (below the lateral line) musculature, as well as parts of the axial skeleton such as vertebrae and ribs. It is a traditional cut widely used in Amazonian cuisine, especially in grilled, roasted, or stewed dishes (PEREIRA et al. 2018). Preparation begins with removal of the viscera, head, and fins. The whole eviscerated fish is then placed on a flat, clean surface, and a sturdy knife or specific saw is used to make crosswise cuts along the longitudinal axis of the body, typically 2 to 4 cm thick, depending on commercial use or consumer preference.

Each steak maintains the integrity of the transverse anatomical structures, including:

- The vertebral column, providing support to the cut;
- Neural and hemal arches, associated with the vertebrae;
- Ribs, radiating laterally from the spine to the body edges;
- White lateral musculature, accounting for most of the cut's volume and lipid content.

The skin is usually left on the steak, helping to preserve the structure and protect the flesh during cooking. The presence of the central bone and skin contributes to moisture retention and enhances flavor.

Rib Cut (Piece)

The rib cut or piece of tambaqui (Figure 3C), popularly known as *pedago* in Amazonian cuisine, is a transverse and sectional cut obtained from the abdominal and thoracic regions of the fish, primarily encompassing the hypaxial musculature and ribs, along with a portion of the vertebral column (RODRIGUES et al. 2017, OLIVEIRA et al. 2025). Preparation begins after evisceration and cleaning of the fish. The head is removed, and the fish body is sectioned transversely into steaks, with thickness ranging from 3 to 5 cm, depending on the size of the specimen. The portions corresponding to the thoracic and ventral regions, which contain the rib set, are then

separated from the other cuts, forming the rib cut.

Anatomically, this cut includes:

- Hypaxial musculature, located below the lateral line and surrounding the ribs; True ribs, which extend in an arc from the vertebrae toward the ventral region, being well developed in tambaqui;
- A section of the vertebral column, including parts of the thoracic vertebrae and their neural and hemal arches;
- In many cases, a portion of the skin is retained, helping maintain the integrity of the cut during cooking.

The *pedago* is appreciated for its firm texture, pronounced flavor, and intramuscular fat content, making it one of the tastiest tambaqui cuts. It is traditionally grilled, fried, or stewed, taking advantage of the enhanced flavor that the bone structures impart to the meat during cooking. In addition to its gastronomic value, this cut has a significant lipid composition, particularly rich in *n*-3 and *n*-6 polyunsaturated fatty acids, as demonstrated in studies of lipid profiles in commercial cuts (SOUZA et al. 2022).

