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Aquaculture in Brazil and worldwide: overview and perspectives

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ABSTRACT

Aquaculture is the cultivation of aquatic organisms through a controlled cultivation process. Currently, half the fish consumed by the world population is produced by aquaculture activity. This review, and informed data, trends, and the general panorama of aquaculture in Brazil and worldwide, as well as the scenario of the tilapia (*Oreochromis niloticus*) production, in order to provide specific directions for future investments and researches. Globally, fish aquaculture productivity is approximately 110 million tons in 2016, with China being the country with the highest productivity (49 million tons). Brazil occupies the 13th place with about 700 thousand tons of aquaculture fish, where tilapia is one of the most cultivated. Furthermore, the ration production for aquaculture is one of the fastest-growing sectors in the country (930 thousand tons of ration represents 1.33% concerning the total feed produced to cultivation of the animals – data of 2016), with emphasis on the biofloc system, which represents a productive method with better cost-benefit and low environmental impact. In general, aquaculture trends are the real progress of this activity, but so that social, economic, and environmental aspects are interconnected and progressing concomitantly.
Keywords: Aquatic organisms, biofloc system, fish farming, fish production, ration.

Introduction

Aquaculture is a process of controlled freshwater cultivation or saltwater organisms, and it is one of the most developed activities in the world. Currently, half of the fish and mollusks used to feed the world's population comes from aquaculture (FAO, 2018). In order to provide and meet the demands of fish consumption worldwide, aquaculture has expanded in many different aspects, especially related to sustainable fish production, implementation of more technological projects and structures, and improvement of production with a better cost-benefit.

Fish is an important food for human consumption, as it is a healthy and nutrient-rich food, and according to the World Health Organization (WHO), fish consumption per person per year should be around 12 kg (Masuda, 2009).

In 2015, the worldwide estimate of per capita fish consumption was approximately 20.2 kg per year (FAO, 2018). These data show the representativeness that fish presents in the feeding of the human population. In the case of Brazil, the annual fish consumption per capita is 9.5 kg (PeixeBR, 2018), an average below that proposed by the WHO.

Thus, there is a necessity to show the trends and future directions within the aquaculture sector and some general panorama of fish in the world and especially in Brazil, since this country has the most substantial amount of water with potential for continental aquaculture in the world and has the most extensive coastal strips in the world (Itaipu Binacional, 2010). Therefore, based on this general analysis of aquaculture and some pertinent facts of this activity, this paper sought to verify and inform the data, trends and a general panorama of aquaculture in Brazil and worldwide, in order to provide specific directions for future investments and research in this sector. Also, the current scenario of the tilapia *Oreochromis niloticus* (Linnaeus, 1758) in Brazil and all world was analysed, since this animal is one of the most cultivated in the aquaculture sector and Brazil is the fourth-largest producer of tilapia in the world (PeixeBr, 2018).

Material and Methods

It was used Google Scholar (https://scholar.google.com) and complemented with Web of Science ISI database set (https://apps.webofknowledge.com/) for the acquisition of articles related to the subject of this study. Furthermore, it was used some references within articles selected by database systems as support. Data on statistics related to aquaculture in Brazil and worldwide were mainly taken from FAO ("Food and Agriculture Organization of the United Nations"), IBGE (in English "Brazilian Institute of Geography and Statistics") and PeixeBr (one of the primary references for aquaculture in Brazil) website. We worked with the most recent and up-to-date data and statistics until the final writing of this study from November 2018 to January 2019, where we can observe recently published references.

Results

Current aquaculture scenario in Brazil and worldwide: data and trends

Aquaculture is the fastest-growing activity in Brazil, and all world (SEBRAE, 2015; Vélez et al., 2016) and this activity works with, according to FAO (2016), controlled cultivation of aquatic organisms in both freshwater and saltwater, such as fish, crustaceans, mollusks, reptiles, plants, among others. Currently, half the fish and shellfish consumed by the world's population is produced by aquaculture, where we can see a three-fold increase in fish production between 1995 and 2007 (FAO, 2018). Some segments can be seen within aquaculture, such as Fish farming (continental and marine): fish; Mariculture: the cultivation of aquatic marine-estuarine organisms; Algae farming: the cultivation of algae; Oyster farming: oyster; Shrimp farming: shrimp farming; and Frog farming: frog.

