Main advances in tilapia production for the sustainable development of aquaculture in Brazil and its economic benefits

Principais avanços na produção de tilápia para o desenvolvimento sustentável da aquicultura no Brasil e seus benefícios econômicos

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1 INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) is one of the most produced species in the world, making the fishing industry one of the pillars of sustainability of the economy in several countries, including Brazil. Its increasing production is due to the fact that it is a species that is prolific in different forms of cultivation and has a rapid growth, besides being a tasty and large fish, with essential characteristics for a good acceptance by the consumer market (PRABU et al., 2019).

With regard to sustainability in the nutrition and aquaculture sectors, tilapia has contributed significantly to food security (ARUMUGAM et al., 2023), playing an important role in meeting the UN Agenda 2030 Sustainable Development Goals (SDGs) on alleviating poverty (SDG 1) and global hunger, nutrition supply (SDG 2) and promoting sustainable socioeconomic growth (SDG 8) (ORGANIZATION, 2018), which highlight the importance of fisheries resources to achieve sustainable food systems and develop economic benefits in order to safeguard global food security (SAMPANTAMIT et al., 2020).

Besides having a market value accessible to low-income populations, because it is an easily farmed species, tilapia has provided great opportunities for economic development in rural areas, allowing the introduction of its culture by farmers with little aquaculture experience (UDDIN et al., 2021). Moreover, being a fish rich in protein,

vitamins, and fatty acids, such as omega-3 (LIN et al., 2018), tilapia can also fill the gap in the growing global demand for good food sources of animal protein, micronutrients, and vitamins.

The Nile tilapia is the second most cultivated fish in the world in captivity since ancient times, by the Egyptians. Historical records dating back to 2000 B.C. show evidence of the cultivation of these fish in ponds for later consumption (CARNEIRO et al., 2022). Currently, the tilapia industry is among the fastest growing fishing industries in the world. Projections of the World Bank (BANK, 2013) state that global tilapia production will reach 7.3 million tons by 2030, a considerable increase from the 4.3 million tons reported in 2010.

This review will discuss the main advances in tilapia production for the sustainable development of aquaculture in Brazil and worldwide, as well as the contribution of the tilapia industry to global food security, with its main production guidelines, consumer market, farming methods, and food management strategies.

2 OBJECTIVE

Conduct a literature search on the main advances in tilapia production for the sustainable development of aquaculture in Brazil and its economic benefits.

3 METHODOLOGY

This is a literature review, developed with 30 articles published from 2010 to 2023 in electronic databases: Portal Capes, *Scientific Electronic Library Online* - Scielo and Google Acadêmico, employing the descriptors: tilapia, psiculture, aquaculture, sustainable development and food security, and their respective synonyms, in Portuguese and English languages. Only published articles that dealt with the theme and were available online were included. Articles outside the proposed period, that did not deal with the theme, that were not available online, and repeated articles found in different databases were excluded.

4 DEVELOPMENT

4.1 TILAPICULTURA IN BRAZIL

Oreochromis niloticus is among the main species used in Brazilian fish farming, being cultivated practically in all regions, where the creations are commonly performed in ponds and net-tanks (DE SOUZA; SANTANA; GARGANTINI, 2021). However,

there are regions where this species has adapted better, due to the favorable climate, the use of appropriate techniques, and the great water potential. Currently, the state of Paraná leads the largest production and expansion of tilapia industrialization in the country with more than 34% of the total volume, followed by São Paulo, Minas Gerais, Santa Catarina, and Mato Grosso (CARNEIRO et al., 2022).

Nile tilapia was introduced in Brazil in the mid 1970s, initially to repopulate ponds in the Northeast of Brazil, and later spread throughout the country. The culture of this species only gained importance in the other regions of the country from the 1990's, especially in the South and Southeast regions. (FURUYA et al., 2010). Its breeding presented numerous advantages over native species, especially in relation to the availability of technical and scientific knowledge available for its intensive production (TAVARES-DIAS, 2019).

