ORGANIZED BY

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# COMMERCIAL DYNAMICS OF AMAZONIAN SPECIES

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## General Introduction

Mangroves in the Amazon region are essential coastal ecosystems, distinct and of great ecological importance. They are mainly located along the northern coast of Brazil, extending from the state of Maranhão to Amapá. These mangroves are vital for protecting the coastline, preserving biodiversity, and sustaining local communities. They serve as breeding grounds for numerous marine species and provide refuge for a diverse range of plant and animal species, including fish, birds, crustaceans, and mollusks. Unfortunately, mangroves are under threat from deforestation, pollution, and coastal development (Bernardino *et al*., 2024).

Due to the economic value of many of these species, it is important to protect mangrove forests from degradation, overexploitation, and pollution for the benefit of wildlife and human populations. Several species are at risk due to environmental changes (Ferreira et al., 2022; Checon et al., 2023). The coastal region of Pará is part of the second-largest continuous mangrove area in the world. Human activities in this mangrove ecosystem revolve around essential natural resources, including the turu (*Teredo* sp.) and the mangrove crab (*Ucides cordatus*), which provide subsistence or monetary benefits to the local rural population (Saint-Paul, 2006; Boulhosa *et al*., 2021; Souza and Vidal, 2024). The importance of these resources for rural families increases as one moves away from urban centers (Saint-Paul, 2006).

Turu or Teredo is a bivalve mollusk found in various regions (Carmo-Santos *et al*., 2023), including the Amazon (Saint-Paul, 2006; Boulhosa *et al*., 2021; Souza and Vidal, 2024), and belongs to the family Teredinidae (Müller and Lana, 1986). It has a long, gelatinous body that resembles a worm (Müller and Lana, 1986). This mollusk is commonly found in mangrove regions such as Pará (Filho *et al*., 2008). It is known for its ability to live in submerged wood, using denticles on its head to create tunnels in decaying mangrove logs (Carmo-Santos *et al*., 2023). These organisms are rich in calcium and iron and are considered a delicacy in certain areas of the Amazon, especially on Marajó Island, where they are enjoyed raw or cooked (Saint-Paul, 2006) and are believed to have aphrodisiac properties (Boulhosa *et al*., 2021).

Likewise, the mangrove crab (*Ucides cordatus*) is a highly valued crustacean in Brazil (Alves *et al*., 2003; Legat *et al*., 2006; Silva *et al*., 2017; Gonçalves *et al*., 2022), playing a significant role in the economy by generating income and employment for communities dependent on its fishery (Legat *et al*., 2006; Silva *et al*., 2017; Oliveira and Fernandes, 2024). Its consumption is a popular feature of Northeastern cuisine, supporting local bars and themed restaurants that attract tourists.

For example, Legat *et al*. (2006) reported that the mangrove crab was intensively exploited in the Parnaíba River Delta region. Overfishing was reported as a concern. At the time, the catch per unit effort was estimated between 14.6 and 22.6 crabs per fisherman per day, with a total monthly catch estimated between 1,314,000 and 2,034,000 crabs, amounting to approximately 21 million crabs harvested annually. On the other hand, Alves *et al*. (2003) reported that mangrove crab collectors in Paraíba faced poverty, a lack of connection to education, and limited access to healthcare. Despite these hardships, they demonstrate deep respect for the mangroves. The monitoring of mangroves becomes necessary for conservation efforts, where the monitoring of the Uçá crab is essential for the conservation of these habitats (Gonçalves *et al*., 2022). The Uçá crab is an important resource for the people who depend on the mangroves in Pará, and extractivists recognize that the size of the Uçá crab is a key factor for commercialization (Oliveira and Fernandes, 2024), in which the crabs are sold whole by fishermen and traders or manually processed for meat extraction.

As important as mangroves, the Amazon Basin is the largest watershed in the world and a unique ecosystem for biodiversity on a global scale. This expansive region includes a variety of aquatic and terrestrial habitats, providing a home for numerous species, many of which are exclusive to the area and play essential roles in maintaining ecological balance (Duponchelle *et al*., 2021). One of these species is *Lithodoras dorsalis*, commonly known as bacu-pedra (Barthem and Fabré, 2004), a catfish belonging to the Doradidae family, native to Amazonian rivers. The bacu-pedra is the only species in the Doradidae family with a body covered by bony plates. With its detritivorous diet, the bacu-pedra aids in the decomposition of organic matter on the riverbed (Barbosa and Montag, 2017), contributing to nutrient recycling and ensuring that water quality is preserved.

When young, they have lateral plates typical of the family, gradually acquiring additional plates as they grow. In the Marajó Bay, individuals ranged from 14.31 to 47 cm in length, with their diet primarily based on plant items such as filamentous algae (35.57%), leaves (27.36%), and fruits (22.77%). They also consume mussels (4.12%), detritus (5.26%), and even human waste (3.44%), demonstrating their opportunistic feeding behavior. Although they are mainly herbivorous, they exhibit an omnivorous and opportunistic nature (Filgueiras and Barthem, 1996). On the other hand, in the Amazon estuary region, juvenile *L. dorsalis* were characterized as herbivorous, with a preference for fruits and seeds, including açaí (*Euterpe oleracea*), aninga-açu (*Montrichardia linifera*), and buriti (*Mauritia flexuosa*). Stomach content analysis revealed a potential role in the dispersal of açaí seeds in the region. As fish grow, they consume more fruits and seeds, suggesting a role in the colonization and dispersial of plant species through a process called ichthyochory (Barbosa, 2012).

Fresh fish has a short shelf life due to biochemical changes that occur shortly after fishing or capture (Franceschelli *et al*., 2021; Rao *et al*., 2023; Sari *et al*., 2024; Luqmana *et al*., 2024). Considering that the way harvesting and slaughtering are carried out has a direct impact on product quality (Chicrala and Santos, 2013), correct storage and transportation of fish to consumers in good quality must be emphasized (Luqmana *et al*., 2024). These biochemical changes not only spoil the fish but also affect its flavor, texture, and appearance (Babalola, 2021; Sari *et al*., 2024). Thus, over the years, various non-mechanized artisanal techniques, such as sun drying, air drying, and brining, have been developed to improve processing efficiency and prevent fish deterioration (Rao *et al*., 2024).

On the other hand, highly mechanized and automated post-harvest technologies, which require controlled settings, are essential for reducing global losses in the fisheries sector (Babalola, 2021; Rao *et al*., 2024), including aquaculture (Chicrala and Santos, 2013). These technologies can significantly impact workers' livelihoods (Rao *et al*., 2024) as well as fish quality (Sari *et al*., 2024). Optimal environmental conditions contribute to cleaner fish storage, minimizing contamination and damage (Sari *et al*., 2024). However, consumer and fisher awareness and understanding of fish quality ensure superior fish quality (Franceschelli *et al*., 2021; Luqmana *et al*., 2024; Sari *et al*., 2024).

For example, in a study by Sari *et al*. (2024), researchers examined the post-fishing practices of fishermen in East Java. They found that although most fishermen used ice to preserve their catch, the amount of ice used was inadequate. The fishermen rationalized this by explaining that they were fishing only for a short period. Additionally, fish consumers believed that the quality of chilled fish was associated with it being old or having been caught several days earlier.

In summary, proper fish processing is essential for public health, economic viability, and environmental sustainability. It ensures that the food consumers eat is safe, nutritious, and environmentally responsible.

**Summary**

1

# Commercialization dynamics of turu *Teredo* sp.: Tradition and economy in the Atlantic Amazon

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**Summary**

This chapter examines the commercialization of *Teredo* sp. (Turu), a mollusk found in mangrove areas, in the municipality of Vigia, Pará, Brazil. It highlights the social, economic, and cultural significance of Turu to local communities, especially artisanal fishermen and crabbers. The study was conducted over the course of 2023, focusing on sales patterns and consumer perceptions. Results show that Turu is sold in two main categories, clean and dirty, with seasonal demand spikes during events like Carnival and Círio. Most consumers buy it regularly, with a majority consuming it raw, often paired with typical ingredients from Pará cuisine. The mollusk is valued not only for its taste but also for its nutritional and medicinal properties, such as its potential to prevent anemia and tuberculosis. Turu contributes significantly to the income of local communities, supplementing earnings by 20-30%. However, more research is needed to explore its full economic impact, consumer behavior, and the seasonal variations in demand. The study suggests further in-depth analysis to better understand Turu's role in the local economy and food culture.

**Keywords:** *Teredo*; mollusk commercialization; food culture; artisanal fishing.

**Introduction**

The term "fish" refers to fish, crustaceans, mollusks, and any other aquatic organisms with economic value. In this regard, the Industrial Inspection Regulation for Animal-Origin Products (RIISPOA) defines fish, crustaceans, mollusks, amphibians, reptiles, echinoderms, and other aquatic animals as products intended for human consumption, this group includes products meant for direct consumption that have undergone any preservation process (other than ice application) or methods with similar effects, kept at temperatures close to melting ice, except for those sold alive (Brazil, 2017).

*Teredo* sp., commonly known as "Turu," is a bivalve mollusk belonging to the Teredinidae family. These organisms are known as "mangrove termites" and are found in mangrove areas, inhabiting decayed logs (Borges *et al*., 2014). According to ICMBio (2018), turus are sessile animals that remain permanently attached to the surface of a substrate or organism. They can be found in brackish waters, colonizing logs during their larval stage and feeding on wood substrate and plankton (Turner, 1966; Antonio, 2018). The coastal ecosystem provides a favorable habitat for these mollusks (Sinyo *et al*., 2020). Turu possesses a small shell located on its head, which it uses to bore into wooden logs (Appelqvist and Havenhand, 2016). These mollusks harbor symbiotic bacteria that aid in cellulose degradation (Elshahawi *et al*., 2013), making them the primary consumers of wood, including roots and stems found in mangrove systems (Macintosh *et al*., 2020). Because of this, mangrove regions are of utmost importance to populations that rely on their resources (Friess *et al*., 2019).

The state of Pará has a rich and diverse culinary heritage that can be explored to generate benefits for traditional communities and artisanal fishers, thereby creating a source of income (Oliveira and Almeida Kato, 2015). Turu is an integral part of the cuisine of many people in Pará. This delicacy, extracted from decayed logs in mangrove areas, is often seasoned or consumed raw (Santos and Pascoal, 2013). These mollusks, found in decomposing wood in mangrove areas, are harvested by local populations (Souza *et al*., 2018; Willer and Aldridge, 2020).

The municipality of Vigia, located in the Salgado region, is the second-largest fishing landing hub, receiving a great diversity of seafood (Batista *et al*., 2020). Vigia has easy access to the Atlantic Ocean, which favors the municipality in developing a robust industrial fishing sector (Júnior *et al*., 2021). Fishing is a highly relevant economic activity, reflecting social and environmental relationships (Zacardi, 2015). The harvesting of turu in mangrove areas is a subsistence activity and a source of income (Lougon, 2015). Vigia is one of the oldest municipalities in the state of Pará, a region rich in natural resources, with a strong industrial fishing sector and a well-established artisanal

fishery (Batista *et al*., 2020). However, there are no documented studies on the commercialization of turu. This mollusk holds significant cultural and commercial importance for traditional communities. Therefore, the objective of this study is to highlight the social relevance and characterize the commercial and economic aspects of turu trade in the municipality of Vigia.