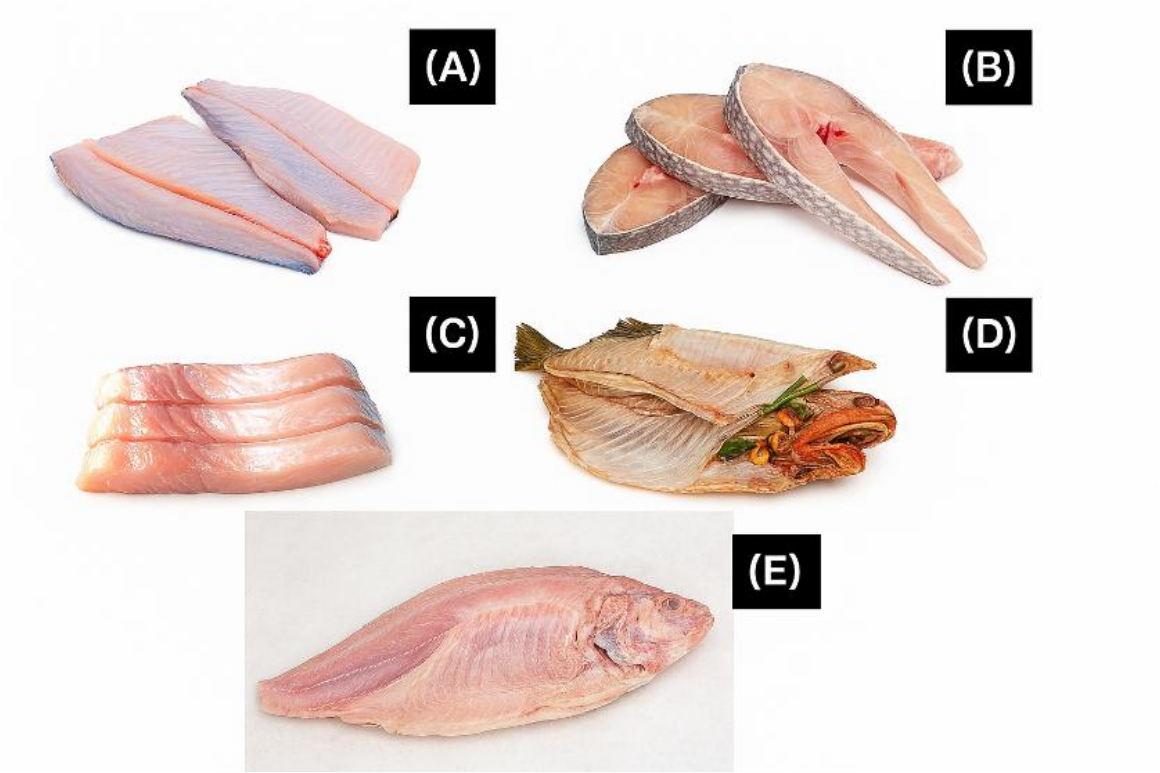


Figure 3. Examples of commercial cuts of tambaqui (*Colossoma macropomum*): fillet (A), steak (B), rib piece (C), butterfly cut (D), and side cut (E). Source: Archives of Prof. Jerônimo V. Dantas Filho.

Commercial Cuts of Pirarucu *(Arapaima gigas)*

Tenderloin Fillet

The pirarucu tenderloin fillet (Figure 4A) is a premium cut obtained from the innermost and central portion of the dorsal musculature of the fish pirarucu, commonly known as pirarucu. It consists of a strip of tender meat, free of bones, located deep along the dorsal midline, just above the vertebral column, and is often compared to

beef tenderloin due to its tender texture, delicate flavor, and high commercial value (CAVALCANTI et al. 2017, FERREIRA et al. 2022). Anatomically, this cut includes:

- The deep epaxial musculature located along the dorsal and lateral line of the vertebral column;
- Long muscle fibers oriented parallel to the body axis, with low connective tissue content (BACELAR et al. 2023);
- Absence of ribs and intermuscular bones, resulting in clean meat with high consumer acceptance;
- An inner layer protected by more superficial musculature (which forms the other conventional fillets).

Preparation method for the cut:

1. After slaughter, the pirarucu is eviscerated, washed, and scaled (when whole).
2. The dorsal fillets are removed by making longitudinal incisions parallel to the vertebral column, carefully separating the superficial musculature from the deep epaxial.
3. The tenderloin fillet is then carefully detached from the base of the spine by precise cuts that preserve its integrity.
4. This cut can be portioned into strips, medallions, or kept whole for sale refrigerated, frozen, or for immediate consumption.
5. Being a lean and tender cut, it is ideal for grilling, roasting, or preparation with haute cuisine techniques (MARTINS et al. 2021).

Cut highlights:

- High nutritional value, particularly for high-quality proteins and low saturated fat content (OLIVEIRA et al. 2018);
- Excellent palatability and texture, making it one of the most sought-after cuts for fine dishes based on Amazonian fish (FERREIRA et al. 2022);
- Its deep origin in the fish musculature requires technical skill in deboning and filleting, commonly done in specialized processing plants and gourmet gastronomy.

Tail Fillet

The pirarucu tail fillet (Figure 4B) is a premium cut obtained from the posterior portion of the Arapaima gigas body, specifically from the tail region, including the epaxial and hypaxial musculature extending to the base of the tail fin. This cut is valued for its firmness, yield, and flavor, being widely used both in regional cuisine and contemporary gastronomy (GONÇALVES et al. 2020).

Anatomically, this cut comprises:

- The posterior epaxial and hypaxial musculature located between the end of the coelomic cavity and the base of the tail fin;
- Long, dense, and uniformly arranged muscle fibers that provide a firm and cohesive texture, ideal for grilling and frying;
- Absence of viscera, with a reduced number of bones, facilitating consumption and culinary preparation;
- The vertebral column may or may not be removed depending on the filleting technique and the product's intended use (BACELAR et al. 2023).

Loin

The pirarucu loin (Figure 4C) is one of the most valued cuts of pirarucu, taken from the dorsal region of the fish along the vertebral column, encompassing the upper epaxial musculature. This cut stands out for its large volume of clean, boneless meat, with long, tender, and juicy muscle fibers, widely used in Amazonian regional gastronomy and gourmet cuisine (MARTINS et al. 2021, OLIVEIRA et al. 2018).

Blanket Cut

The blanket cut of pirarucu (Figure 4D) is one of the most traditional and robust cuts obtained from pirarucu, characterized by a large strip of meat that includes the dorsal and ventral musculature on one side of the fish, usually retaining the skin and, in some cases, the ribs and fin (GONÇALVES et al. 2020).
Cut characteristics:

- Extensive and visually impressive cut, often used for festive and collective preparations;
- Offers excellent yield of premium meat, rich in proteins and firm in texture (FERREIRA et al. 2022);
- The presence of skin and lateral bones enhances flavor and presentation, especially in roasted Amazonian dishes.

