

## The Brazilian Pirarucu supply chain: situation, perspectives, and challenges

Cadeia produtiva do Pirarucu brasileiro: Situação, perspectivas e desafios

La cadena de suministro de Pirarucu brasileño: Situación, perspectivas y desafíos

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### **Abstract**

This study suggests that pirarucu is a fish capable of having competitive products in the national premium fish market and analyze the opportunities and constraints of this supply chain in Brazil. To achieve that, a semi-structured interview was conducted with 22 players of the cultivated pirarucu supply chain in Brazil, resulting in more than 13 hours of dialogue to understand who the players are, and the main challenges and opportunities for this market. The pirarucu products (such as frozen fillet and loin) are premium products and can become competitive in the niche market of value-added fish, if their constraints are overcome, since they have intrinsic potentialities and extrinsic values to the consumer. The non-conformity of the information added to the lack of knowledge about the species were identified as the main limitations of the organization of the supply chain. Fish farmers show interest in strengthening the cultivated pirarucu supply chain. The processing industry and the consumers demand a regular supply, and input suppliers realize that this is an important national market. In any case, there is a market for premium pirarucu, and it is noticeable that there is a demand for superior quality fish, and pirarucu presents several characteristics valued by the consumer.

**Keywords:** Aquaculture; Competitiveness; Fishery; Food production; Arapaima gigas; Supply chain management.

### **Resumo**

Este estudo sugere que o pirarucu é um peixe capaz de ter produtos competitivos no mercado nacional de pescados premium e analisar as oportunidades e restrições dessa cadeia produtiva no Brasil. Para tanto, foi realizada uma entrevista semiestruturada com 22 players da cadeia produtiva do pirarucu cultivado no Brasil, resultando em mais de 13 horas de diálogo para entender quem são os players e os principais desafios e oportunidades para esse mercado. Os produtos de pirarucu (como filé e lombo congelados) são produtos premium e podem se tornar competitivos no nicho de mercado de pescado de valor agregado, caso suas restrições sejam superadas, pois possuem potencialidades

intrínsecas e valores extrínsecos ao consumidor. A percepção de assimetria de informação e a falta de conhecimento sobre a espécie foram apontadas como as principais limitações da organização da cadeia de suprimentos. Piscicultores demonstram interesse em fortalecer a cadeia produtiva do pirarucu cultivado. A indústria processadora e os consumidores exigem um abastecimento regular, e os fornecedores de insumos percebem que este é um importante mercado nacional. De qualquer forma, existe um mercado para o pirarucu premium, e percebe-se que há uma demanda por pescado de qualidade superior, sendo que o pirarucu apresenta diversas características valorizadas pelo consumidor.

**Palavras-chave:** Aquicultura; Competitividade; Pesca; Produção de alimentos; Arapaima gigas; Gestão de cadeia de suprimentos.

### Resumen

Este estudio sugiere que el pirarucu es un pez capaz de tener productos competitivos en el mercado nacional de pescado premium y analiza las oportunidades y limitaciones de esta cadena de suministro en Brasil. Para lograrlo, se realizó una entrevista semiestructurada con 22 actores de la cadena de suministro de pirarucú cultivado en Brasil, lo que resultó en más de 13 horas de diálogo para comprender quiénes son los actores y los principales desafíos y oportunidades para este mercado. Los productos de pirarucú (como el filete y el lomo congelados) son productos premium y pueden volverse competitivos en el nicho de mercado del pescado con valor agregado, si se superan sus limitaciones, ya que tienen potencialidades intrínsecas y valores extrínsecos para el consumidor. La percepción de asimetría de información y la falta de conocimiento sobre la especie fueron señaladas como las principales limitaciones de la organización de la cadena de suministro. Piscicultores muestran interés en fortalecer cadena de suministro de pirarucu cultivado. La industria procesadora y los consumidores demandan un suministro regular y los proveedores de insumos se dan cuenta de que este es un mercado nacional importante. De todos modos, hay un mercado para el pirarucú premium, y se nota que hay una demanda de pescado de calidad superior, y el pirarucú presenta varias características valoradas por el consumidor.

**Palabras clave:** Acuicultura; Competitividad; Pesca; La producción de alimentos; Arapaima gigas; Gestión de la cadena de suministro.

## 1. Introduction

Fish meat is among the animal proteins with the highest production and consumption worldwide (Lozano et al., 2014), presenting low theory of fat, rich in proteins, vitamins and minerals, standing out from other foods of animal origin (Sartori & Amancio, 2012). However, logistical difficulties of a highly perishable and cold-dependent product; In addition to great challenges in the coordination and organization of transport agents, make the development of the Brazilian aquaculture complex.