## Material and Methods

The municipality of Vigia is located in the northeastern mesoregion of the State of Pará, in the Salgado Paraense microregion, 103 km away from the capital, Belém. It has a territorial area of 401.589 km² and an estimated population of 50,832 inhabitants (IBGE, 2022).

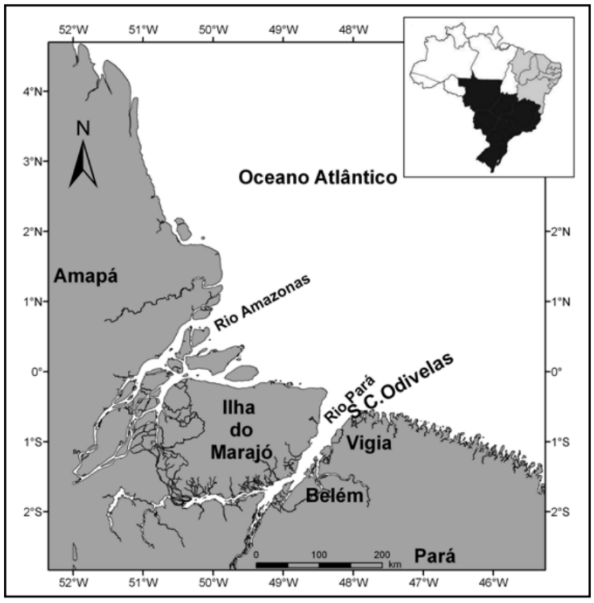


**Figure 1**. Geographical Location of the Municipality of Vigia, northeastern State of Pará. Source: Mourão *et al*. (2007).

The data collection took place twice a month from January to December 2023 in the municipality of Vigia, Pará. During the study period, the quantity (liters) and the average price (US$) of turus sold to the local population were observed.

To assess consumer perception, the study employed a qualitative research method, using semi-structured questionnaires to balance structure and flexibility in data collection, combining open and closed questions. This method was chosen because it is widely used in descriptive and exploratory research, allowing for an understanding of participants' opinions, experiences, and perspectives (Ruslin *et al*., 2022).

The aim of this study was to obtain information on the respondents' gender, purchase frequency, consumption methods, and perception of the food’s nutritional value. Additionally, the

participation of interviewees at sales points was ensured through the Free and Informed Consent Form (TCLE).

**Results and Discussion**

The commercialization of turus in the municipality of Vigia takes place at the local municipal market, where these products are sold in their natural form. They are stored in containers such as styrofoam boxes or 20-liter buckets, as illustrated in fig 3. The predominant unit of measurement used by turu producers is the liter, a measure that is easy to understand and facilitates daily use, as shown in fig 4.

The variation in the quantity of turus sold from January to December 2023, as demonstrated in fig 2, indicates seasonality in the demand for this product. The months of February and September recorded the highest sales, standing out with a sales volume exceeding 200 liters. This observation is associated with the occurrence of Carnival and Círio, periods of high demand that can be explained by the increased movement of people in the region, resulting in higher sales of this specific product. The occurrence of Carnival and Círio contributed to the increased purchase of turus, as these events are known for attracting tourists from other regions of the state and even from other states in the country, which may explain the higher demand for this product during these periods.

The data presented indicate a significant variation in the number of liters sold throughout the study period, totaling 1,772 liters. Data analysis revealed important aspects of turu commercialization patterns in the Northeastern region of Pará. It is needed to highlight that there was lower commercialization in March and July, suggesting possible seasonality or specific factors that affected demand during these periods. Such variation may be related to climatic conditions, seasonal changes in consumer behavior, or even logistical and distribution issues. Additionally, when analyzing these data, it is essential to consider the overall market context and external factors that may influence the commercialization of turus. The data provided demonstrate commercialization patterns over time and suggest areas of interest for a deeper analysis of demand determinants and the most effective commercial strategies for turus in Northeastern Pará.

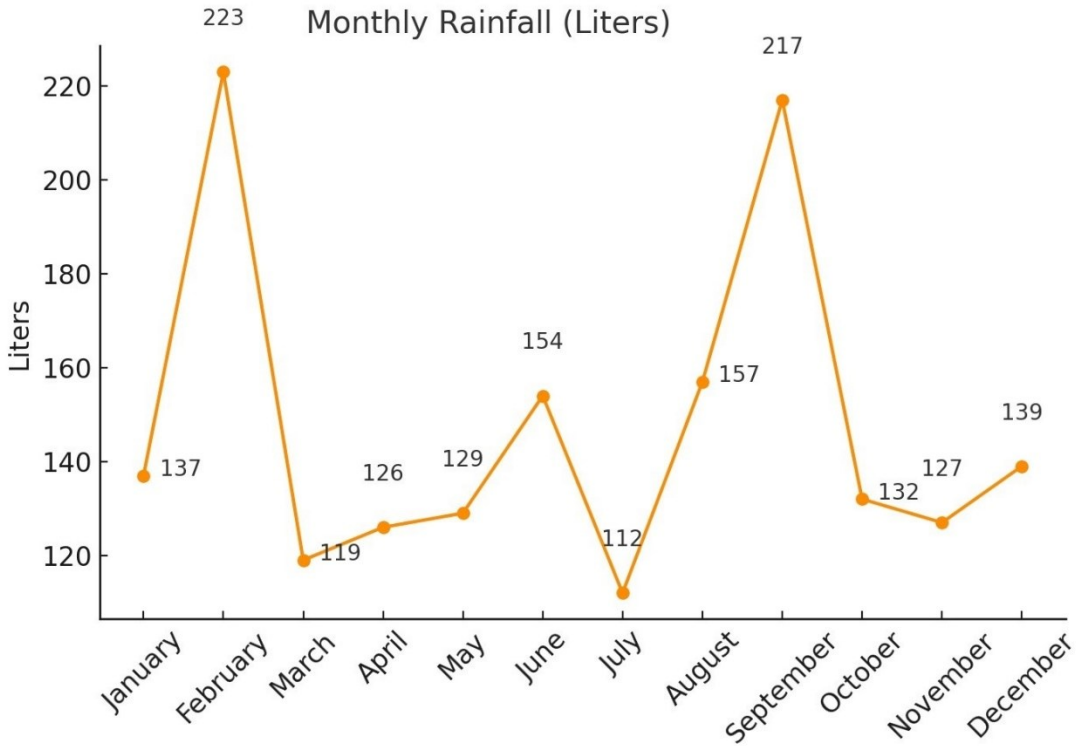


**Figure 2**. Quantity of turu *Teredo* sp. (Liters) sold at the market in the municipality of Vigia, Pará, from January to December 2023.

**Figure 3**. Turu *Teredo* sp. (Liters) stored inside a styrofoam box.
**Source:** Batista (2023).

**Figure 4**. Recipient used as a measure in the commercialization of turu *Teredo* sp.
**Source:** Batista (2023).

To be marketed, the turus are classified in two ways (Fig 5), dirty turus, sold at the price of US$ 2.55 and clean turus at the price of US$ 3.37. The terms clean turus and dirty turus are attributed to the mollusk due to the presence or absence of organic matter in the animal's digestive tract. When the organic matter is removed from the digestive system, the merchant calls it a clean turu, and when this cleaning does not occur, the term used is dirty turu. It is worth noting that the techniques used to remove the organic matter include the use of needles or thorns from citrus trees such as lemon trees, orange trees, or tangerine trees, thus demonstrating a traditional and practical knowledge of the turu collectors. These techniques aim to ensure the hygienic and organoleptic quality of the turus, contributing to their acceptance in the local market. The price differentiation highlights a common commercial practice in market systems where the quality and presentation of the product directly impact its value (Oliveira, 2020). Furthermore, its appreciation in local cuisine shows a cultural and gastronomic connection that can be explored as a competitive advantage in the commercialization of these products (Oliveira and Almeida Kato, 2015). The turu is part of the subsistence, generation, and supplementing income for communities and fishermen, being a mollusk admired in local cuisine (Boulhosa *et al*., 2021). This economic and social importance of the turus is fundamental, promoting sustainable practices, the appreciation of turus as a source of income and food in the region, suggesting potential for local economic development, especially if strategies are adopted that reconcile commercial exploitation with the conservation of natural resources and the strengthening of traditional practices (Lougon, 2015).


**Figure 5**. Turu *Teredo* sp. (Liters) sold at the market in the municipality of Vigia, Pará.
**Source:** Batista (2023).

In relation to the points analyzed, 3 of the 7 commercial points keep the product under refrigeration, ensuring a longer shelf life, thus guaranteeing better quality and durability. Refrigeration is an essential practice for the preservation of perishable foods, as it slows the growth of microorganisms responsible for food deterioration. Low temperatures reduce enzymatic and bacterial activity, thus prolonging the shelf life of products (Miotto, 2012; Odeyemi *et al*., 2023). Even if the food does not show visible signs of deterioration, such as changes in appearance, taste, or odor, the lack of proper handling and preservation can compromise the health of the consumer (Viegas, 2014).

Of the 400 participants, 226 were male and 174 were female, showing a predominance of men among the interviewees. The participants were aged between 18 and 76 years, indicating a diverse sample in terms of age. 158 people stated that they buy the mollusk at least once a month, 112 interviewees said they buy the product twice a month, 52 consumers were identified as frequent buyers, purchasing the product three times a month, and 46 people make purchases every 3 months, indicating a less frequent consumption pattern. 32 of the interviewees stated they are buying the turus for the first time. Most of the interviewees seem to buy the turus regularly, with a significant

percentage purchasing it monthly or even more frequently. The 52 frequent consumers demonstrate a particular interest or recurring need for the product. The presence of 32 interviewees buying the mollusk for the first time may indicate a potential expansion of the customer base, which could be important for marketing strategies and product development (Table 1).

| Regularity of Purchase | Consumers |
|---|---|
| Once a month | 158 |
| Twice a month | 112 |
| Three times a month | 52 |
| Every three months | 46 |
| First time | 32 |
| **Total** | **400** |

**Table 1**. Purchasing frequency of turu *Teredo* sp. by the consumers interviewed in the municipality of Vigia, PA.

The consumption of turus by the interviewees is an interesting topic that can be addressed considering the nutritional, cultural, and medicinal aspects associated with this food. Consumption occurs in two ways: cooked or raw. 392 interviewees consume it raw, while 8 cook it. The raw consumption of this delicacy usually occurs with the use of typical ingredients from Pará cuisine, such as lemon, garlic, salt, and parsley. Not only is the turu itself consumed, but also the broth, a milky substance released by the mollusk (Murrieta *et al*., 1999; Santos and Pascoal, 2013). Emphasizing Pará cuisine, which stands out as one of the richest in Brazil, with unique ingredients and preparations (Oliveira *et al*., 2020).