Mechanically Separated Meat (MSM)

Mechanically separated meat (MSM) from pirarucu (Figure 4E) is a product obtained through the mechanical removal of residual meat adhered to the fish's bony structures and carcasses after conventional filleting. This process allows maximum utilization of the raw material, transforming the remaining muscle tissue into a protein-rich fish paste used in processed products such as burgers, sausages, breaded items, and pâtés (SILVA et al. 2019).

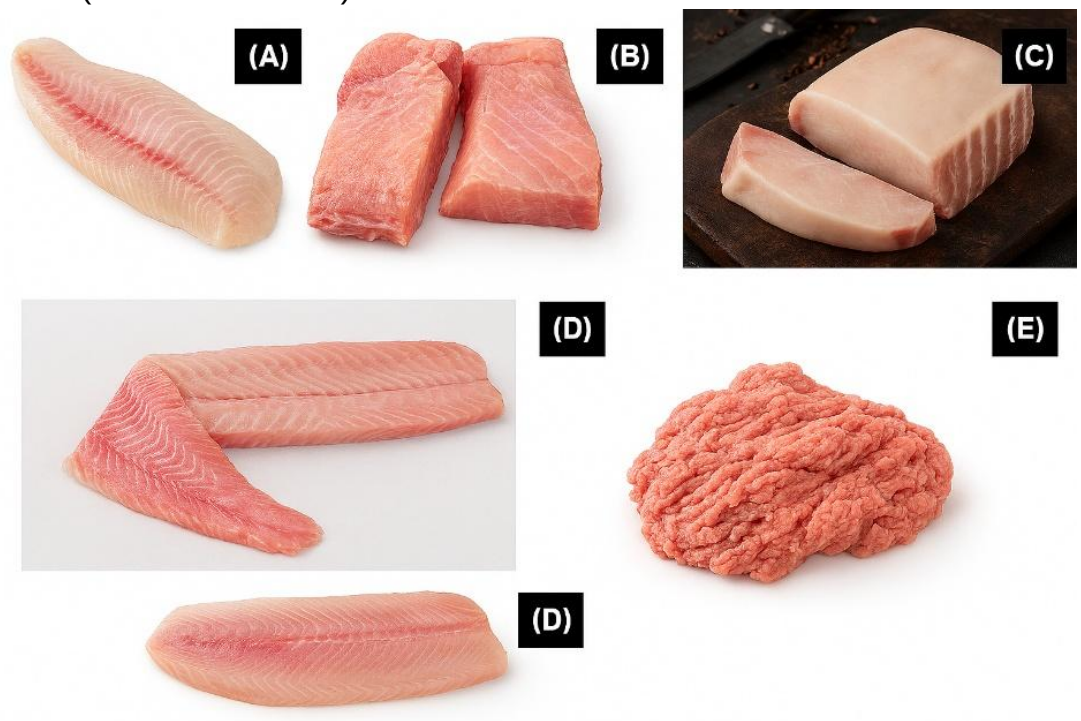


Figure 4. Examples of commercial cuts of pirarucu (*Arapaima gigas*): tenderloin fillet (A), tail fillet (B), loin (C), Blanket cut (D), and mechanically separated meat (MSM) (E). Source: Archives of Prof. Jerônimo V. Dantas Filho.

Nutritional Information of Commercial Cuts

Table 1 presents the lipid profile (in g 100g^{-1}) of different commercial cuts of tambaqui within the weight class used for commercialization in Rondônia, with data obtained from CAVALI et al. (2022 a, b). The contents of monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), *n*-6 and *n*-3) families are compared, as well as the main individual fatty acids: DHA (docosahexaenoic acid), EPA (eicosapentaenoic acid), ALA (alpha-linolenic acid), and AA (arachidonic acid).

Among the cuts evaluated, the fillet showed the highest MUFA content (45.12 g 100g^{-1}), while the side cut stood out for the highest PUFA content (19.05 g 100g^{-1}) and *n*-3 fatty acids (14.49 g 100g^{-1}). The fillet and rib cut also had high *n*-3 levels, with 12.27 g 100g^{-1} and 12.87 g 100g^{-1}, respectively. The highest concentration of ALA was observed in the steak (2.69 g 100g^{-1}), while the fillet had the highest AA content (3.31 g 100g^{-1}). DHA ranged from 0.42 to 0.57 g 100g^{-1}, with emphasis on the fillet. The butterfly cut and side cut presented similar lipid profiles, especially regarding MUFAs, PUFAs, and long-chain fatty acids such as EPA and DHA.

These results indicate that the different commercial cuts of tambaqui have distinct lipid compositions, which can influence both their nutritional value and consumer preferences, as well as their applications in the food industry.

Table 1. Lipid profile (g 100g^{-1}) of commercial cuts of tambaqui (*Colossoma macropomum*) in the weight class for commercialization in Rondônia state, Brazil.