One way to encourage the organization of distribution channels is to adapt the final product and direct it to a specific market segment, enabling to aggregate product value and practice superior pricing. In the market for differentiated products, the sale of premium meat has been an interesting alternative for some products that have attributes valued by consumers. However, few fish species have this potential; and a good example of a product with favorable attributes to compete in the premium meat market is the meat of the pirarucu (*Arapaima gigas*).

Pirarucu is considered a fish of great importance in the Amazon and this fact has caused a strong interest among fish farmers in this commercial exploitation (Oliveira et al., 2014). The pirarucu is accepted because of its large size, muscle yield, white muscle, good palatability, low-fat contents, and absence of intramuscular bones in some of its muscle cuts (Cortegano et al., 2017). Pirarucu meat was already considered a noble product by the high purchasing power segments in Brazil. In addition, as one of the largest freshwater fish in the Amazon, this new species is promising for cultivation in fish farming (Chung et al., 2020).

However, the production base to serve this market still needs to be understood, organized, and coordinated, as the agents in this supply chain face serious challenges to become competitive and resilient in an increasing demand market. The food authenticity is set by the stakeholders, not just the products, for which they represent a public policy and institutional environment exists around a product, and they help to create the concept of authenticity (a social construct) and how its semantic field applies (Grunert, 2017).

Therefore, studies on the species and its supply chain are essential to enable its sustainable production. Based on that information, here we describe the supply chain of the cultivated pirarucu, reporting and analyzing the impressions and positions of specialists in national fish.

## **2. Methodology**

This is a qualitative exploratory study, based on a semi-structured questionnaire in a standard script. The research presents a cross-section, analyzing a specific moment in the supply chain (Nique & Ladeira, 2014). Twenty-two interviews were carried out, to identify the main agents in the chain and describe their interrelationships. Were analyzed more than 13 hours of dialogue with specialists from the national fish supply chains (8), pirarucu producers (6), processors (slaughterhouses) (3), food-service agents (chefs and cooks) (4), as well as an input supplier (1).

### **2.1 Ethics Statement**

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethics approval was required because this research did not use any animals, only bibliographic research and interviews with specialists were used. Local guidelines did not require ethical approval for interviews and questionnaires.

### **2.2 Population and Sample**

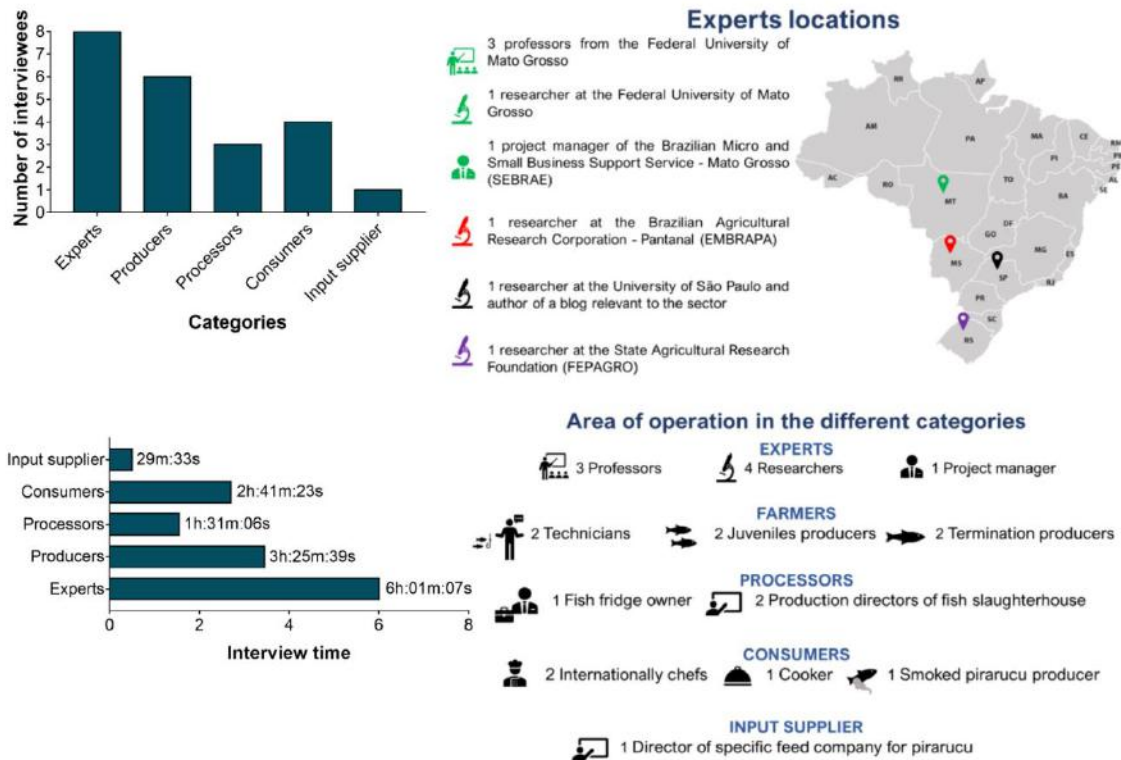
The pirarucu fish was selected because it offers a product with high added-value and because it was the main source of protein in the Amazon region in the 19th century, being essential in feeding native populations and workers who migrated during the rubber cycle. The products selected for the study were the fillet and the pirarucu loin, frozen and packaged in small portions.