It is interesting to note that the majority of interviewees (330 out of 400) claimed to be aware of the nutrients present in turus, such as calcium, zinc, potassium, sodium, and iron. These nutrients play crucial roles in several health benefits, such as bone strengthening, blood pressure regulation, and oxygen transport in the blood. Of the 400 interviewees, 367 consume turus due to the health benefits these mollusks offer, particularly highlighting the milky liquid broth released by the mollusk. This broth is associated with healing properties for various diseases, such as anemia and tuberculosis, as reported by Oliveira (2019); Conceição (2023). The broth from Turu *Teredo sp*. is used to prevent anemia and tuberculosis in the Amazon region, and the consumption of these mollusks is linked to medicinal and aphrodisiac effects (Andrade, 1979; Figueiredo, 1994; Neto, 2006; Almeida, 2019). These mollusks have a high protein content, fatty acids, and omega-3, thus providing a high nutritional value (Bispo *et al*., 2004; Paalvast and Van Der Velde, 2013). Ribeiro *et al*. (2023)

highlights the richness of substances that benefit the body, demonstrating a high-quality natural food with easily absorbed nutrients.

**Conclusion**

It is concluded that the commercialization of *Teredo* sp. plays an important role in supplementing the income of traditional communities, such as artisanal fishermen and crabbers, representing a significant portion of their monthly income, estimated between 20% and 30%. However, it is important to note that the traders did not provide specific information about the exact value of their monthly income, only stating the income supplements in percentage form. This aspect highlights the need for future research aimed at obtaining more accurate data on the income of these traders, in order to provide a more detailed and precise analysis of the economic impact of Teredo commercialization in this community.

Considering that *Teredo* sp. is a food appreciated in the local cuisine, further research is necessary to evaluate additional commercial and social aspects. It is suggested that these studies include a larger and more diverse sample to provide more robust insights. Moreover, the data collection period over one year may not capture all seasonal variations in consumption patterns, which could be relevant for a complete understanding of buying habits. Therefore, conducting more comprehensive and in-depth studies could provide a more complete and accurate view of the role of *Teredo sp*. in the local economy and food culture of the traditional communities of Vigia, Pará.

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# 2

# Sensory quality and food safety in the Amazonian context

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**Summary**

The aim of this study was to determine the fillet quality index in the fish processing industry by applying the quality index method to fillets of green weakfish (*Cynoscion virescens*), red snapper (*Lutjanus purpureus*) and red grouper (*Epinephelus morio*). The quality attributes were represented according to the quality index score, where the best quality index was set at 0. Regarding mucus, color, texture, blood and fiber arrangement, the green weakfish fillets had higher quality index than the other species. However, red snapper had a better-quality index in terms of color, red grouper did not show any superior index compared to the other species. This study showed that the quality index method was efficient for assessing the quality of the fillets sold. Moreover, quality control techniques on board the vessel, such as catch handling, rapid processing and storage are necessary to improve fish quality.

**Keywords:** Sensory analysis; fish processing; freshness; quality index method.

## Introduction

In the food industry, quality management plays an important role, directly influencing the safety and quality of products from production to final consumption (Okpala *et al*., 2021). Quality control involves a series of rigorous processes that ensure food meets established standards of hygiene, freshness, nutritional value and safety (Nimbkar *et al*., 2023). In addition, traceability and food authentication are key components in ensuring the integrity and transparency of products throughout the supply chain, allowing for accurate identification of the origin of ingredients and verification of compliance with regulations (Freitas *et al*., 2020). These practices are essential for consumer confidence and the prevention of food fraud.

Among the evaluation criteria, freshness can be evaluated by its taste and smell, together with hygiene quality, which is measured by the consumer's perception of the odor, appearance and texture of food (Bernardo *et al*., 2020). Consumers are increasingly concerned about the origin and nutritional quality of products, ease of access to good quality products and simplicity of preparation (Silva Maciel *et al*., 2018; Petrescu *et al*., 2019).

On this view, the composition of vitamins, minerals, fiber and macronutrients that make up the nutritional quality of the product, as well as the taste, are determining factors in the product's acceptance on the market (Pereira *et al*., 2023). These parameters are fundamental to ensuring that food not only meets dietary needs, but also promotes the health and well-being of consumers.

The quality index method is a technique widely used in the sensory classification of fish in the seafood industry, making it possible to assess freshness and predict the remaining shelf life of specific species or products (Paiva *et al*., 2012). This method is used to assess the freshness of fish by means of smell, texture, appearance, blood, mucus and muscle fibers (Amaral and Freitas, 2013). Quality index method is essential in the seafood industry as it helps determine the quality of products, ensuring that only fresh and safe fish reach the end consumer (Freitas *et al*., 2021).

Given the potential increase in fish processing in the Amazon region, and by the fact that fish fillets possess significant economic value and enjoy widespread consumer acceptance, sensory evaluations throughout the production chain must be needed. This is important to guarantee the nutritional and hygienic quality of the product (Ghani Kuvei *et al*., 2019).

The aim of this study was to evaluate the variation in the quality index of fillets during processing, as well as to investigate the relationship between processing conditions (temperature, storage time, processing methods) and the quality index of fish of Amazonian origin.

**Material and Methods**

One hundred fifty commercial fillet samples were analyzed, equally distributed between green weakfish (*Cynoscion virescens*), red grouper (*Epinephelus morio*), and red snapper (*Lutjanus purpureus*), with fifty samples of each species. Fishing takes place along the coast of the state of Pará, extending to the coast of the state of Amapá, as illustrated in (Fig. 1). The starting point is in the municipality of Bragança and continues to the coastal region of the state of Amapá, covering a catch area that extends up to 200 nautical miles from the Brazilian coast. The analysis was carried out in a fish processing industry located in the municipality of Bragança, Pará. The quality index method was used, as described by Paiva Soares and Gonçalves (2012) and Bonilla *et al*., (2007).

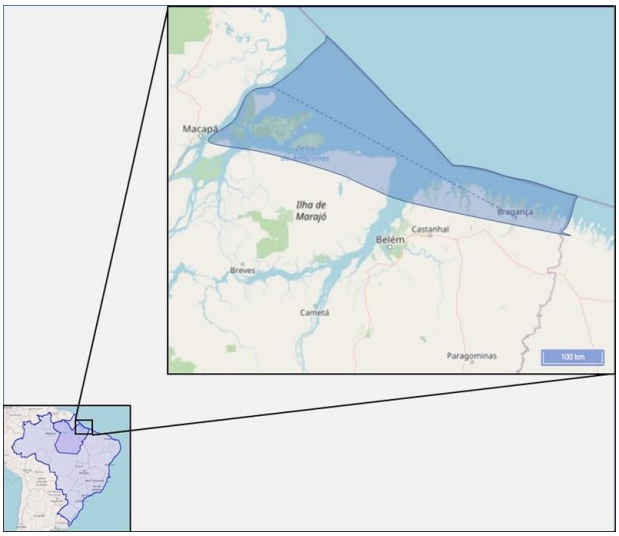


**Figure 1**. Fishing area along the coastlines of Pará and Amapá.

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The ideal quality index was set at 0, indicating that a higher score corresponds to a lower quality fillet. Principal Component Analysis was constructed using the averages of the quality index, six sensory attributes were evaluated using the quality index method.

The quality index were submitted to One-Way Analysis of Variance (ANOVA), where the independent factor (type of species) was compared with the dependent factors, i.e. each parameter analyzed (Table 1) and the overall index obtained. These analyses were performed using Statistica 7.0 software (STATSOFT, 2007). When ANOVA indicated significance, Tukey's post-hoc test was applied to identify which species showed significant differences in relation to the parameters analyzed. In addition, principal component analysis was carried out as a method of multivariate

analysis, with the aim of examining the interrelationships between the dependent and independent variables, as well as visualizing dimensions related to each other. Principal component analysis was carried out using Past 4.03 software (Hammer and Harper, 2001).

**Results and Discussion**

The quality attributes were evaluated based on the quality index score, which ranges from 0 to 2, except for the odor and texture parameters, which range from 0 to 3, resulting in a total of 0 to 14 points. The results indicated that the principal component analysis 1 explained the most variation, accounting for 57.54% of the quality attributes, while the principal component analysis 2 explained 42.46%. Five of the six quality parameters showed the highest correlation with red grouper, while red snapper only showed a correlation with one quality parameter. The principal component analysis for green weakfish showed that the quality attributes were closer to zero, thus indicating better fillet quality compared to the other species (Fig. 2).

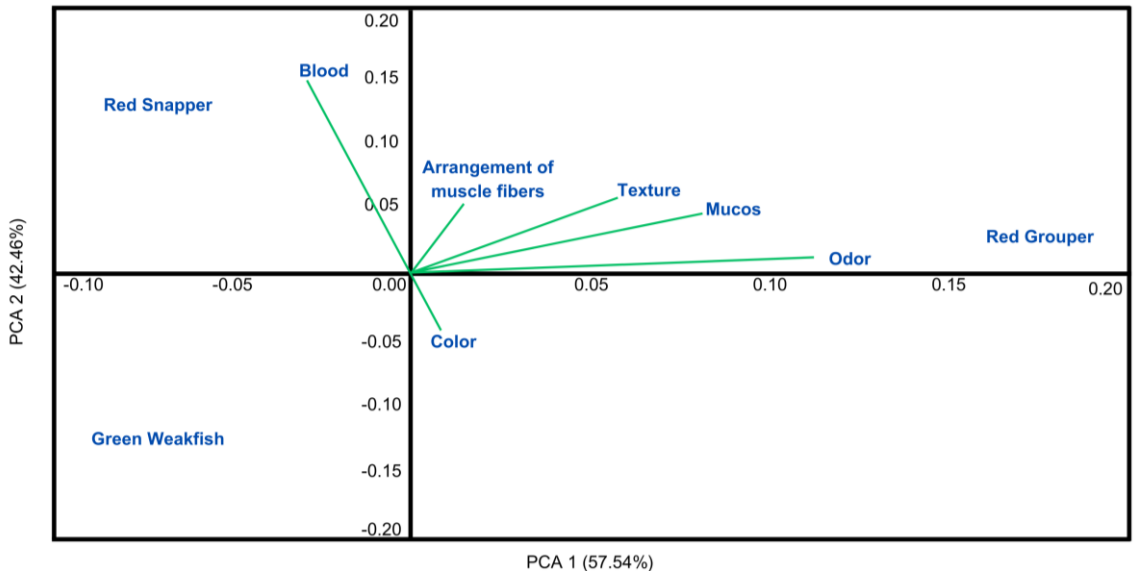


**Figure 2**. Principal component analysis for evaluating the quality of fillet samples of green weakfish (*Cynoscion virescens*), red grouper (*Epinephelus morio*) and red snapper (*Lutjanus purpureus*) species.

It was observed that the quality index found in green weakfish fillets, related to the parameter's mucus, color, texture, blood and fiber arrangement, were higher than those of the other species evaluated. However, red snapper had a higher quality index specifically in relation to color. The red grouper did not show any superior index compared to the other species. There was a

significant difference ($p < 0.05$) between the species for the sensory attributes odor and blood evaluated in this study (Fig. 3).