Tilapiculture has been recognized as an important agro-industrial activity, capable of generating great financial return for producers. It is estimated that the world fish production in 2020, reached 87.5 million tons, with aquaculture accounting for about 66% of this production (FAO, 2022). According to a survey by the Brazilian Pisciculture Association, from 2014 to 2022, the production of farmed fish in Brazil grew 48.6%, being the most exported species, representing 98% of Brazilian pisciculture exports, totaling US$ 23.2 million in this last year. Also in 2022, Brazil produced 550,000 tons of tilapia, which represents 63.9% of national fish production and puts Brazil among the four largest producers of this species, behind only China, Indonesia, and Egypt (PEIXE BR, 2023).

4.2 TILAPIA CONSUMPTION

As seen previously, tilapia aquaculture is an extremely relevant economic activity, being a source of animal protein and income for millions of people, besides being a productive sector capable of sustaining the current global demand for fish (COBO et al., 2019). Its prominence in the consumer market begins with the filleting process, which is one of the most sustainable ways in the utilization of tilapia, since the filet represents 30 to 40% of the weight of the fish (STONEHAM et al., 2018).

A study carried out by the Axxus Institute in partnership with Peixe BR in 2022, with 4.2 thousand people interviewed in all regions of the country, of all age groups and social classes, showed that 76.9% of the participants said they consume tilapia. According to the research, the inclusion of tilapia in the diet of Brazilians is highly motivated by factors related to health and well-being. Among the characteristics most mentioned by

the interviewees about the fish are the fact that it is tasty and healthy; that it contains a lot of protein, vitamins, and omega 3; that it is easily digestible; that it helps to maintain weight; that it has no fat; and that it has few bones. On the other hand, they would like to find the product at the point of sale more easily and with more cut options (PEIXE BR, 2023).

In fact, tilapia has important organoleptic and nutritional characteristics that increase its consumption. Compared to many other fishes, tilapia fillets have a low fat (up to 0,9g/100g) and calorie (95Kcal/100g) content, depending on the size of the fish, the culture system, the composition of the diet, and the feeding management. Its white meat, with a firm texture and mild flavor, makes it increasingly sought after. It is also easy to fillet and handle in the kitchen, and has no "Y"-shaped bones (myocetes). In addition, tilapia meat also presents excellent nutritional characteristics, being an excellent source of proteins of high biological value and essential amino acids (ABOLAGBA; MELLE, 2021).

4.3 TILAPIA FARMING

4.3.1 Species characteristics

Throughout evolution, several fish species have developed ways to adapt to their aquatic environment. Although it is a freshwater species, tilapia can tolerate osmotic and alkaline stresses up to a particular range, as well as low dissolved oxygen concentrations (DA PAIXAO LEMOS et al., 2018).

They reach first gonadal maturation at four or five months of age, and from then on can produce 75 to 1000 young every 22 to 40 days during the entire reproductive period. The spawning season occurs during the months when the water temperature remains highest, above 24°C. The fish are born sexless and define it by consuming their first food, which nature has impregnated with sexuality-inducing factors (DAI et al., 2021). At this point, man developed the technology of sex reversal, making the fish born in an environment where there are only foods impregnated with the male sex factors. In this way, it is possible to obtain up to 100% male individuals, which offer a greater amount of meat, in a shorter time in captivity.

Among the farmed fish, tilapia also stands out for its resistance to diseases, tolerance to high densities and adverse environments. Being considered an ectothermic species, the body temperature and metabolism of tilapia are directly linked to the temperature variation of the environment (SALAAH, 2021). The water temperature has great importance on their vital functions, where variations of this factor can affect the

availability of nutrients, cause diseases, lack of appetite, lead to problems in their growth and presence of microorganisms in the water (YANG et al. (YANG et al., 2021).

With regard to water pH, the advisable values for best results should be between 6 and 8.5 and the ammonia concentration should be below 0.24 mg/l, but they coexist very well with a fairly wide range of acidity and alkalinity in water with pH variations between 5 and 11. However, very extreme values such as below 3.5 or above 12 cause mortality in less than 6 hours of exposure (DA PAIXAO LEMOS et al., 2018).