Researchers and professionals who work nationally were considered as experts. This made it possible to identify the most important questions for the continuity of the research. Producers in the state of Rondônia were chosen due to their representativeness for national production, with the state having the largest number of aquaculture establishments working with the species, being 835 in all (PEIXEBR, 2020).

In the category of processors, were included the three pirarucu meat processing with SIF (Federal Inspection Service) existing in Brazil, located in the states of Acre, Rondônia and Mato Grosso do Sul. Representing the consumers of premium pirarucu meat, were selected the active ones from the food-service sector, chefs or cooks who use the species in haute cuisine. These agents were based on the differentiated attributes that best guarantee the use of the product's potentials.

The inputs suppliers were represented by the only company that provides specific feed for pirarucu in Brazil until the moment of this research, selected because a differentiated product must count on specialized suppliers, to guarantee attributes of greater value and efficiency for the supply chain, contributing to its competitiveness (Figure 1).

**Figure 1.** Profile of the interviewees, location in Brazil and time of interviews used to compose the collection of information related to the pirarucu supply chain.



Source: Authors.

### 2.3 Data Analysis

The data were analyzed through the coding and categorization of the collected content. All 22 interviews were transcribed, respecting the linguistic peculiarities of the interviewees, and maintaining the colloquiality of their speeches. Thus, the answers were divided into two categories: description of the stakeholders in the pirarucu supply chain and description of bottlenecks.

After transcription and organization, a content analysis was performed according to the method proposed by Flick and Gibbs (2009). The first interviewee was chosen because he is a national reference for the pirarucu meat supply chain. Subsequent interviewees were an indication of the previous interviewee, and an indication was requested at the end of the interview, respecting the principles of the snowball technique (Goodman, 1961). This type of sampling was chosen because it is a supply chain with information published and available to the public, making its analysis difficult.

### 3. Results

The agents of the pirarucu meat supply chain include input suppliers, juvenile producers, finishing producers, slaughterhouse, retail, and consumers (Table 1).

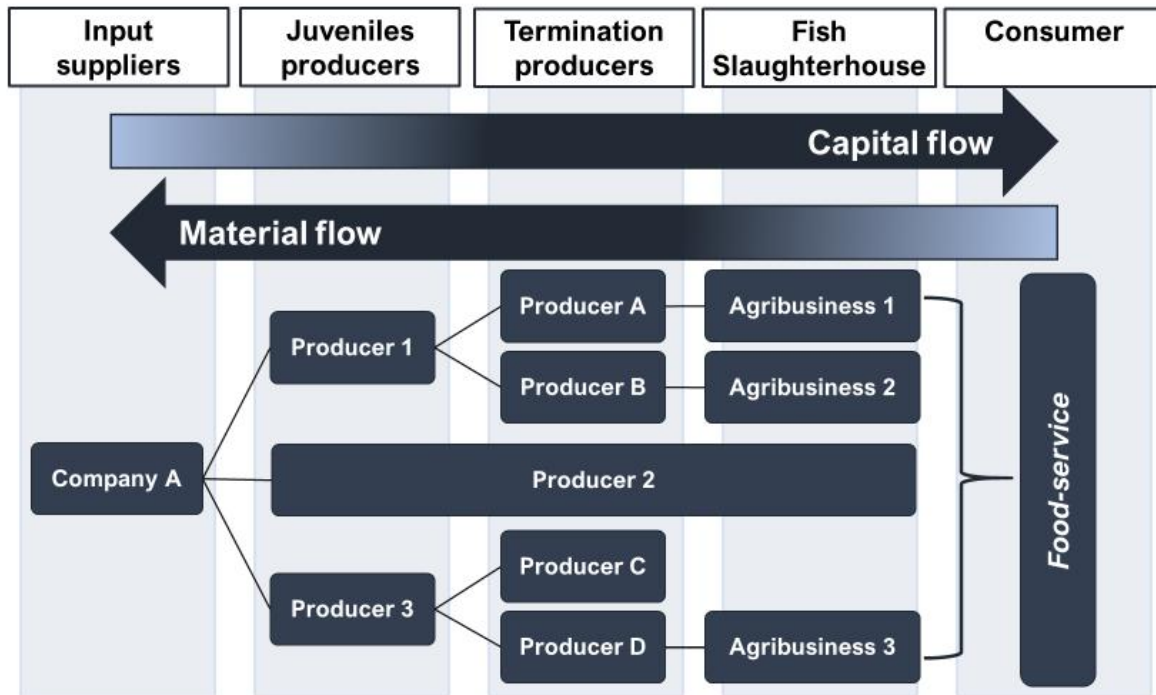
**Table 1.** Identification and definition of the main stakeholders in the pirarucu supply chain cultivated in Brazil, their characteristics.