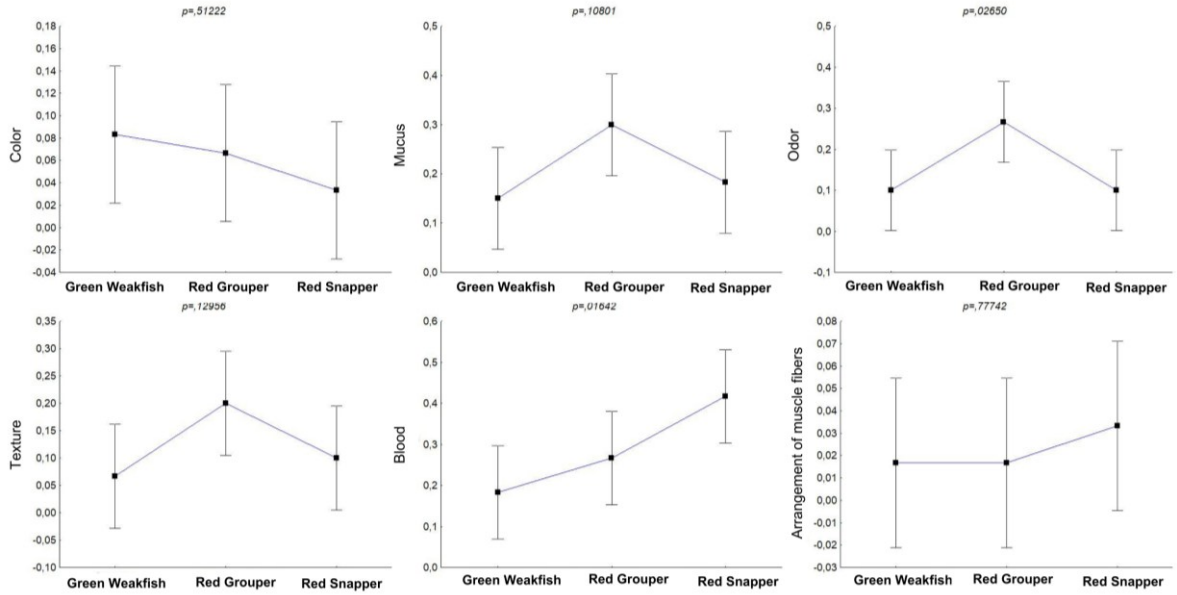


**Figure 3**. Sensory attributes used to assess the quality of fillet samples of green weakfish (*Cynoscion virescens*), red grouper (*Epinephelus morio*) and red snapper (*Lutjanus purpureus*) species.

The attributes evaluated using the quality index method indicated that the green weakfish fillet had the best quality index compared to the red snapper and red grouper. However, none of the species reached a quality index equal to 14, showing that the fillets of the species analyzed can be within the acceptable quality range (Fig. 4).

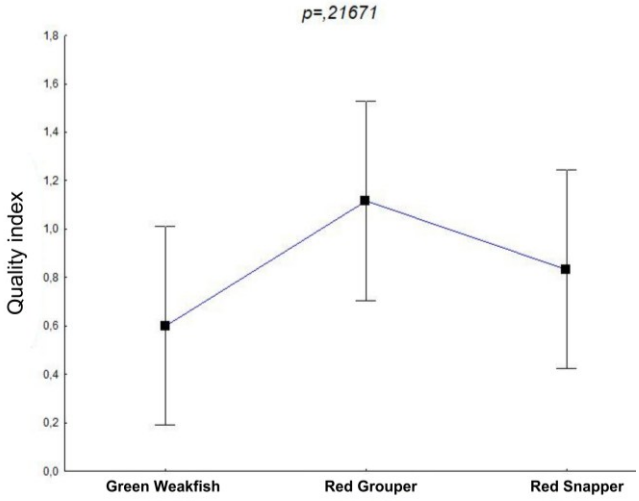

**Figure 4**. Quality index of fillet samples from the species green weakfish (*Cynoscion virescens*), red grouper (*Epinephelus morio*), and red snapper (*Lutjanus purpureus*).

To assess the quality of the fillets, a quality spreadsheet was used based on the criteria categorized with the quality index, with the following classifications: excellent (0-3), good (4-7), fair (8-10) and rejectable (11-14). As presented by Batista *et al*. (2023), all the fillets analyzed were found to be within the acceptable quality index (Table 1).

**Table 1**. Quality attributes of fish fillets.

| Species | Excellent (0-3) | Good (4-7) | Fair (8-10) | Rejectable (11-14) |
|---|---|---|---|---|
| *Cynoscion virescens* | 45 | 5 | 0 | 0 |
| *Epinephelus morio* | 43 | 7 | 0 | 0 |
| *Lutjanus purpureus* | 46 | 4 | 0 | 0 |

Sensory methods are fundamental for calculating a quality index, allowing the quality and freshness of fish to be properly assessed and determined (Britto *et al*., 2007). In order to determine the freshness of a fish, the visual and olfactory senses are important in the application of the quality index, where a demerit score is applied; the lower the score, the fresher the fish is (Nunes *et al*., 2007). In a study on the shelf life of Nile tilapia fillets (*Oreochromis niloticus*), Paiva Soares and Gonçalves (2012) used a quality index method that classified 6 different parameters, with a maximum score of 14. In the work of Bonilla *et al*. (2007) with Atlantic cod (*Gadus morhua*), 8 parameters were identified, resulting in a maximum score of 18. In a similar study conducted by Sveinsdóttir *et al*. (2002), Atlantic salmon (*Salmo salar*) was evaluated with 11 parameters, with a maximum score of 24.

Sensory perceptions play a key role in determining significant changes in fish musculature, thus promoting food safety and quality (Vieira, 2022). Paiva Soares and Gonçalves (2012) observed that fish musculature has an intrinsic relationship between its characteristics, where different muscle colorations correlate with the different species of fish from which the fillets come. This shows that muscle characteristics vary according to the species analyzed and the parameters observed. Costa *et al*. (2013), in their study on assessing the freshness of fish, highlighted the importance of analyzing appearance and smell, showing that quality and freshness are determined by sensory changes that alter the color, texture and smell of the fish.

According to Batista *et al*. (2023), the parameters analyzed showed significant variation, especially regarding the coney (*Cephalopholis fulva*), where attributes such as mucus, smell, texture and fiber arrangement showed greater changes compared to other species and their respective parameters and characteristics.

**Conclusion**

The results indicate that the quality index method is an effective tool for assessing fillet quality, showing that no fillet analyzed was below the established quality standards. However, the implementation of more efficient quality control techniques such as catch handling, rapid processing and storage are essential to guarantee the quality of the fillets, highlighting the need for continuous improvement.

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3

# Bacu fishing, *Lithodoras dorsalis* (Siluriformes: Doradidae) in Pará, Northern Brazil: Economic relevance and fishing tradition

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**Summary**

This study investigated the economic and cultural importance of the siluriform bacu fish *Lithodoras dorsalis* (Doradidae) in the municipality of Vigia, Pará, northern Brazil. The research analyzed the commercialization of the fish, highlighting its relevance for artisanal fishing and cultural events, such as the Bacu Festival. Data were collected between April and December 2024, using interviews with fishermen and traders, in addition to statistical analysis. The results indicate that the demand for bacu is constant, with seasonal peaks driven by environmental and cultural factors. Commercialization occurs mainly in the form of whole fish and fillets, with price differences due to processing. Regular consumption reflects the importance of bacu in the local diet, while the festival drives its economic appreciation. The research highlights the need for sustainable management to ensure the preservation of the species and the economic stability of the fishing community.

**Key words**: Artisanal fishing, Marketing, Seasonality of consumption, Bacu Festival

## Introduction

Aquaculture has emerged as a promising alternative for the sustainable production of animal protein, meeting the growing global demand for food (FAO, 2024). The siluriform fish of the Doradidae family, the bacu *Lithodoras dorsalis* (Valenciennes, 1840), native to the Amazon basin to French Guiana, stands out due to its economic potential and its favorable biological characteristics. Originating from the Amazon basin, this fish is known for its robustness, fast growth rate and high adaptability to different environmental conditions (Whittaker, 2014). With an important role in seed dispersal, it is an example of how interactions between aquatic and terrestrial species are essential for the ecology of the Amazon basin (Barbosa *et al*., 2012). This process not only benefits floodplain vegetation but also sustains the biodiversity and resilience of the Amazon ecosystem. The species is adapted to the variable conditions of the Amazonian environment, being able to survive in both clear and murky waters, common during seasonal floods. Understanding and conserving these interactions are fundamental for the preservation of the Amazon and its ecological processes (Santos and Santos, 2005).

The local culture includes the “Bacu Festival”, a traditional event held in the city of Vigia, in the state of Pará, Brazil. It takes place on the third weekend after Easter (Saturday and Sunday) on the Arapiranga Waterfront, on the Açaí River, where a sport fishing tournament for bacu (the fish that gives the event its name) takes place. There are prizes for catches, including the largest, medium and smallest bacu, as well as the “panemão”, which does not catch any. Typical foods are sold and the Baile da Saudade takes place on the Friday before the sport fishing (Nazaré, 2013). This is a cultural celebration that highlights the importance of the bacu fish, a common species in the region, both in the gastronomy and in the local economy. In addition, there are musical performances, typical dances and other cultural activities that showcase the richness of the local heritage, also valuing regional crafts. The festival attracts not only residents of Vigia, but also tourists from other regions, helping to strengthen the sense of identity and belonging among participants, while boosting tourism and generating income for the city's merchants and residents (Pará, 2012).

This study investigated the economic relevance and cultural importance of the siluriform bacu fish *L. dorsalis* (Doradidae) in the municipality of Vigia, Pará, northern Brazil.

## Material and Methods

The research was conducted in the municipality of Vigia, in northeastern Pará, the microregion of Salgado Paraense, 103 km from the capital Belém, has a territorial unit of 401.589 km² and an

estimated population of 50,832 inhabitants (IBGE, 2022). A region with a strong fishing tradition and known for the bacu festival, a cultural event that highlights the importance of the species for the local economy. Data collection took place between April and December 2024, covering different seasonal periods to assess variations in the availability and commercialization of bacu.

The semi-structured interview methodology was adapted from Ruslin *et al*. (2022). Data were obtained through structured interviews with local fishermen and traders to understand the capture practices, commercialization and seasonality of the species. Direct observations during the "Bacu festival", recording information about sport fishing and the cultural relevance of the species in the community. Secondary data collection in agencies such as the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) and the State of Pará Tourism Secretariat (SETUR-PA).

The data were analyzed using descriptive statistics, as follows: Calculation of means and standard deviations to assess variations in the catch and price of the species throughout the year. Content analysis to categorize the perceptions of fishermen and consumers about the sustainability and economic importance of bacu. Participants signed an informed consent form (ICF), ensuring confidentiality of information. All interviews and recordings were previously authorized, respecting ethical research standards.

The research focused on the commercialization and sociocultural relevance of Bacu only in Vigia, without covering other locations. In addition, climatic and economic factors may have influenced the data collected.

**Results and Discussion**

In the municipality of Vigia, the commercialization of bacu is based on artisanal fishing, with sales primarily intended for local consumption and cultural events, such as the Bacu Festival. It was observed that the price of a bundle containing seven fish sold along the municipal waterfront is US$ 3.14 (Fig 1). Additionally, the price of filleted fish per kilogram is US$ 4.36 (Fig. 2).