Cut	Lipid profile								Ref.
	MUFAs	PUFAs	*n*-6	*n*-3	DHA	EPA	ALA	AA	
Butterflied	43.52	17.06	13.49	3.57	0.53	0.93	0.28	0.63	CAVALI et al. (2022a)
Fillet	45.12	15.43	2.60	12.27	0.57	0.17	2.15	3.31	CAVALI et al. (2022b)
Rib	42.71	15.30	6.93	12.87	0.46	0.32	0.14	1.12	CAVALI et al. (2022b)
Steak	39.88	13.09	5.44	8.86	0.42	0.69	2.69	0.19	CAVALI et al. (2022b)
Whole cut	43.52	19.05	6.72	14.49	0.53	0.93	1.28	0.63	CAVALI et al. (2022b)

Legend: MUFAs: monounsaturated fatty acids; PUFAs: polyunsaturated fatty acids; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; ALA: α-linolenic acid.; Market weight: 1.8 to 2.4 kg.

Table 2 presents the lipid profile (g 100g^{-1}) of different commercial cuts of pirarucu within the weight class for commercialization in Rondônia state, based on data obtained by DANTAS FILHO et al. (2022 b) and CAVALI et al. (2023). The analyzed parameters include the contents of monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), *n*-6 and *n*-3 families, as well as the concentration of specific fatty acids: DHA, EPA, ALA, and AA.

The MSM cut showed the most pronounced lipid profile among the cuts evaluated, with the highest levels of PUFAs (28.02 g 100g^{-1}), *n*-3 (12.92 g 100g^{-1}), DHA (4.41 g 100g^{-1}), EPA (6.18 g 100g^{-1}), and AA (4.16 g 100g^{-1}), demonstrating its high nutritional value. The tail fillet also stood out for its ALA content (3.43 g 100g^{-1}) and balanced levels of polyunsaturated fatty acids. Other cuts, such as the tenderloin fillet, loin, and blanket cut, showed more varied profiles. For example, the blanket cut exhibited a high *n*-6 content (17.75 g 100g^{-1}) and total PUFAs (23.21 g 100g^{-1}), as well as relevant amounts of DHA and EPA. The tenderloin fillet had the lowest values

of n-3 fatty acids and derivatives, while the loin had a high proportion of *n*-6 compared to *n*-3.

These data highlight the diversity in lipid content among pirarucu cuts, with MSM being the most nutritious in terms of essential fatty acids, showing functional potential and interest for the food and nutrition industry.

Table 2. Lipid profile of commercial cuts of pirarucu (*Arapaima gigas*) in the weight class for commercialization in Rondônia, Brazil.

Cut	Lipid profile								Ref.
	MUFAs	PUFAs	*n*-6	*n*-3	DHA	EPA	ALA	AA	
MSM (Mechanically Separated Meat)	40.04	28.02	15.10	12.92	4.41	6.18	1.00	4.16	DANTAS FILHO et al. (2022 b)
Tenderloin	38.87	11.68	8.85	2.83	0.42	0.69	0.69	0.18	CAVALI et al. (2023)
Tail fillet	34.11	16.81	6.47	2.30	0.39	0.93	3.43	0.33	CAVALI et al. (2023)
Loin	39.41	15.61	2.22	0.42	0.42	0.62	0.57	0.11	CAVALI et al. (2023)
Blanket	36.32	23.21	5.46	2.20	1.20	1.06	0.60	0.21	CAVALI et al. (2023)

Legend: MSM: mechanically separated meat; MUFAs: monounsaturated fatty acids; PUFAs: polyunsaturated fatty acids; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; ALA: α-linolenic acid. Market weight: 11 to 14 kg.

DISCUSSION

Characterization and Implications of Commercial Cuts of tambaqui *(Colossoma macropomum)*

The anatomical standardization of commercial cuts of tambaqui holds strategic importance for the aquaculture sector in the Amazon, with direct effects on carcass yield, industrial utilization, consumer acceptance, and the value added to the final product. The different types of cuts—such as fillet, steak (posta), rib portion, Whole flatted (espalmado), band, and eviscerated whole fish—reflect the diversity of culinary uses and the level of processing required (CAVALI et al. 2022a).

The fillet, for instance, is considered the most premium and commercially valued cut. Its high proportion of white muscle, free of intermuscular bones and with low saturated fat content, makes it ideal for fresh sale or convenience products such as frozen or vacuum-packed fillets. Lipid profile studies have already shown significant levels of *n*-3 series polyunsaturated fatty acids in this cut, increasing its nutritional and functional appeal (NAVA et al., 2023).

The steak (posta) represents a traditional cut, widely accepted in Brazil's North and Northeast regions, especially for preserving the fish's characteristic flavor in dishes like fish stews (caldeiradas) and moquecas. The presence of vertebrae, ribs, and skin contributes to moisture retention during cooking and enhances desirable sensory attributes. The same is observed in the rib portion, or "pedago", which is widely used in grilled or fried preparations due to its firmness and intramuscular fat content. Although it yields less than the fillet, it is highly valued in regional commerce and institutional catering (CAVALI et al. 2022b).