Stakeholders	Definition	Characteristics	Market
<b>Input suppliers</b>	They sell various inputs such as feed, medicines, equipment, and services.	They are companies that work with animal nutrition and health, operating in the market of other species of zootechnical interest, and are starting research to meet the demands of the intensive cultivation of pirarucu. In the national market, mainly specific drugs, and feed, it is still quite incipient since the supply chain is still recent.	Only one company offers specific feed for pirarucu. Most producers used feed prepared for other species or smaller species, for natural food.
<b>Juvenile producers</b>	They remove breeding stock from nature and reproduce them in captivity.	The producers of juvenile pirarucu are experienced in Amazonian fish. Usually tambaqui ( <i>Colossoma macropomum</i> ) (whose supply chain and market are more structured).	Only three juvenile producers are authorized by IBAMA to operate in Brazil.
<b>Finishing producers</b>	They buy the juveniles and cultivate them in excavated tanks - density of 10 to 15 tons of fish per hectare - until they reach the slaughter weight of 12 to 15 kg in 12 months of cultivation.	Like juvenile producers, finishing producers have experience in species of Amazonian fish. This peculiarity allows producers to invest in higher risk species, such as pirarucu.	There are several agents that work with different species and consider the pirarucu as a complementary income of greater value, but less volume.
<b>Processors</b>	They are slaughterhouses where slaughter, cut processing and the incorporation of different technologies are carried out.	Processing workers follow the pattern of other stakeholders in the pirarucu supply chain. In this way, they are companies specialized in Amazonian fish species, having tambaqui as their main product and processing pirarucu when demand exists. Slaughterhouses plants are not adapted for the species (anatomically different from fish that are regularly slaughtered) and the pirarucu supply is not regular, which is the main obstacle to the company's specialization. As there is no quality standard in the product, the slaughterhouses end up reducing the price paid for having many losses in the process.	There are three configured pirarucu slaughterhouses enabled by the Brazilian Federal Inspection Service.
<b>Consumers (food service)</b>	Places where premium pirarucu products are offered, such as restaurants and fish boutiques.	As it is a product with an irregular offer, it is not common to be purchased at retail, being a product intended for food service. Restaurant chefs who value national cuisine are the main consumers of this fish. And their customers have an occasional consumption, when they try a regional dish with the application of haute cuisine techniques.	Most of the regular consumers of pirarucu meat are native to their traditional production areas.

Source: Authors.

In addition to the sectors described, it is important to highlight the support entities, since it is this financial and technical support that enables the organization of the supply chain. Entities such as SEBRAE, BNDES, EMATER have been instrumental in setting up fish farms and processing agroindustry, as they contribute to the coordination of the chain and the professional instruction of its agents (Figure 2).

**Figure 2.** Main agents and flows of the pirarucu supply chain in Brazil.



Source: Authors.

Once the supply chain was mapped, its bottlenecks were diagnosed (obstacles that hinder the evolution of the sector), found in all stages of the process, shown in Table 2.