**Figure 1**. Bacu *Lithodoras dorsalis* traded on the shore of the municipality of Vigia, Pará. Source: Batista (2024).

**Figure 2**. Bacu fillet (*Lithodoras dorsalis*) sold on the waterfront of Vigia, Pará. Source: Batista (2024).

It was observed that 2,551 "units" of bacu were traded between April and December of 2024. Additionally, a seasonal variation was noted, influenced by environmental factors and regional demand. April recorded the highest sales volume, with 498 units sold, while July had the lowest volume, with 186 units traded (Fig 3).

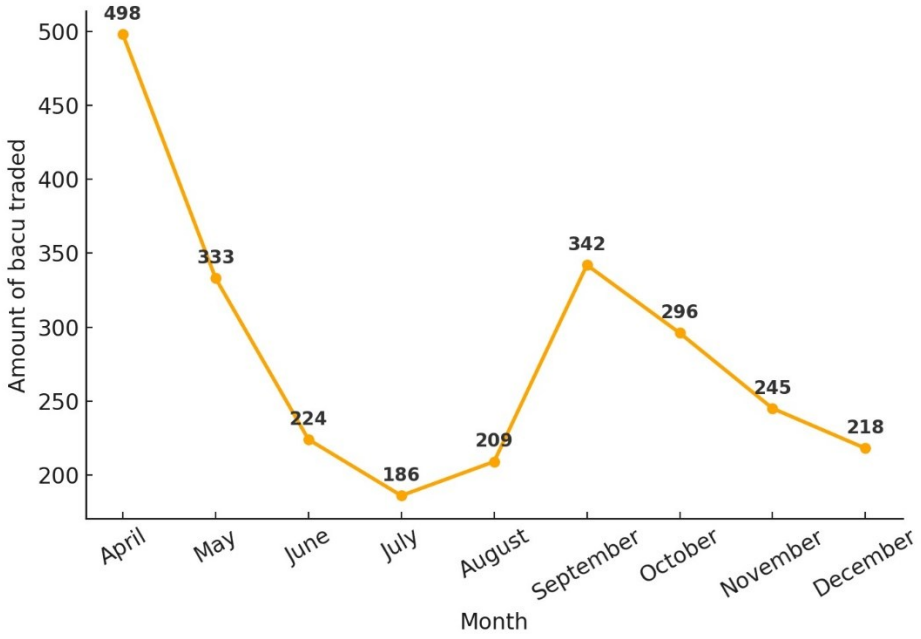


**Figure 3**. Quantity of bacu *Lithodoras dorsalis* (units) traded at the market in the municipality of Vigia/Pará from April to December 2024.

However, consumer purchasing patterns indicate a constant and regular demand. Among the 267 respondents, 142 reported purchasing the fish at least once a month, highlighting frequent consumption. Another 88 consumers buy it twice a month, reinforcing the economic importance of *bacu* in their diet. Additionally, 30 consumers reported weekly consumption, indicating a strong presence of *bacu* in some families' diets. Only 7 consumers stated that they purchase the fish only during festive periods, usually around the *bacu* festival, when both supply and demand increase (Fig 4).

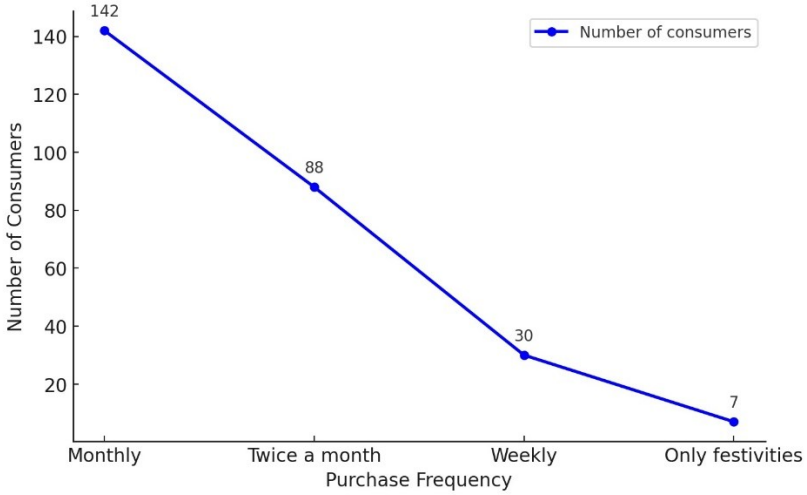


**Figure 4**. Number of consumers interviewed at the market in the municipality of Vigia, Pará, from April to December 2024.

The commercialization of bacu in Vigia is deeply linked to artisanal fishing practices, reflecting the local population's dependence on fishing for subsistence. The municipality ranks second in fish capture in the state of Pará, exhibiting a diverse range of fishing techniques and a strong community structure among fishers (Mourão *et al*., 2007; Pereira da Silva *et al*., 2022).

The price disparity between whole fish and fillets can be attributed to various factors, including processing costs and market valuation. A batch of seven fish is sold for US$ 3.14, while fillets reach a higher price of US$ 4.36/kg. This difference highlights the economic dynamics of the market, as prices may be associated with additional processing costs, including filleting, storage, and packaging, as well as the higher market valuation of processed products (Tsikliras and Polymeros, 2014; Nakandala, Lau and Zhang, 2021; Kurniawan, 2023).

The seasonal variation observed in sales, with peaks in April (498 units) and July (186 units), underscores the significant impact of environmental factors and demand fluctuations. This pattern can be attributed to multiple influences, including climatic conditions, cultural events, and consumer behavior, which are essential for understanding the dynamics of seasonal demand (Linsenmeier, 2024; Hutsal and Stoliar, 2024). The availability of bacu is influenced by several ecological factors, including migratory patterns, hydrological cycles, and weather conditions, which collectively affect its capture. Moreover, the demand for bacu may fluctuate due to cultural events and festivities that drive increased consumption. The following sections detail these aspects (Silva, 2008; Quaintenne, 2010; Michelin, Ceron and Santana, 2020).

The observed consumer behavior highlights a significant trend toward local food consumption, particularly fish, with a notable purchase frequency among interviewed individuals (Litavniece *et al*., 2017). This consistent demand reflects a broader shift in consumer preferences toward local food, influenced by various factors that enhance the perceived value of such products (Banerjee and Quinn, 2022). The weekly consumption reported by 30 respondents underscores its nutritional and gastronomic importance, while the seasonal purchase by seven consumers during festivities highlights the strategic role of the Bacu Festival in driving commercialization (Pará, 2012). This pattern reflects broader trends observed in various contexts where cultural and economic factors influence the consumption and commercialization of local species (Jaramillo Hurtado, 2020). The Bacu Festival, similar to other cultural events, serves as a focal point for increased sales and consumption, driven by traditional practices and market dynamics (Nazaré, 2013; George and Chandrasekar, 2015).

The stability of bacu sales throughout the year is crucial for the economic security of artisanal fishers and the local economy. This stability underscores the importance of sustainable management

policies to ensure the continued exploitation of the species without depleting natural stocks. Effective strategies can enhance resource sustainability and support local livelihoods.

## Conclusion

The commercialization of bacu (*L. dorsalis*) in the municipality of Vigia, northeast Pará demonstrates the strong relationship between artisanal fishing and the local economy. The research showed that the sale of the fish is related to both daily consumption and cultural events, such as the "Bacu Festival", which plays an essential role in increasing demand. The analysis of prices revealed the appreciation of the processed product, reflecting the costs of filleting and storage, while the seasonal variation in sales highlights the influence of environmental factors and consumer behavior on the availability and commercialization of the fish.

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4

# Marketing of uçá crab (*Ucides cordatus*) in Pará, Northern Brazil: Tradition and challenges of the local market

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**Summary**

This study analyzed the commercialization of the uçá crab (*Ucides cordatus*) in Vigia, Pará, Brazil, between April and December 2024. Structured interviews were conducted with 12 merchants and crab collectors, along with questionnaires administered to 267 consumers to assess purchasing patterns, consumption habits, and product perception. Data collection included information on sales volume, average prices, and logistical challenges. A stable market was observed, with sales peaks in April and September, influenced by seasonal factors and religious festivities. Consumption was regular, with most consumers purchasing crabs monthly. The analysis highlighted challenges in the sustainable management of the activity, particularly difficulties in complying with the closed season due to the economic dependence of collectors. The results emphasize the economic and cultural significance of the uçá crab in the region, underscoring the need for effective policies for sustainable management.

**Key words**: Consumption patterns, Sustainable management, Market dynamics, Fisheries management.

## Introduction

The uçá crab (*Ucides cordatus*) is a species found in coastal areas, particularly in mangrove ecosystems (Araujo Cordeiro *et al*., 2024). The species is distributed along the western Atlantic coast, from Florida, in the United States, to Santa Catarina, in southern Brazil (Leite, Rezende and Silva, 2013). Along the Brazilian coast, from Amapá to Santa Catarina, with its southern limit in Laguna (Pinheiro, Souza, Borba, 2015; Pinheiro *et al*., 2024), as we can observe in the figure below.

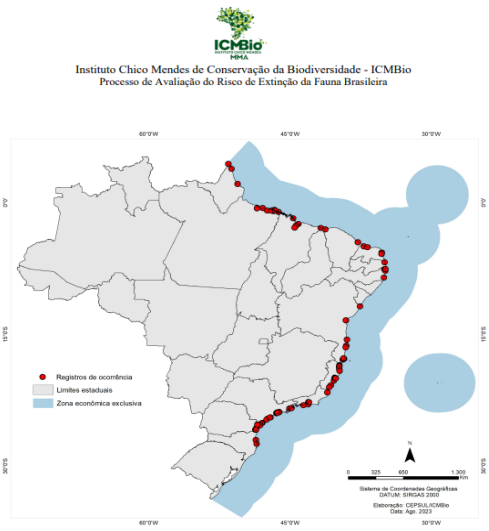


**Figure 1**. Distribution and occurrence areas of the uçá crab along the Brazilian coast. Source: Pinheiro *et al*. (2024).

The uçá crab plays an important role in supporting the socioeconomic activities of coastal communities. Additionally, the species provides a supplementary source of income, being essential for the subsistence of traditional populations (Fogaça *et al*., 2018; Araujo Cordeiro *et al*., 2024). This species holds cultural and economic significance in local gastronomy, being an integral part of traditional dishes, usually prepared in stews and savory dishes, highlighting regional cuisine (Sousa *et al*., 2022).

The practices of capturing, cleaning, cooking, and preparing the uçá crab are deeply rooted in the culture of traditional communities, serving as a means of reinforcing identity and community unity. These activities are generally passed down from generation to generation, emphasizing the importance of ecological understanding of the mangrove ecosystem (Gustavsson and Riley, 2018; Oliveira *et al*., 2019; Costa, 2024). The ecological importance of this species in mangrove ecosystems lies in its crucial role in nutrient cycling, sediment bioturbation, and maintaining the overall health of

these environments (Gao *et al*., 2024).

The crab *U. cordatus* contributes to the decomposition of organic matter, facilitating the availability of nutrients for other organisms in the mangrove ecosystem. Its burrowing behavior aerates the soil, improving the habitat for various microorganisms and promoting plant growth (Souza and Pinheiro, 2021; Spinassé and Tognella, 2024). The relationship between environmental factors and physiological responses in *Ucides cordatus* highlights its role as a significant indicator of environmental health due to its sensitivity to various pollutants, including heavy metals (cadmium, lead, and copper) as well as microplastics (Silva Rocha *et al*., 2020). Studies have observed growth abnormalities in these animals in polluted areas, posing risks not only to the crabs but also to human health through consumption. Additionally, respiratory and osmoregulatory functions may be compromised when adversely affected by microplastics, suggesting that body size and condition can indicate levels of environmental stress (Silva *et al*., 2023; Silva *et al*., 2024).