The whole flatted tambaqui and the band cut combine gastronomic value and practicality. By preserving bone structures and exposing bilateral muscle, they are ideal for whole grilling preparations, maintaining juice and texture. These cuts are widely used in Amazonian cuisine restaurants and have become icons of local gastronomy (CAVALI et al., 2023). Eviscerated and chilled whole tambaqui and the

backbone with head stand out due to logistical advantages and full utilization. The former maintains fish integrity, favoring presentation at the point of sale and targeting markets that prefer fresh, whole fish. The latter is used in broths and regional dishes, representing an important portion in carcass utilization (CAVALI et al. 2021).

These findings demonstrate that the valorization of tambaqui cuts goes beyond anatomy; it involves sensory, nutritional, cultural, and market-related aspects. Moreover, technical knowledge on how to prepare each cut allows for yield optimization and reduced loss during fish processing.

Potential and Differentiating Features of pirarucu *(Arapaima gigas*) Commercial Cuts

In the case of pirarucu, the diversity of cuts also responds to the demand for higher value-added and gourmet products. The tenderloin, obtained from the innermost and dorsal portion of the muscle, is known for its soft texture and lack of bones. Comparable to beef tenderloin, this cut has drawn increasing interest from contemporary cuisine and is used in sophisticated dishes and exports of Amazonian fish. The tail fillet stands out for its firm muscle fibers, uniform portioning, and low bone content, making it ideal for medallions, moquecas, and grilled dishes. Its heat resistance and succulence are highly appreciated by chefs and consumers alike (CAVALI et al. 2023).

These cuts demonstrate the feasibility of structuring a pirarucu processing chain aimed at the premium market, with products offering high sensory and nutritional appeal. Previous studies have already shown that pirarucu meat is rich in high biological value proteins, with low saturated fat and a favorable fatty acid profile (COUTINHO et al. 2019). From a technological standpoint, anatomical utilization of pirarucu requires skilled labor for obtaining premium cuts, representing an opportunity for workforce training and enhancing processing unit value.

Nutritional Aspects

The growing demand for healthier foods has driven studies on the nutritional composition of different types of meat, especially focusing on the lipid profile—particularly the content of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids—recognized for their cardiovascular and metabolic benefits. In this context, native Amazonian fish species, widely valued in regional aquaculture, emerge as high biological value protein sources with promising lipid characteristics.

This study observed that dorsal and belly cuts (ventrecha) of native Amazonian species stand out for their high levels of MUFA and PUFA, corroborating previous findings that these fish are rich in essential fatty acids—especially oleic acid (C18:1*n*9), eicosapentaenoic acid (EPA, C20:5*n*3), and docosahexaenoic acid (DHA, C22:6*n*3)—which are associated with the prevention of noncommunicable chronic diseases. The belly cut, due to its greater fat deposition, exhibited a more pronounced lipid profile, reinforcing its potential as a functional cut for consumers seeking high nutritional density foods.

Comparatively, studies with species raised in intensive systems, such as tilapia (*Oreochromis niloticus*) and pintado (*Pseudoplatystoma* spp.), indicate lower fat contents and reduced PUFA *n*-3 levels—especially EPA and DHA—reflecting physiological and dietary differences between groups. In contrast, native Amazonian

species like tambaqui and pirarucu offer cuts with significant concentrations of these fatty acids, especially when raised under appropriate feeding and management conditions (CAVALI et al. 2023).

The PUFA/SFA ratio observed in native fish, especially in fattier cuts, meets the nutritional recommendations for healthy foods—being higher than 0.45, the minimum value recommended by FAO/WHO (2008) for cardiovascular disease prevention. Moreover, the *n*-6/*n* -3 ratio, a key indicator of lipid balance, was considered appropriate, suggesting a positive contribution to modulating inflammatory processes.

It is important to note that factors such as diet, growth stage, farming environment, and cut type directly influence the meat's lipid composition. Therefore, nutritional and management strategies that promote PUFA *n*-3 deposition in tissues—such as the use of fish oil-rich ingredients or selected plant sources—can further enhance the functional value of Amazonian fish meat (GONÇALVES et al. 2020).

In summary, the data reinforce the nutritional value of commercial cuts from native Amazonian fish, especially the belly cut, as promising options for human consumption—combining sensory quality with health promotion. These findings support the strengthening of the regional production chain by valuing differentiated cuts in the consumer market (MARMENTINI et al. 2024).

Yield and Value Added to Cuts

The tambaqui fillet yields vary depending on the filleting method used, including factors such as live weight, nutritional composition (total lipids, proteins, minerals), and cut type. However, the fillet is increasingly in demand due to its nutritional value and popularity as a healthy consumer choice (SILVA et al. 2022). Its commercialization generates income for producers and positively impacts traders and the entire production chain (ROSSI et al., 2025).