**Table 2. Bottlenecks in the supply chain of pirarucu meat grown in Brazil.**

Bottleneck	Justification	Interviewee quotes
Lack of technical knowledge	<p>The lack of biological and zootechnical information, such as reproduction, nutrition, health, and management, makes the production of pirarucu still very rudimentary. Therefore, its potentialities are unknown and, consequently, little explored</p>	<p>“When you have a supply chain that starts with research, you get there at the front ... When you verticalize it, to support yourself, you must go together, research, laboratory, and sale of the final product ..”. (Director of the feed supply company specific for pirarucu)</p> <p>“Threatened with extinction, due to extractive fishing ... Until today, the total technological dominance of the pirarucu cultivation is unknown ...” (UFMT researcher)</p> <p>“The first bottleneck was to get matrices and make fingerlings ... The second bottleneck is the rations (availability, price, and quality) these rations are carnivorous fish, they are not specific to pirarucu, so we must evolve a lot, especially in the nutritional part of fish ...” (Production technician)</p> <p>“If you do not have a solid production base, you do not have a solid and structured market to sell this fish ...” (FEPAGRO researcher).</p> <p>“The opposite is true, the institutions that should give support to us, are looking for support from the producer! ... we spent 2 kg of feed to make 1 kg of pirarucu. An expensive fish. You see that salmon spends less than 1 kg of feed to make the same kilo of meat. So it's a bottleneck ...” (Slaughterhouse's owner)</p> <p>“It is all very new ... Studies to determinate levels of protein, energy, fiber, mineral part, vitamin ... We do not have all these levels specified for pirarucu ... Today we do not have these levels, as we have for tilapia and some other fish (catfish, trout ...) in the case of pirarucu do not have! ...” (Director of specific feed company)</p> <p>“Unfortunately, in Brazil there is no medicine registered with ANVISA (National Health Surveillance Agency), for fish, only tetracycline, so we use chicken, pork, sheep, rabbit medicine ... Looking for a solution ... Inputs they are all outsiders, feed, and medicine ...” (Largest producer of pirarucu fingerlings in the world)</p> <p>“It is different from talking about a catfish, a salmon, a sardine, a tilapia, a carp that have worldwide knowledge. That is why it has a very long work to structure its supply chain, from research to the final consumer ...” (Director of a specific feed company).</p>
Absence of human resources *	<p>The lack of technical knowledge can be explained by the absence of major players to boost the production chain through established demands. When thinking about well-structured supply chains, such as poultry and pork, for example, large companies coordinate strategic and innovation actions, directing agents to improve the chain's competitiveness. In the case of national fish, this association is more difficult. The absence of major players hinders massive investment (of financial and technical resources) in production. Respondents stressed the risk of a new activity until it becomes stable and safe. The participation of companies capable of supporting this risk is fundamental.</p>	<p>“Large companies that have the capacity to manage risk, since the supply chain is still embryonic, with many technological gaps, there are many problems to be solved. A large industry has a margin to do many tests yet ...” (Embrapa researcher - Pantanal).</p> <p>“After a production link with the industry has been established, this will certainly be respected, because it is the business of ‘great people’ ...” (FEPAGRO researcher)</p> <p>“And the biggest difficulty is the fattening of this fish. As I told you, spending R \$ 2,500.00 / day is difficult, there must be market security, producing without a market is complicated ...” (Largest producer of pirarucu fingerlings in the world).</p> <p>“Costs a lot of money ... You must buy fingerlings which is expensive ... Spend a lot of food on a fish that eats a lot ... And that you need a lot of monitoring in production ... So, whoever ventures even in the fattening of pirarucu, it must be smart ...” (FEPAGRO researcher).</p> <p>“It is expensive, it is a noble product and that is why you cannot go wrong ... So far it is R\$ 8.60 (value of the kilo of the finished fish) until it arrives in the refrigerator it should cost R\$ 10.00 more (per kilo) ... If you are 90-100 days late you lost the whole profit ...” (Largest producer of arapaima fingerlings in the world).</p> <p>“It is not a production for beginners, the cost of pirarucu is extremely high. So, you need to have capital, to have planning, it is not for everyone ... It is a carnivorous fish the feed is expensive. Today a 25 kg bag should cost R\$ 65.00. Today the fingerling is sold at R\$ 15.00 above 20 cm and above 70 g, we do not sell fingerling less than that. And today the market price of fatty fish is R \$ 8.71 a kilo ... At the market in Cacoal (city in the state of Rondônia) you will buy a kilo of fillet for around R \$ 40.00 ...” (Production technician).</p> <p>“It is a producer with greater purchasing power, because the pirarucu fingerling costs 10 times more than a round fish fingerling ...” (Project managerat SEBRAE - MT).</p>
Lack of logistics	<p>The lack of logistics was another point addressed by the interviewees. The consumption of premium pirarucu meat is concentrated in the south and southeast regions, much of the production is in the north region. In this way, logistics becomes a bottleneck for quality and price of the final product.</p>	<p>“An example would be the chicken market ... Price, quality standard and scale of production are the three factors that limit pirarucu to increase its consumption ... If production is not on the northern axis of Mato Grosso, it is very distant the production of soy and corn, making the feed too expensive. Logistics would be the first bottleneck for expansion ...” (Embrapa researcher - Pantanal).</p> <p>“The possibility of producing a product with high added value is full, but there is a distance between the producer and that product itself and the consumer of that product. There is no easy access to this market ... There are consumers who are willing to pay the price if the product has a specific quality. However, accessing them is still a difficulty for us ...” (Smoked pirarucu producer).</p> <p>“Today we are paying the producer R\$ 7.50/Kg. We know you do not pay the cost ... But we already paid up to R\$ 9.00 so the consumer would not be willing to pay R \$ 50.00 per kilo of the fillet ... Today he is paying R\$ 40.00 but R\$ 50.00 no more... If I bought a pirarucu at R\$ 7.00 there in the producer's tanks, it will arrive in my refrigerator at R\$ 7.50, if he lost 60%, that kilo has already turned R \$ 18.00 (just for loss in the process), so I have spent on energy, with labor, he goes there for R\$ 22 - 23.00, then to send to another state, he goes there to his R\$ 24.00; 25.00, then it arrives at the supermarket they put the margin of 30%, it gives the R\$ 38.00 ... 40.00 ... If you have pirarucu to sell, I will try to sell it and later I will buy you. This does not work ...” (Owner of a slaughterhouse).</p>