The uçá crab is captured by crab collectors and sold to the local population and tourists from other parts of the federation. However, despite the high level of commercialization, there are numerous discussions regarding the sustainability of capture methods (Duarte *et al*., 2014). The method allowed by law is "braceamento" (Fig. 2), a capture technique that does not use any tools other than the collectors' arms and hands and is less invasive (Martins, 2024). Some collectors use illegal traps known as 'redinha,' which, although effective, are more harmful, pose environmental risks, and contribute to the intense exploitation of the uçá crab, raising concerns about the sustainability of its capture methods (Duarte *et al*., 2014; Soares *et al*., 2020).

**Figure 2**. Execution of the 'braceamento' technique by the crab catcher in the municipality of Vigia, Pará, Northern Brazil. Source: Albuquerque *et al*. (2022).

The commercialization of uçá crab is an important source of income for traditional communities. The trade takes place in local markets and fairs, where live animals are sold (Sousa *et al*., 2022). The production chain begins with the capture of the animals, followed by transportation in small boats, reaching intermediaries, and then being sold in local markets (Duarte *et al*., 2014). The commercialization of this crustacean promotes essential sustainable practices, ensuring the preservation of the Uçá crab and the associated traditions (Souza *et al*., 2020). The commercialization of Uçá crab is mainly linked to community festivals and religious celebrations, as well as gastronomic festivals held in various coastal cities, highlighting local culture and encouraging tourism (Costa, 2025).

Mangrove regions have great biodiversity, and there is concern regarding overfishing of organisms in these systems, as well as urban expansion in these areas (Friess *et al*., 2024). The removal of the mangrove zone due to construction or environmental modifications causes an imbalance in the food chain, affecting the environment and influencing populations of Uçá crabs, in addition to compromising the livelihoods of communities that directly depend on these resources (Dayal *et al*., 2022). In light of such challenges, it is necessary to implement regulations to ensure the

conservation of mangroves, the establishment of preservation areas, and to promote information and awareness about the closed fishing season (Arfan *et al*., 2024). The inclusion of local communities in environmental education initiatives can contribute to sustainable balance and preservation, as the participation of traditional communities is essential for knowledge exchange regarding the maintenance of biodiversity in the mangrove ecosystem (Ximenes *et al*., 2024).

The uçá crab is a species of great ecological and economic importance, protected by conservation policies, such as the closed season, popularly known as the "andada," which prohibits its capture and commercialization during the reproductive period, allowing populations to recover and maintain sustainable levels (Lima *et al*., 2018). However, despite the environmental significance of this measure, it presents significant challenges for communities that rely on the manual capture of crabs as their main source of income. The lack of interest and misinformation among the population, combined with the socioeconomic implications, results in financial difficulties for these communities during the closed season, including increased unemployment and low income (Mikpon *et al*., 2020; Qin *et al*., 2022).

The closed seasons for the Ucides crab are regulated by specific norms, such as the Interministerial Ordinance MPA/MMA No. 22, of December 30, 2024, which establishes the prohibition dates in the states of Amapá, Pará, Maranhão, Piauí, Ceará, Rio Grande do Norte, and Paraíba: 12/30/2024 to 01/04/2025, 01/13/2025 to 01/18/2025, 01/29/2025 to 02/03/2025, 02/27/2025 to 03/04/2025, and 03/29/2025 to 04/03/2025. In the states of Pernambuco, Alagoas, Sergipe, and Bahia, the established periods are: 12/30/2024 to 01/04/2025, 01/29/2025 to 02/03/2025, 02/27/2025 to 03/04/2025, and 03/29/2025 to 04/03/2025 (MPA, 2024). These dates highlight the scope of conservation measures and reinforce the need for complementary strategies to mitigate the socioeconomic impacts on affected communities, promoting both environmental sustainability and social well-being.

The municipality of Vigia is one of the oldest in the state of Pará, a region known for its natural wealth, as well as a strong industrial fishing industry and a consolidated artisanal fishing sector (Batista *et al*., 2020). In view of this, the aim of this study was to demonstrate the social relevance and characterize the commercial and economic aspects of crab commercialization in the municipality of Vigia.

## Material and Methods

The study was conducted in the municipality of Vigia (00°51’30’’ S 48°08’30’’ W), located in the northeast of the State of Pará, in the Salgado Paraense microregion, 103 km from the capital

Belém, in the North of Brazil. It covers a territorial area of 401.589 km² and has an estimated population of 50,832 inhabitants (IBGE, 2022). Data collection took place four times a month, between April and December 2024, in the municipality of Vigia, Pará. Twelve merchants and crab collectors contributed to this study, providing important information about the commercialization and capture methods.

The data collection was conducted through structured interviews over a period spanning from April to December 2024. No data was collected during the first three months due to the closed season in the state, which occurred from January 12 to 17, 2024, February 10 to 15, 2024, and March 11 to 16, 2024. This period was established by SAP/MAPA Ordinance No. 325, dated September 30, 2020, during which the capture, transport, processing, industrialization, and commercialization of the Uçá crab were prohibited to protect the reproductive cycle of the species (Semas, 2024).

During the data collection period, the quantity marketed per stall, the average price (R$), and the crabs sold to the local population of Viges were observed. In addition, semi-structured questionnaires were applied to 267 consumers to assess the frequency of purchase, as well as the forms of consumption and nutritional value of the food according to the consumers. The data obtained were recorded in a field diary, along with photographic records (when authorized). The interviews took place with the following groups.

Crab collectors: To understand capture practices, seasonality, and challenges related to management and commercialization.

Consumers: To map purchase preferences, consumption frequency, and perceptions about product quality and price.

Besides the collection of secondary data through documents and reports provided by public agencies and research entities, such as the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), the Ministry of Fisheries and Aquaculture (MPA), and the Chico Mendes Institute for Biodiversity Conservation (ICMbio).

The analysis of the interviews and observations was conducted using content analysis techniques, categorizing the information into themes such as: cultural tradition of capture and commercialization, main logistical and market challenges, the perception of the actors involved regarding sustainability and management policies, average price information, capture volumes, and gross profit. These were organized into tables and graphs.

The statistical analysis included the calculation of means, standard deviations, and tests to compare variables between the different periods (high and low season).

It is important to note that the Free and Informed Consent Form (TCLE) was applied to the

interviewees who were at the sales points. All interviews were conducted with the prior consent of the participants, respecting the ethical principles of research. The anonymity of the interviewees was guaranteed, and the data were used exclusively for academic purposes. The research was limited to commercialization in Vigia and did not encompass the analysis of the entire production chain in other regions. Seasonal data may vary due to climatic conditions or legal restrictions not anticipated during the data collection period.

**Results and Discussion**

The production chain of the uçá crab in Vigia is characterized by a strong presence of informal markets, which play a key role in commercialization. During the peak season, average prices ranged from US$ 2.63 to US$ 3.50 per string of 12 units, as shown in figure 3.

**Figure 3**. Crab marketing in a rack on the shoreline of the municipality of Vigia, Pará, Northern Brazil. Source: Batista (2024).

Additionally, over the course of nine months, from April to December, a total of 2.612 crab baskets were sold in the municipal market and along the city's coastline, as recorded in the data collection months. April recorded 352 baskets sold, followed by September, which had the highest sales with 403 baskets. July had the lowest number of baskets sold, with 208, followed by October with 226 baskets. However, even though there is a variation in sales over the months, it is important to note that the total annual sales observed is 2.612 crab baskets sold between April and December

2024. If we consider the total number of crabs sold, which was 31.344, as each basket contains 12 crabs, this indicates a steady demand throughout the year, demonstrating a stable market for sales, as seen in Table 1.

**Table 1**. Quantity of Uçá crabs sold in bundles at the market in the municipality of Vigia, Pará, Northern Brazil, between April and December 2024.

| Monthly quantity of crabs sold in a row | | |
|---|---|---|
| April | May | June |
| 352 | 296 | 338 |
| July | August | September |
| 208 | 268 | 403 |
| October | November | December |
| 226 | 242 | 279 |
| Total number of crabs sold 2.612 | | |

Overall, regularities were observed in the purchasing patterns of crab consumers, highlighting that they tend to buy at specific time intervals. Out of 267 consumers, approximately 137 purchase crabs once a month, demonstrating a constant and regular demand. Those who buy twice a month totaled 95 consumers, also indicating significant demand. A group of 27 consumers was observed to purchase crabs three times a month, suggesting a stronger preference or more intense consumption of the product, likely associated with regular use in recipes or specific occasions. On the other hand, 8 consumers reported purchasing only once every three months, representing a group that consumes crabs mainly during festive periods or special offers when prices are lower than the current market rate. No records were found of first-time buyers, indicating that most consumers are already familiar with the product, highlighting a well-established market with habitual buyers.

Moreover, the interviews revealed that among the respondents, there are concerns about the sustainability of the activity, especially regarding the capture of crabs during their reproductive phase and the lack of adequate enforcement during the closed season (Nascimento *et al*., 2012; Lima *et al*.,

2018). Many gatherers reported difficulties in complying with regulations due to their economic dependence on the activity (Ramos *et al*., 2016).

In the month of September, we observed approximately 403 crab stalls being marketed. This is due to seasonal factors and religious festivities that take place in the municipality, such as the Círio in honor of Our Lady of Nazaré, during which there is an increased demand for crab purchases (Frugoli and Bueno, 2014). During peak months (September with 403 stalls and April with 352 stalls), this increase in supply can be attributed to favorable conditions for capture or changes in consumption patterns. In contrast, July had the lowest number of observed crab stalls, around 208, which can be explained by seasonal variations in crab availability and the school vacation period. During this time, a significant portion of the population travels to the Pará coast and the rural areas of the state, considerably reducing the population in Vigia and the demand for crab purchases (Pinheiro *et al*., 2018; Nascimento *et al*., 2023). Moreover, it is important to highlight that various factors influence the fluctuation of crab commercialization, including crab availability, climatic variations, and aspects related to crab capture (Soares *et al*., 2024). These data assessments are highly relevant for evaluating the dynamics of the crab trade in the municipality of Vigia. They contribute to identifying seasonal patterns and adjusting supply, marketing, and pricing strategies accordingly (Albrecht *et al*., 2021). The results indicate a total of 2.612 stalls marketed over nine months. Such findings contribute to understanding consumption trends and enable more efficient stock management and commercial practices.