4.4 AQUACULTURE STRATEGIES

The search for diversification in aquaculture practices and the adaptation of existing technologies is part of the improvement process of the activity, aiming to reduce production costs and environmental impacts, so that the sector develops in a more sustainable way (KIM; ZHANG, 2018; LEITE et al., 2019; DANTAS et al., 2020). The best biological performance of *O. niloticus* species has a broad association with the performance of the selected production technique in culture in combination with technological and environmental factors.

Numerous advances have been employed in order to overcome the various challenges of tilapia farming, such as climate change, land availability, socioeconomic concerns, and environmental barriers. Strategies and practices adopted for the greater success of tilapia production include Bioflocculus (BFT) technology; cage culture systems for growing potential high-yielding tilapia varieties, such as the genetically improved farmed tilapia strain (GIFT); backyard brackish water aquaculture; recirculatory aquaculture (RAS) systems, hybrids, and monosex populations; and Integrated Multitropical Aquaculture (IMTA) (ARUMUGAM et al., 2023).

Other techniques such as polyculture (multiple species in the same production system) and integrated fish farming (fish farms integrated with agricultural land crops) provide additional income to farmers (PINHO et al., 2021). This technological advancement helps to overcome the challenges of the agri-farming sector. The integration of BFT and SRA has resulted in improved resource utilization and production by providing supplemental feed for Nile tilapia (HISANO et al., 2019).

4.5 NUTRITIONAL FACTORS

Nutrition is an essential factor in the viability and success of aquaculture. Feeding practice in an aquaculture system requires the choice of appropriate feed sizes,

determination of feeding frequency and timing, and successful delivery of the predetermined feed to the culture system. To maintain optimal growth and immune functions, the feed must contain energy and nutrients that meet the requirements for tilapia culture (DA SILVA et al., 2020).

Nutrients play a vital role in regulating metabolism and maintaining homeostasis in fish (LALL; DUMAS, 2022). In this sense, several parameters are used to measure growth as a function of the feed offered, such as: body weight gain, protein efficiency ratio, specific growth rate and weight gain.

The food requirements of tilapia vary according to the stage of development, water temperature and size of the fish (AZAZA; DHRAIEF, 2020). However, it is critical to balance the diet with adequate macro- and micronutrients, avoiding overfeeding, which can cause water quality concerns such as increased fish waste and uneaten food (HERATH; SATOH, 2022).

As an omnivorous fish, tilapia have a good capacity to digest animal and vegetal food. Fishmeal is an important source of nutrients in fish food and has been widely used since the beginning of fish farming. However, due to the depletion of fishmeal stocks and fluctuations in its sale price, investigations are already underway to find a more suitable alternative (BOYD et al., 2020).. Plant-based alternatives, for the most part, are preferred due to their nutritional profile and abundance. However, the antinutritional factors present in plant sources make it difficult to completely replace the meal in fish feed.

The production of fish food is extremely difficult, as it often requires the exploitation of arable land to grow crops that are then processed into fish food (BOYD et al., 2020). This is a considerable issue, as arable land may be better utilized for human food production than for fish food production. The growing need for fish food is consuming a large amount of arable land that could otherwise be exploited to produce food for human consumption (FRY et al., 2016). The land used to manufacture fish feed could be used to grow crops that could feed humans in many parts of the world, particularly in areas where food insecurity is already a serious concern (CONNOR; MÍNGUEZ, 2012).

Several studies have been conducted in search of cultures that use feed supply in conjunction with the stimulation of natural food, through fertilization of the culture systems, which can bring economic benefits to the producer and minimize costs with artificial feeding (ARUMUGAM et al., 2023). It is critical to investigate sustainable alternatives for fish feed production. In a study by Rumbos et al.the use of insect-based

protein sources was investigated, which would reduce pressure on arable land and water resources while providing a long-term source of protein for tilapia production.

5 CONCLUDING REMARKS

To meet the global demand for food and achieve the UN SDGs, the aquaculture industry has been seeking productive solutions in tilapia farming to ensure the efficient use of resources. With important advances in aquaculture technology and improvements in the tilapia diet, it is already possible to observe an increase in fish production, leading to the sustainable development of aquaculture, besides offering a latent contribution to global food security.

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