Excerpts from the interviews are described with the description of their responses in the same terms as they were said, in order to preserve the particularities of their expressions. Making adaptations for translation from Portuguese to English. Source: Authors.

Despite the bottlenecks presented, for all respondents, the cultivated pirarucu has a competitive potential to enter the market niche for premium fish.

#### 4. Discussion

Pirarucu is not very demanding in water quality, but sensitive to down temperatures, stopping feeding at temperatures below 20.8°C and reaching mortality at temperatures of 16°C (Lawson et al., 2015). For this reason, a very restricted production zone is formed, being possible only in the northern and central-western regions of Brazil. The best representative of these regions is the state of Rondônia, the largest producer of pirarucu, 82.6% of production and 74.6% of the value of Brazilian production (IBGE, 2017). This scenario became a reality due to public articulations and private initiatives, in addition to the action of a company stimulating production with guaranteed purchase contracts for finished fish. Thus, this study made it possible to understand the reality in the main representative state of the pirarucu meat supply chain in Brazil.

There are still some information gaps regarding the cultivation of pirarucu that must be filled to supply the needs in this sector. This may explain the weak structure of the production of pirarucu from cultivation. Presenting a supply chain initiated with a poor structure of suppliers of inputs (with a single company that offers specific ration for its development). No drug or genetic improvement company has launched specific products to date. A clear challenge for input companies is the carnivorous habit of fish, which hinders intensive cultivation, with the use of extruded food being an alternative with good results, after a period of adaptation (Pereira-Filho et al., 2003).

The properly offered diet stands out as one of the most important zootechnical processes in fish production. It is decisive for the productivity and profitability, since it directly interferes in the growth and health of the animals and represent a large part of the operational costs in intensive fish farms. Only one company is investing in vertical production, distributing juveniles to producers responsible for growth and termination, so the pirarucu is reacquired and transported to the industry. This finding is interesting due to the possible comparison with the productive model of the chicken supply chain.

In general, the structuring of the cultivated pirarucu supply chain follows the representation of Table 1, initially with producers of juveniles experienced in reproducing Amazonian fish species and having acquired knowledge from non-scientific sources, based on direct observation of production and on the attempt and error. These producers sell juveniles, about 15 cm, to finishing producers, also experienced in managing the growth of species with greater technological dominance, such as tambaqui. Finally, these finishing producers sell the fish to slaughterhouses (when the animals reach about 12 kg). The slaughterhouses process pirarucu only when market demand arises, the slaughter being sporadic. Chefs demand products that have a regional identity for their dishes and, at the same time, have intrinsic characteristics to receive haute cuisine techniques, present in the cultivated pirarucu.

Pirarucu producers (both juvenile and terminator producers) have shown interest in cultivating the species, although none of them dedicate themselves exclusively to the activity, as it still offers market risks, mainly due to sporadic demand and high production costs. A large part of the pirarucu productions in Rondônia is small enterprises. The articulation of small producers is vital for organizing the productive sector, both to guarantee their permanence in the activity and to minimize the socio-environmental impact of production.

The production of juvenile pirarucu by laboratories is not uniform every year, due to the low technological development of the reproductive management of the species, which also interferes in the price practiced by producers (Lima, 2018). Nevertheless, the market has been quite interesting for the production destined for slaughter. Considered a profitable business for those who invest in technologies, producing their own young people, managing to add value to the products, to reach new market niches with higher prices. These sales are made directly to traditional restaurants or supermarket chains in large Brazilian capitals that prefer animals ranging between 9 and 15 kg (Fogaça, de Oliveira, Carvalho & Santos, 2011), since they present a more tender meat, with less abdominal fat and show advantages in distribution and marketing logistics (Cortegano et al., 2017).