Regarding the regularity of purchases, we observed a pattern in monthly consumption, with most consumers opting to buy once a month. This indicates that the product has habitual consumption but does not require frequent purchases, demonstrating a medium-consumption product with a more spaced-out purchase frequency. Those who consume twice a month reinforce the idea of a slightly more frequent product demand, highlighting a search for variety or fresher products on a more regular basis. These data align with the study by Tolon and Elbek (2016), which observed the frequency of seafood consumption, indicating that 25% of respondents consume seafood once a month, while 28% consume it once every two weeks. Those who consume three times a month demonstrate a dedicated and loyal demand, reinforcing the product's importance and leading us to consider strategies to further ensure consumer loyalty. On the other hand, the number of those who purchase every three months is quite low, indicating that these consumers are more occasional or only buy when market prices are lower than usual. However, no presence of new consumers was observed, suggesting that crab consumers are regular and already familiar with the product, which is a positive sign of market stability. Thoriq *et al*. (2025) highlight that those who purchase crabs every three months can only do

so when prices are favorable, indicating the need for pricing strategies to convert these occasional buyers into regular customers. This suggests that the market is consolidated and has a loyal audience, reinforcing the possibility of developing commercialization and marketing strategies to attract less frequent buyers while strengthening regular consumers. The results obtained align with the study by Lima *et al*. (2018), which points out that consumer demand remains high and steady, highlighting its cultural significance. Similarly, Santos *et al*. (2017) also showed that consumers demonstrate significant demand by consuming crabs three times a month.

**Conclusion**

The production chain of the uçá crab in the municipality of Vigia, in northern Brazil, exhibits distinctive characteristics of a well-established informal market, with a stable demand throughout the year. Commercialization is influenced by seasonal factors, such as religious festivities and climatic variations, but maintains a significant volume. The regular consumption by the local population, with most consumers purchasing the product monthly or biweekly, reinforces the cultural and economic relevance of this resource in the region.

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5

# Commercialization of oysters and consumer perception in the municipality of Bragança, Pará.

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**Summary**

The aim of this study was to characterize the commercialization of oysters and consumer perception at the Family Farming Fair (FAF) located in the municipality of Bragança. A variation in quantity and a consistent pattern in oyster prices were observed in 2017, with the highest values recorded in April and November. It was found that consumers lacked information regarding oyster preservation at the time of purchase, their nutritional properties, and the depuration process. Therefore, it is essential to conduct educational interactions through lectures, booklets, and workshops to share fundamental information about oysters and food safety.

**Key words**: Aquaculture, *Crassostrea gasar*, Northeastern Pará, Oyster Farming.

**Introduction**

The global production of mollusks has been gradually increasing in recent decades, with a growing consumption being observed (FAO, 2012; FAO 2018; FAO 2022). In 2020, global exports of bivalve mollusks totaled more than USD 4 billion, representing nearly 3% of the worldwide export value of aquatic organisms (FAO, 2022). The largest production comes from China, where oyster farming has been practiced for approximately 700 years (Lam and Morton, 2003; FAO, 2017).

According to FAO, in 2020, aquaculture production grew by almost 6%, and it is estimated that the production of aquatic organisms will reach over 200 million tons by 2030, showing a 15% growth compared to 2018, when it reached nearly 180 million tons (FAO, 2020).

In Brazil, oyster farming is a profitable activity, and it is not necessary to have advanced technologies to start such a business (Conde *et al*., 2023). The low initial cost and limited use of technology have attracted farmers and fishermen to develop this activity, boosting the increase in oyster production and commercialization (Lavander *et al*., 2013; Tureck *et al*., 2014; Sampaio *et al*., 2019).

According to data from IBGE, the South region is the main producer in the country, with a highlight on the state of Santa Catarina, responsible for 97.9% of the national production, with 10.401.597 tons (IBGE, 2021). It is important to note that in 2017, the cultivation areas and natural banks in the state of Santa Catarina were preventively closed, preventing the removal, commercialization, and consumption of bivalve mollusks (oysters, mussels, scallops) due to the presence of harmful algae found in certain cultivations (CIDASC, 2017).

The emergency measure was in compliance with the regulations of the National Program for Hygienic-Sanitary Control of Bivalve Mollusks (PNCMB), established by the Ministry of Agriculture, Livestock, and Supply (MAPA) and the Ministry of State for Fisheries and Aquaculture (MPA), with the aim of monitoring and supervising the minimum requirements necessary to ensure the safety and quality of food intended for human consumption (MAPA, 2012; CIDASC, 2017).

Data from national production show that the consumption of oysters has been increasing significantly, with a predominance of raw consumption (Barreto *et al*., 2008; Lee *et al*., 2008, FAO, 2012, FAO, 2022). This form of consumption considerably increases the risks of disease transmission to consumers, as oysters are filter-feeding mollusks capable of storing pathogenic microorganisms in their tissues, which are harmful to health (Trombeta and Normande, 2018). Therefore, the application of the depuration process is necessary, as it is the ideal method for controlling microbiological contamination (Rodrick and Schneider, 2003; Lees *et al*., 2010; Rong *et al*., 2014).

The debugging method consists of immersing oysters in tanks with clean water for a certain period of time. Through the natural filtration process of the mollusks, pathogens present in their tissues are eliminated, ensuring the food's safety (Lee *et al*., 2008; Rebouças and Gonçalves, 2014; Trombeta and Normande, 2018). To avoid post-purification contamination of food, it is necessary to take care during handling throughout the production chain, once again preventing food contamination (Ribeiro *et al*., 2016).

In the state of Pará, oyster production is recent, having been practiced for just over a decade (Macedo *et al*., 2016; Sampaio *et al*., 2019), as the first research to assess the possibility of oyster farming in the Northern region of Brazil only occurred between 2001 and 2003 (Sampaio and Boulhosa, 2007; Hoshino, 2009; Macedo *et al*., 2016). With the positive results obtained, the activity began to be practiced in 2006 in five municipalities (seven communities) in northeastern Pará: São Caetano de Odivelas (Pererú de Fátima and Vila Pererú communities); Curuçá (Lauro Sodré and Nazaré do Mocajuba communities); Maracanã (Nazaré do Seco community); Salinópolis (Santo Antônio do Urindeua community); and Augusto Corrêa (Nova Olinda community) (Hoshino, 2009; Brabo *et al*., 2016; Sampaio *et al*., 2019).

In recent years, the state of Pará has seen a significant increase in oyster production, rising from 8.250 tons in 2013 to 53.109 tons in 2021 (IBGE, 2021), ranking 5th in the national oyster production chart, generating US$ 90.547.00 annually (IBGE, 2021). The majority of the state's production comes from the Nova Olinda community, part of the Association of Farmers and Aquaculturists of Nova Olinda (AGROMAR), located in the municipality of Augusto Corrêa, 18 km from the city of Bragança. The oyster production of the community in 2021 was 32.209 tons (IBGE, 2021).

The aim of this study was to characterize the marketing of oysters at the Family Agriculture Fair (FAF) and analyze consumers' perceptions regarding the consumption method and information about oysters. In this way, it contributes to the advancement of the AGROMAR economy and the Bragantina microregion.

## Material and Methods

The municipality of Bragança is located in the northeastern mesoregion of the State of Pará, in the Bragantina microregion (Fig 1), 210 km away from the capital Belém. It has a territorial area of 2,091.930 km² and an estimated population of 123,082 inhabitants (IBGE, 2022).

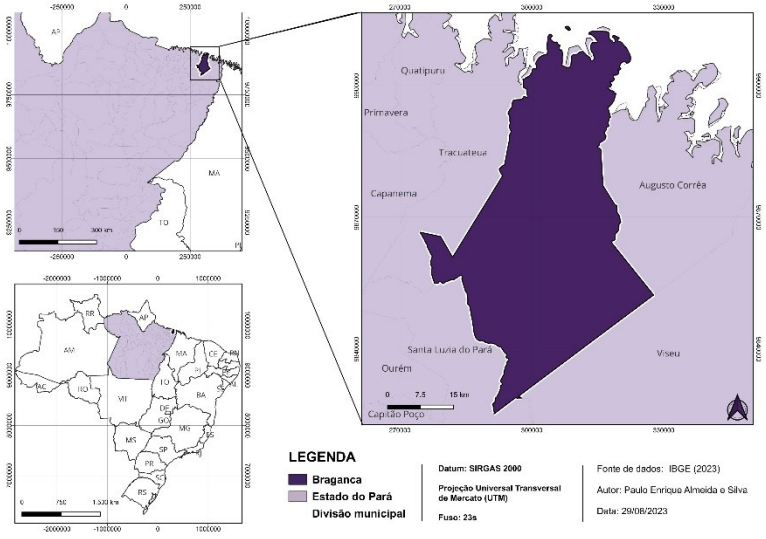


**Figure 1**. Geographical Location of the Municipality of Bragança, Northeast of the State of Pará. Source: Sampaio (2024).

The data collection took place on Saturdays, from February 2017 to February 2018. The quantity (dozens) and the price (US$) of oysters sold to the Bragantina population were recorded.

To analyze consumers' perception of oysters, semi-structured questionnaires were randomly applied, containing open and closed questions, to 50 consumers of both genders. The survey investigated purchasing frequency, consumption methods, product storage practices, perceptions of sustainable farming, the nutritional value of the food, and the oyster depuration process.

## Results and Discussion

In the municipal headquarters, you can find the Family Farming Fair (FAF), created in 2009 as part of an event called the "Cassava Festival," organized by Cáritas Diocesana de Bragança in partnership with the Technical Assistance and Rural Extension Company of the State of Pará (EMATER), the Bragança Rural Workers' Union (STTR), and the Edgar de Souza Cordeiro Agricultural School.

The event brought together several family farmers from different communities to discuss the cassava production chain, culminating in the fair held on July 26, 2009. Currently, the Family Farming Fair (FAF) operates on Saturdays, Sundays, and the eve of holidays from 5:00 AM to 12:00 PM. The main objective of the FAF is to provide small farmers from the Bragantina region with the opportunity to sell their produce at affordable prices directly to consumers. Associated producers pay a weekly fee of US$ 0.85 to help maintain the security and upkeep of the space.

The members of the Association of Farmers and Aquaculturists of Nova Olinda (AGROMAR) joined the Rural Workers' Union of Bragança in 2016 to work at the Family Farming Fair (FAF) with the aim of marketing the oysters produced in the Nova Olinda community.

The commercialization of oysters carried out by AGROMAR in the municipality of Bragança takes place in three ways: through the Family Farming Fair (FAF), via private enterprises (restaurants), and by orders.

At the Family Farming Fair (FAF), sales take place in person, where the consumer goes to the establishment to purchase food directly from the producer. Oysters are sold in their natural form, in dozens (standardized by size) and stored in styrofoam boxes without ice (Conde *et al*., 2023). According to Miotto (2012), the storage container for the product must be refrigerated, respecting the time and temperature to avoid compromising the food's quality.

During the study period, the number of oysters sold at the Family Farming Fair (FAF) varied throughout the months (Table 1). A total of 1.208 dozen oysters were sold, equivalent to 14.496 oysters, with an annual average of 93 dozen. The months of April, June, and November 2017, as well as January 2018, stood out.

**Table 1**. Quantity of oysters (dozens) sold at the Family Farming Fair, Municipality of Bragança, Pará, from February 2017 to February 2018.

| **Quantity of oysters (dozens) sold** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | 2017 | | | | | | | | | | | 2018 | |
| **Month** | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | Jan | Feb |
| **Dozens** | 69 | 52 | 284 | 70 | 44 | 68 | 61 | 69 | 70 | 205 | 86 | 45 | 85 |

The commercialization of oysters obtained in April 2017 accounted for 23.5% of the annual total, a result of the Easter holiday, which indicated a period of higher demand for the product.