The yield of the tambaqui steak (*posta*) depends on the fish's total weight, cutting method, and size. Nutritional value and cut quality are fundamental for the product's economic viability (SILVA et al. 2021). Demand is linked to consumer satisfaction and market needs (VIANA et al. 2018). Negative factors such as improper preparation and poor cutting techniques can reduce yield and profitability. The cut’s price may vary depending on demand and product quality, influencing its market attractiveness.

The yield of the whole flatted tambaqui (*espalmado*) also varies according to cutting methods and fish size. The quality of this cut ensures consumer satisfaction and product demand (OLIVEIRA et al. 2025). However, this type of cut requires skilled labor, potentially increasing production costs (OLIVEIRA et al., 2025). Storage and handling are critical to maintaining quality, as improper storage may compromise texture, flavor, and color—affecting all cut types.

The pirarucu loin is a premium cut, valued for its quality and unique characteristics, with significant yield relative to the fish’s total weight (ROCHA et al. 2023). It is a high-value product known for its firm texture and mild flavor (SILVA et al., 2025). The growing demand for this cut reflects its popularity among consumers—especially in markets that appreciate high-quality fish—making it a profitable option for producers.

Mechanically separated meat (MSM) contributes to reducing fish waste by utilizing parts that would otherwise be discarded (BACELAR et al. 2023). This cut improves

production efficiency and reduces losses (NASCIMENTO-TERADA et al., 2024). It is also more affordable compared to other cuts and is commonly used in processed products such as pâtés, fishballs, and others.

Potential and Differentiating Features of Pirarucu Commercial Cuts

The commercial exploitation of pirarucu demonstrates unique potential for adding value in Amazonian aquaculture, targeting gourmet and export markets. Premium cuts, such as the loin (or tenderloin) and tail fillet, are characterized by their soft texture, low levels of intramuscular bones, and mild flavor, attributes that equate them to high-standard proteins like noble beef cuts. Obtaining these cuts requires skilled labor, which, on one hand, increases processing costs but, on the other, opens an avenue for professional training and valorization of the final product (CAVALI et al. 2023).

The sensory differentiation and nutritional excellence, with high protein content and a beneficial lipid profile (COUTINHO et al. 2019), position pirarucu as a key species for conquering market niches that demand superior quality and sustainability, strengthening the Amazon's gastronomic identity (GONÇALVES & SANTOS 2024).

Nutritional Aspects

Cuts of tambaqui and pirarucu stand out not only for their sensory appeal but also for their remarkable nutritional profile, constituting excellent sources of high biological value protein and quality lipids. The fatty acid profile is particularly favorable, with significant levels of polyunsaturated fatty acids (PUFAs) from the omega-3 series, such as EPA (C20:5*n*-3) and DHA (C22:6*n*-3), especially in ventral cuts (ventrecha) where there is greater fat deposition (CAVALI et al. 2023). The PUFA/SFA (saturated fatty acids) ratio found in these native fish often exceeds the index of 0.45, recommended by FAO/WHO (2008) for promoting cardiovascular health. This nutritional advantage is amplified when compared to intensively farmed species, such as tilapia, whose lipid profile is influenced by grain-based diets (HASHIMOTO et al. 2024). Therefore, consuming these cuts goes beyond gastronomic satisfaction, representing a dietary strategy for the prevention of non-communicable chronic diseases.

Yield and Value Added to Cuts

The yield of commercial cuts is a crucial economic parameter, varying according to species, animal weight, slaughter technique, and handler skill. In tambaqui, the fillet, although it presents a lower percentage yield relative to live weight compared to bone-in cuts like the steak (posta), commands the highest prices in the market due to its convenience and consumer acceptance (SILVA et al. 2019, 2020, 2021).

On the other hand, cuts like the whole flatted tambaqui (espalmado) and the steak maximize carcass utilization, reducing waste and meeting a consolidated regional demand, which ensures their economic viability. In pirarucu, the commercialization of noble cuts like the loin, despite requiring more meticulous processing, adds exponential value to the product, directing it to the most profitable market segments (ROCHA et al. 2023). MSM emerges as a pivotal strategy for the economic sustainability of filleting, as it allows for full utilization of the carcass, transforming waste into valuable by-products, such as pâtés and surimi, and increasing the overall profitability of the process (SANTOS et al. 2020; BACELAR et al. 2023).

CONCLUSION

The standardization of commercial cuts for tambaqui (*Colossoma macropomum*) and pirarucu (*Arapaima gigas*) is pivotal for establishing quality benchmarks in Amazonian aquaculture, as it facilitates rigorous quality control, traceability, and strategic product segmentation to meet diverse market needs—from regional consumers seeking traditional flavors to gourmet and international markets demanding boneless cuts of superior sensory quality. This anatomical and technical study of fish cuts represents a fundamental step toward optimizing the fish production chain, enhancing economic sustainability, promoting full utilization of the animal, and valorizing Amazonian food biodiversity. Moreover, it contributes significantly to sustainable aquaculture practices by increasing process efficiency, reducing waste, and adding value to products from biodiverse ecosystems.