#### 4.1 Industry

Industry is an important part of the supply chain, as it transforms raw materials into products, representing the connection between production and consumption. As such, processors need to understand both demands. The average yield obtained for the pirarucu fillet, without skin and without scales, is 41.41% (Oliveira et al., 2014), which is considered high, compared to other commercially exploited aquaculture species.

In the study by Fogaça et al. (2011), the pirarucu has three different weight ranges presented, in filleting, an average yield of 47% for animals between 7 and 9 kg, 49% for animals between 11 and 13 kg and 50% for animals between 14 and 16 kg of live weight. In addition, the same author observed a greater tendency for fat deposition in the ventral region of the fillet, especially in heavier fish. However, this characteristic makes the heavier fish considered as semi-fat, not being interesting for the market of premium products, even though according to Oliveira et al. (2014) the lipid content of the dorsal region is low. This information justifies the preference for less heavy fish (11 and 13 kg) for slaughter, although the fillet yield is lower than that of heavier fish.

Bearing in mind the current and future challenges for food industries, Pirarucu processors should also consider: emerging microorganisms and toxins; food allergens; co-optimization between safety and quality (sensorial and nutritional); food processing and products tailored to specific ages, genetic characteristics, lifestyles and enhanced nutrient availability; processes to achieve less water and energy consumption; environmental, social and economic apprehensions compelling food industry to extract all the possibilities of each raw material; global warming; and missions (Augusto, 2020). The same author also indicates a congruence between different traditional and non-traditional technologies to enhance food processing.

#### 4.2 Consumers and retail

After getting to know the industry's perspectives, consumers were interviewed, in this case, chefs (foodservice sector). These agents perceive value in premium pirarucu meat products. In our study, the desire for a stable market, with constant availability of quality product, was notable. The product (pirarucu) is of interest to the consumer, but for the purchase to take place it is necessary to have a regular offer in the market.

There is a great distance between a producing region, north and Midwest, and regions in which consumers are willing and have the purchasing power to consume the flesh of the cultivated pirarucu. For Medina, Gallardo & Aubourg (2009) this situation is even more worrying since the nutritional value of the fish is associated with the conditions of the quality of its freshness. The period for consumption, maintaining the sensory quality of the whole fish is observed by Oliveira et al. (2014) with a limit between 26 and 28 days.

Until the 1960s, Imbiriba (2001) observed that there were some medium-sized companies in Belém - PA that sold the dry-salted product, in addition to several smaller establishments. Today, however, the product can be found in several large retail chains in the main capitals, connected to Amazonian culture. An example of local culture is related by Silva (2018) in which fish is still widely consumed with cooked cassava and bananas, a way that the indigenous people identify as the authentic way that Peruvian Cocama tastes this fish.

Commercially, it is important to create strategies to add value to the products of the pirarucu processing. Actions such as providing more attractive ways of presenting fish to the consumer market. Often, the sale of pirarucu meat, mainly from extractivism, shows a product without any type of cut standardization at a high price, which ends up competing with other more traditional species. Producers are paid a low price for the raw material, which, in turn, is little explored by the processing industries and traded minimally processed for large retail companies. Moreover, intrinsic attributes such as caloric value and protein content are not related to the retailing price of different commercial fish cuts in the Brazilian market, possibly because sensorial, market and cultural factors are responsible for the price variations (Dantas et al., 2021).

The high performance of the pirarucu carcass makes it possible to process its meat using different ways of conservation methods. Silva et al., (2016) show that salting and drying, for example, result in traditional presentations of Amazonian cuisine, sold in large open markets and popular fish markets in the northern region of the country. For higher culinary, the dorsal cut of raw pirarucu is proper for *sous vide*, vacuum cooking, and can be storage for up to 49 days, assuring its attractiveness for high quality markets niches (Pino-Hernández et al., 2020).

Pirarucu meat inlays are also options to explore the potential of the species by diversifying the product portfolio with possibilities of adding commercial value, mainly for less noble cuts and fillet residues. Despite not related to premium products, this reclamation contributes by adding alternatives financial resources, in addition to offering an alternative for waste management. Moreover, sustainable food supply chain to reduce environmental impacts, enhancing food waste recycling, and strengthening facilities sharing and articulation with other industries should be considered to address current challenges and meet future requirements (Zhong et al., 2017).