Another highlighted month was November 2017, with sales equivalent to 17% of the studied period, a situation that occurred due to the holiday and the celebration of the Círio de Nossa Senhora de Nazaré, a traditional religious event in the city of Bragança.

On the other hand, in June 2017 and January 2018, the lowest sales rates were recorded, corresponding to 3.6% and 3.7%, respectively, of the dozens of oysters sold during the research period. This decrease occurred due to the absence of producers on four weekends, as they depend on

public transportation to travel to the municipality of Bragança, and the access roads were not in good condition for traffic, a situation experienced during the rainy season in the region.

At the Family Agriculture Fair, the selling prices charged by oyster producers (per dozen) vary according to the sizes (Figure 2): baby (60 to 79 mm) is sold for US$ 1.53, medium (80 to 99 mm) for US$ 1.69, and master (over 100 mm) for US$ 2.05.


**Figure 2**. Oyster Classification Meter.
Source: Cordeiro (2018).

It is worth noting that the pricing of a dozen oysters adopted by the Association of Farmers and Aquaculturists of Nova Olinda (AGROMAR) was developed by the Brazilian Service of Support to Micro and Small Enterprises (SEBRAE) in collaboration with the producers, analyzing the annual cost accounting, thus ensuring profitability and preventing losses for the oyster farmers.

The prices used by AGROMAR have pleased oyster consumers in the municipality of Bragança, as 86% (n=43) of the 50 participants in the study responded that the prices charged for a dozen oysters are good, while 14% (n=7) of consumers prefer a lower price. These values demonstrate customer satisfaction with the price, ensuring the success of the product's commercialization. It is worth noting that 96% (n=46) of the interviewees approve of the existence of another oyster sales point in the municipality of Bragança, which could increase the volume sold. Macedo *et al*., (2016) highlight that in the community of Santo Antônio do Urindeua, in the municipality of Salinópolis, Northeast Pará, oysters are sold at prices higher than those of AGROMAR.

Besides selling by the dozen, producers from that region also sell oysters individually, with prices varying according to size: Baby (dozen = US$ 2.05; unit = US$ 0.17); Medium (dozen = US$ 2.55; unit = US$ 0.21); Master (dozen = US$ 2.73; unit = US$ 0.23). It is worth mentioning that of the total 15 producers from AGROMAR, only 3 sell oysters at the FAF. Oysters are the only aquaculture products sold at the Fair, as they are food originating from farming.

The sale of oysters in the municipality of Bragança also takes place through orders made remotely, that is, via instant messaging apps (WhatsApp). This strategy is used by the members of the Association of Farmers and Aquaculturists of Nova Olinda (AGROMAR) by creating a digital group to handle orders and promote interaction between oyster farmers and consumers.

To fulfill the order through this communication channel, the consumer pays a higher amount due to the freight cost for the transportation from the community of Nova Olinda to the municipality of Bragança. According to the rules of the AGROMAR WhatsApp group, for delivery in Bragança, the order must have a minimum quantity of 10 dozen, and the price per dozen decreases as the quantity of oysters increases (Table 2).

**Table 2**. Oyster marketing standards through Orders established by AGROMAR for the municipality of Bragança, Pará, in 2017.

| **Marketing Standards** | | |
|---|---|---|
| **Classification** | **Quantities (Dozens)** | **Value per Dozen (US$)** |
| Baby (60 to 79 mm) | 10 to 19 | US$ 1.87 |
| | 20 to 29 | US$ 1.70 |
| | Mais de 30 | US$ 1.53 |
| Average (80 to 99 mm) | 10 to 19 | US$ 2.13 |
| | 20 to 29 | US$ 1.87 |
| | More than 30 | US$ 1.70 |
| Master (above 100 mm) | 10 to 19 | US$ 2.55 |
| | 20 to 29 | US$ 2.31 |
| | More than 30 | US$ 2.28 |

In the marketing of oysters by order (dozens), a total of 257 dozens were sold during the study period, with an annual average of 15 dozens. There were fewer orders in January, June, and October 2017, but higher sales volumes in April and November 2017, with 73 dozens sold in each of those months.

Besides the Feira da Agricultura Familiar (FAF) and orders, sales also occur for private businesses in the municipality of Bragança and the surrounding region. According to monitoring conducted at a commercial establishment (restaurant) operating in the municipality, a total of 60 dozen oysters are purchased monthly from AGROMAR at a price of US$ 1.87 per dozen, including delivery. The order is placed via a WhatsApp group, with no purchase and sale contract with the association. The establishment incorporates the product into the preparation of its dishes, selling them at prices ranging from US$ 2.73 to US$ 4.45.

The consumers showed a certain regularity in purchasing oysters (Table 3), where 12% (n=6) buy oysters weekly, 68% (n=34) buy oysters once a month, 12% (n=6) buy oysters twice a month, and 2% (n=1) buy oysters three times a month, demonstrating a monthly loyalty to the product.

**Table 3**. Frequency of oyster purchase (dozens) by consumers interviewed in the municipality of Bragança, Pará.

| **Marketing Standards** | | |
|---|---|---|
| **Purchase Frequency** | **Consumers** | **Percentage** (%) |
| Every Saturday | 6 | 12 |
| Once a month | 34 | 68 |
| Two times a month | 6 | 12 |
| Three times a month | 1 | 2 |
| Every three months | 1 | 2 |
| First time | 2 | 4 |
| **Total** | **50** | **100** |

It is interesting to note that 2% (n=1) of consumers purchase the product every three months, while 4% of respondents (n=2) were buying oysters for the first time, stating they were unaware of oyster sales at the Family Agriculture Fair (FAF).

In regard to the way oysters are consumed, it was observed that 50% (n=25) of the respondents consume them grilled/baked, 24% (n=12) consume them raw, and 26% (n=13) use both consumption methods.

In this way, it is observed that half of the consumers cook the food, an ideal method to prevent foodborne infections, as oysters can cause diseases due to their eating habits, since they are filter feeders and bioaccumulators of microorganisms (Silva *et al*., 2003; Barreto *et al*., 2008; Vieira *et al*., 2008).

Barreto *et al*. (2008) highlight that this biological characteristic of oysters presents higher risks to public health, and the habit of consuming this food raw or partially cooked, without any prior

treatment, can cause foodborne infections, especially in immunocompromised individuals. Therefore, the population should adopt new eating habits and cook food properly in order to eliminate any pathogens present. Guedes *et al*. (2012) emphasize that to obtain safe food, Good Manufacturing Practices (GMP) measures are necessary.

The consumer's health can be compromised even when the food does not show signs of spoilage in appearance, taste, or smell (Viegas, 2014). Therefore, it is of utmost importance to ensure the hygienic-sanitary quality of this food throughout the entire production chain, from cultivation/fattening to commercialization, providing food safety for the consumption of the product in its natural state (Pereira *et al*., 2006).

When investigating the knowledge used by consumers in oyster preservation, it was found that 60% (n=30) know how to store the product, while 40% (n=20) revealed that they do not, demonstrating the risk consumers face by not knowing or practicing the proper methods for storing/preserving oysters, compromising the quality of the food and food safety itself.

Of the consumers who reported knowing, 48% (n=24) use the refrigerator to store the product, 6% (n=3) use ice, and 6% (n=3) use the freezer. According to Lopes (2007), cold is one of the most suitable and widely used methods for food preservation, as it inhibits or slows down the growth of microorganisms, as well as reducing chemical and enzymatic reactions. By using this practice, the food's shelf life will increase, providing consumers with safe food

Brabo *et al*. (2016) emphasize that live oysters can be consumed within six days when stored under refrigeration, or their shelf life can be extended when removed from the shell and kept at freezing temperatures.

Regarding nutritional interest, it was found that 76% (n=38) of the respondents do not know the nutrients present in oysters, and 24% (n=12) claimed to be aware of them. The lack of information among the majority of the respondents proves how much this topic is ignored by consumers, who do not recognize the importance and benefits of this food for the population's health. The information provided is limited, as only a small number of nutrients present in the food are mentioned, such as calcium, zinc, potassium, sodium, magnesium, and iron, emphasizing that the nutritional load and benefits of oysters are significant.

The muscle tissue of oysters has a high nutritional content, rich in proteins, glycogen, vitamins A, B1, B2, C, and D, minerals such as phosphorus, zinc, calcium, iron, iodine, omega-3, and low levels of fats. Consuming an average-sized oyster provides about 10 calories (Wakamatsu, 1973; Sampaio and Boulhosa, 2007; Lingham *et al*., 2016). Thus, the consumption of oysters ensures health benefits and improvements in quality of life for consumers.

Ribeiro *et al*. (2016) emphasize that the soft tissues of oysters, despite being protected by the shell, can be contaminated during the stages of their production chain. Therefore, it is observed that consumers have a mistaken perception regarding the quality of oysters, believing that they do not pose health risks, trusting in the complete absence of microorganisms in this food.

In contrast, 56% (n=28) of the respondents believe that oysters are not free from microorganisms, highlighting several factors that contribute to this issue, such as the way the food is handled, the quality of the cultivation site, the production process, transportation, and sale.

When questioning them about the purification technique, it was found that 88% (n=44) were unaware of the existence of this procedure. Santos *et al*. (2014), when studying the consumer profile in the city of Valença, Bahia, observed the same lack of information, with 93% of consumers not knowing what it was. The lack of consumer knowledge on the subject completely impacts the demands for a quality product, since purified food drastically reduces the risks of food contamination. Oysters from the Nova Olinda community are not purified, preventing the proof of the food's quality to consumers.

Of the total number of interviewees, only 22% (n=6) reported having a reasonable understanding of the purification technique, with a unanimous report of cleaning the impurities from the organism. Souza *et al*. (2022) explains that in the purification process, oysters are placed in tanks where clean water is pumped, and these animals are monitored for a certain period to allow for their decontamination. Thus, it is a technique used to remove the impurities present in the soft tissue of oysters and other bivalve mollusks, making them safe for consumption.

Valenti *et al*. (2010) highlight that the use of good management practices (BMP) is a way to move towards sustainability, but they emphasize that it is not enough. For a crop to be considered sustainable, a system must be adopted that generates income, optimizing the use of capital and natural resources, while promoting human development.

It is noted that consumers' perceptions are relevant, highlighting key elements present in sustainable farming. Despite the significant number of contributions from the interviewees, 46% (n=23) were unable to respond, highlighting the lack of knowledge on the subject, given that sustainability is the only way to ensure the existence of food for generations.

**Conclusion**

The commercialization of oysters at the Family Agriculture Fair (FAF) has been becoming promising for the municipality of Bragança, as well as for the producers of AGROMAR. However, more investments are needed in promoting oyster commercialization in the municipality of Bragança,

aiming to address the lack of information and awareness about the activity, seeking to attract more consumers and consequently increasing demand for commercialization.

It was found that there is a lack of knowledge regarding the quality, preservation, nutritional information, and the purification technique of oysters. Additionally, the water analysis prevents the evaluation of the microbiological conditions of the cultivation area and, consequently, the soft tissue of the oysters, not ensuring the food's safety for the consumer. Therefore, further studies are necessary.

It is recommended to develop educational interactions through lectures, booklets, and workshops to share essential information about oysters and consumer food safety.

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