AUTHOR CONTRIBUTIONS

Conceptualization, methodology, and formal analysis, MBA, ASCMR, and CSL; software and validation, JVDF; investigation, MBA; resources and data curation, MBA, RHBS, and CSL; writing-original draft preparation, MBA, BPL, and JVDF; writing-review and editing, JBC, ASCMR, and BPL; visualization, AFD, and RHBS; supervision, JVDF; project administration, JBC; funding acquisition, JVDF. All authors have read and agreed to the published version of the manuscript.

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INSTITUTIONAL REVIEW BOARD STATEMENT

This research was approved by the Ethics Committee on Animal Use (CEUA/IACUC) of the Federal University of Rondônia (UNIR), under protocol No. 012/2021 (Annex A) – Project “Biosafety, Health, and Nutritional Quality of Fish.”

INFORMED CONSENT STATEMENT

For the development of interviews with managers of fish processing units, the study was authorized by the Research Ethics Committee (CEP) of UNIR, under authorization protocol CAAE No. 60744322.5.0000.5300 and certificate No. 077412/2022 (Annex B) – Project “Sanitary Characterization of Fish Farming in Rondônia.”

DATA AVAILABILITY STATEMENT

The data can be made available under request.

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CONFLICTS OF INTEREST

The author declares there is no conflict of interest.

REFERENCES

BACELAR RG et al. 2023. Mechanically separated meat prepared with edible tilapia filleting waste from a public fish market. Acta Scientiarum. Animal Sciences 45: e60993.

BALDISSEROTTO B. 2013. Fisiologia de peixes aplicada à piscicultura. Santa Maria: Editora UFSM.

BARDIN L. 2011. Análise de conteúdo. São Paulo: Edições 70.

CARDOSO HS et al. 2023. Levantamento de pontos críticos e potencialidades da cadeia produtiva e análise do índice de sustentabilidade de pisciculturas. Scientia Naturalis 5: 194–224.

CAVALCANTI DN et al. 2017. Qualidade de cortes comerciais de pirarucu (*Arapaima gigas*) criados em cativeiro. Revista Brasileira de Engenharia de Pesca 10: 54–62.

CAVALI J. et al. 2023. Fatty acid profile, omegas and lipid quality in commercial cuts of pirarucu (*Arapaima gigas* Schinz, 1822) cultivated in excavated tanks. Acta Scientiarum. Animal Sciences 45: e61186.

CAVALI J. et al. 2022a. Proximal composition, fatty acid profile, omegas and lipid quality in the tambaqui (*Colossoma macropomum* Cuvier, 1818) (Serrasalmidae) em “flatted cut”. Acta Veterinaria Brasilica 16: 262–272.

CAVALI J. et al. 2022b. Fatty acid profile, omegas, and lipid quality in commercial cuts of tambaqui (*Colossoma macropomum* Cuvier, 1818) cultivated in ponds. Boletim do Instituto de Pesca 48: e700.

CAVALI J. et al. 2021. Morphometric evaluations and yields from commercial cuts of black pacu *Colossoma macropomum* (Cuvier, 1818) in different body weights. The Scientific World Journal 3305286.

CAVALI JB. & DANTAS FILHO JV 2024. Estimativas da piscicultura no estado de Rondônia. Scientia Naturalis 6: 335–351.

COUTINHO NM et al. 2019. Fatty acid composition and influence of temperature on the lipid stability of *Arapaima gigas* meat. Brazilian Journal of Food Technology 22: e2018132.

DANTAS FILHO JV et al. 2022a. Minerals, omegas, and lipid quality in mechanically separated meat from *Arapaima gigas* filleting residue. Revista Brasileira de Ciências Agrárias 17: e2760.

DANTAS FILHO JV et al. 2022b. Mineral composition in commercial cuts of *Colossoma macropomum* (Cuvier, 1818) and *Arapaima gigas* (Schinz, 1822) in ideal weight class for commercialization. Acta Veterinaria Brasilica 16: 172-179.

FAO. 2016. Codex Alimentarius: Code of practice for fish and fishery products. Rome: FAO.

FAO/WHO. 2008. Fats and fatty acids in human nutrition: Report of an expert consultation. FAO Food and Nutrition Paper 91.

FERREIRA MA et al. 2022. Caracterização físico-química e sensorial de cortes de pirarucu (*Arapaima gigas*). Boletim do Instituto de Pesca 48: e20220015.

GIL AC. 2019. Métodos e técnicas de pesquisa social. 7.ed. São Paulo: Atlas.