Another major challenge for the premium pirarucu market is competition with pirarucu of illegal origin, which limits the number of buyers, since inspection is deficient and the illegal product tends to be cheaper and available all year round, as it does not respect the legal limits of extractivism. Furthermore, this is a threat to consumers' confidence in the quality and safety of this product in the long term.

#### 4.3 Input suppliers

Finally, the director of the only company that produced specific input for pirarucu was interviewed. This company, in the second half of 2016, launched the first line of specific feed for the species. This was undoubtedly an important step towards consolidating the supply chain. The appeal was in the sense of the need for time to carry out research, which in the case of pirarucu are more backward than the non-scientific knowledge itself. It is noteworthy that the nutritional management of the species is performed with ration for pintado (*Pseudoplatystoma corruscans*) or with the population of smaller fish (such as tilapia - *Oreochromis niloticus*) in the cultivation tank for natural food.

It is estimated that the requirement for optimal dietary protein for juvenile pirarucu is about 36% of digestible protein, a high value, which associated with the size of adult fish makes it difficult to carry out nutritional and health research on this species (Magalhães Júnior et al., 2017).

#### 4.4 Overall analysis

There is no specific Brazilian legislation for premium food, it is necessary to prove the superior attributes of the product so that the use of the term premium on the label is authorized, according to RDC 259 (Brasil, 2002), IN 22 (Brasil, 2005) and RIISPOA (Brasil, 2017). Such attributes can include origin and traceability, design, social and ecological responsibility, fair trade, healthy food, food security, elaborated points of sale, convenience, or high quality (FIERGS, 2020).

Moreover, traditional foods, such as Pirarucu meat for Amazonian consumers, are considered as part of the culture of populations. Therefore, the successful market of these products on a balanced innovation and on consumer acceptance and interpretations of tradition perceived based upon authenticity, innovation, adaptation (Guiné et al., 2021).

Analyzing the interviews, the information asymmetry between the different actors was clear. Producers want availability of inputs and a stable market to increase production. At the same time, input companies, industry and consumers want an increase and regularity of supply. As in other incipient chains, all actors have similar objectives, despite the lack of articulation between them. In fact, a well-structured supply chain brings advantages to all the agents that compose it, as stated by Chopra & Meindl (2011), it would not be possible to achieve success with just a few people accumulating good results. The producers are guaranteed to sell, the industry is guaranteed regular supply and the consumer is guaranteed the origin, quality,

and stability of the offer due to the sector's organization. In addition, we have a clear reduction in information asymmetry, which is indispensable to establish a secure ambient for negotiation between agents.

In a supply chain, growth is only possible when there is effective interaction between all links, which is a basic precept of its consolidation. However, this is not yet observed in the production of the cultivated pirarucu. When thinking about well-structured meat supply chains in Brazil, we realize that there will always be bottlenecks to be overcome, such as safety in the quality of the products in the beef chain. As an example, the results of the “weak meat operation” (March 2017), not intended here, go into the merit of the operation and its dissemination strategies. Still, even in structured chains, we have advertising bottlenecks, such as those faced by the pork supply chain during the 1970s, when such a product was perceived as an unhealthy, due to excess cholesterol or the myths of cysticercosis. This analysis is essential, since learning from agro-industrial examples of strongly structured chains is an alternative to accelerate the development of the cultivated pirarucu supply chain, in a way that allows fish to be positioned as a high-quality protein in the consumer market dispute in Brazil.

Finally, considering the actual and future epidemiologic crisis, food access should be protected through the valorization of local farmers, with proper access to logistic and market to deliver their product to consumers even with decreases in tourism and face-to-face access do storages and traditional retailers. Additionally, social wellbeing policies for instance cash transfer programs global financial assistance and to declared essential agricultural inputs, farms, food processing, and distribution so they be exempted from lockdown measures, to ensure so adequate food flow in amounts from farm to fork (Laborde et al., 2020).

## 5. Conclusion

The perception of information asymmetry and the lack of knowledge about the species was attributed as the biggest limitation of the chain's organization. Therefore, experts emphasize the importance of conducting studies to better understand the species. Producers show an interest in strengthening the supply chain of cultivated pirarucu. The slaughterhouses and consumers who want the most regular supply, and the producers of input realize that this is an important market for national zootechnical activity.

In any case, there is a market for premium pirarucu, and it is well known that there is a demand for superior quality fish, and pirarucu has several characteristics valued by the consumer. Only then will the product's potential (intrinsic and extrinsic values) be better used. It became clear that premium pirarucu is not only a strategic alternative for the competitiveness of national fish, but, perhaps, it is the only possibility for the cultivated pirarucu supply chain, since it competes for quality and not for price.

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