GONÇALVES AA et al. 2020. Tecnologia do pescado: ciência, tecnologia, inovação e legislação. 2.ed. São Paulo: Atheneu.

GONÇALVES ACT & SANTOS LCR. 2024. Bioeconomy in Central Amazon: Participatory Management of Pirarucu (*Arapaima gigas*). Journal of Contemporary Administration 28: e240195.

GOTARDI DG. 2023. Qualidade da água, perfil socioeconômico e caracterização sanitária da piscicultura familiar em microrregiões no interior de Rondônia. Dissertação (Mestrado em Ciências Ambientais). Rolim de Moura: UFRO. 71 p.

HASHIMOTO AJ et al. 2024. Biochemical and hematological characterization of pirarucu (*Arapaima gigas* Schinz, 1822) juveniles fed with different nutritional feeding systems. Acta Scientiarum. Animal Sciences 46: e66797.

LAKATOS EM & MARCONI MA 2017. Fundamentos de metodologia científica. 8. ed. São Paulo: Atlas.

LINSTONE HÁ & TUROFF M. 2002. The Delphi method: Techniques and applications. Boston: Addison-Wesley.

MARMENTINI RP et al. 2024. Qualidade lipídica de peixes nativos da Amazônia, panorama e perspectivas de mercado da piscicultura brasileira. Revista Brasileira Multidisciplinar 27: 149–168.

MARTINS ML et al. 2021. Cortes comerciais do pirarucu: técnicas e aplicações culinárias. Revista da Gastronomia Amazônica 6: 78–90.

NASCIMENTO-TERADA JS et al. 2024. Fungi influence in the chemical composition, textural quality, buoyancy, and floatation time of poorly stored fish feeds. Boletim do Instituto de Pesca 50: e862.

NAVA V. Determination of Fatty Acid Profile in Processed Fish and Shellfish Foods. Foods 12: 2631.

OLIVEIRA AC et al. 2018. Perfil nutricional de diferentes cortes de pirarucu (*Arapaima gigas*). Acta Amazônica 48: 325–332.

OLIVEIRA AVD et al. 2025. Nutritional quality in spine and head broth of tambaqui *Colossoma macropomum* Cuvier, 1818 (Actinopterygii: Characiformes: Serrasalmidae). Revista Brasileira de Gestão Ambiental e Sustentabilidade 12: 419-430.

PEIXE BR. 2025. Anuário 2025 da Peixe BR da Piscicultura. São Paulo: Peixe BR. Available from: https://www.peixebr.com.br/anuario-2025/

PEREIRA KS et al. 2018. Características anatômicas e aproveitamento industrial do tambaqui (*Colossoma macropomum*) em diferentes cortes comerciais. Boletim do Instituto de Pesca 44: 1–8.

R CORE TEAM. 2022. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing.

ROCHA ASCM et al. 2023. Proximate composition, energy value, and lipid quality in loin in different weight classes of pirarucu (*Arapaima gigas*) from fish farming. Boletim do Instituto de Pesca 49: e79.

RODRIGUES LD et al. 2017. Cortes comerciais de tambaqui (*Colossoma macropomum*) e suas aplicações na culinária regional amazônica. Revista Brasileira de Engenharia de Pesca 10: 21–28.

RONDÔNIA. AGÊNCIA IDARON. 2023. Destino das GTA's de abate de animais aquáticos de 2020 a 2022. Porto Velho: IDARON.

ROSSI GG et al. 2025. Amazon Caviar – Profile of fatty acids, omegas and lipid quality indeces in roes of *Arapaima gigas*. Revista Brasileira Multidisciplinar 28: e-20252537.

SANTOS JL et al. 2020. Características anatômicas e rendimento de cortes do pirarucu criado em tanque-rede. Pesquisa Agropecuária Tropical 50: e62150.

SILVA, EE et al. 2025. A new pre-slaughter stunning method promotes quality of tambaqui (*Colossoma macropomum*) fillets compared to conventional methods. Boletim do Instituto de Pesca 51: e91.

SILVA JV et al. 2022. Exigência de valina dietética para tambaqui (*Colossoma macropomum*) com diferente peso corporal. Ciência e Agrotecnologia 46: e002122.

SILVA RD et al. 2019. Aproveitamento de resíduos do processamento de peixes: obtenção e uso da carne mecanicamente separada. Ciência Rural 49: e20180512.

SILVA RM et al. 2021. Técnicas de processamento de pescado e valorização de cortes de tambaqui na indústria frigorífica. Revista Agro@mbiente 15: 67–76.

SOUSA FA et al. 2020. Perfil lipídico de filés de tambaqui criado em sistemas intensivos e seu potencial nutricional. Revista Brasileira de Zootecnia 49: e20190234.

SOUZA ACL et al. 2022. Composição química e perfil de ácidos graxos de diferentes cortes de tambaqui comercializados no Norte do Brasil. Ciência e Agrotecnologia 46: e026922.