World aquaculture, especially fish farming, is dominated by several species of carp, which occupy the top positions in the production ranking. Soon after, in the 4th position, the tilapia of the Nile *Oreochromis niloticus* (Linnaeus, 1758) represents the species with greater importance in the world. At the same time, salmon from the Atlantic, which occupies the 8th position in the ranking of production, is the most valued species in the world ranking, obtaining the highest economic revenues per kilo produced (FAN, 2018).

According to FAO (2018), in 2016, farmed food fish comprised more than 80 million tons (US$ 231.6 billion), where fish (54 million tons) presented a value of almost US$ 138.5 billion (Table 1). Crustaceans and Molluscs presented a value of US$ 57.1 and US$ 29.2 billion, with a total production of 7.9 (crustaceans) and 17.1 (mollusks) millions of tons (for more details see Table 1).

Table 1. Economic values practiced in the different groups of aquaculture production in 2016, mainly: FAO (2018).

	Continental Aquaculture	Marine Aquaculture	Amount		Value	
	Millions of tons	Millions of tons	Millions of tons	Volume (%)	Millions of US$	Value %
Fish	47,516	6,575	54,091	67,6	138,5	59,8
Crustaceans	3,033	4,829	7,862	9,9	57,1	24,6
Mollusks	0,286	16,853	17,139	21,4	29,2	12,6
Other	0,531	0,407	0,938	1,1	6,8	3,0
Total	**51,367**	**28,664**	**80,030**	**100**	**231,6**	**100**

Considering years later, the cultivation of traditional aquatic species has reached sustainable limits of 171 million tons per year in 2016, according to FAO (2018), and world aquaculture contributed more than 80 million tones (110.2 considering aquatic plants). This production generated an income of over USD 232 billion for producers. Fish farming is the segment with a more significant production force, providing a total of 54.1 million tons, followed by mollusks, with 17.1 million, and crustaceans, with 7.9 million (FAO, 2018). Until the 1980s, aquaculture presented a static growth. Since then, it has been one of the most abundant supplies of fish for human consumption.

In 2016, the countries with the highest aquaculture production were: China, in the first place (more than 49.2 million tons), followed by India (5.7 million tons), Indonesia (4.9 million tons), and Vietnam (3.6 million tons). Next, are

Bangladesh (5th), Egypt (6th), Norway (7th), and Chile (8th). Brazil occupies the 13th (FAO, 2018). Also, in the period from 2001 to 2016, aquaculture was the fastest-growing sector when compared to other sources of food production.

In 2004-2014, there was an annual average growth of, approximately, 8% in aquaculture, surpassing the other meat sectors (cattle, chickens, and pigs). The result of this growth is evident in the world ranking established by FAO, where Brazil was in 36th place in 1990, becoming the 13th place in 2016 (FAO, 2018). Of the total fish produced by aquaculture in 2016 (640.4 thousand tons), fish farming is the most representative, with a production of 507 thousand tons and moved R$ 3.2 billion (IBGE, 2016), representing 70.9% of the total value of production. Soon after the fish farming, we have shrimp farming, and oysters, scallops, and mussels farming with 52 thousand and 20 thousand tons produced, respectively (Table 2).

Table 2. Quantity produced and production value of the leading aquaculture products, in descending order of production value, Brazil, IBGE (2016).

Main aquaculture products	**Quantity produced**	**Production value**	
		Total (1000 R$)	**Percentage**
Fish (kg)	507,121,920	3,264,611	70.9
Shrimps (kg)	52,118,709	888,933	19.3
Fingerlings (thousands)	1,134,219	265,884	5.8
Shrimps larvae and post-larvae (thousands)	12,611,705	115,263	2.5
Oysters, scallops and mussels (kg)	20,828,670	68,480	1.5
Other animals (1)	-	2,526	0.1
Seeds of oysters, scallops, and mussels (thousands)	66,702	1,836	0.0
Total	-	**4,607,533**	**100.0**

According to PeixeBR (2018) data, in 2017 the South region was one with the highest production related to aquaculture (25.8%), followed by North (23.8%), Central West (17.6 %), Southeast (16.7%) and Northeast (16.1%) (Figure 1). It is worth noting that, in 2017, the state with the highest production was Paraná (112 thousand tons), followed by the states of Rondônia (77 thousand tons), São Paulo (69.5 thousand tons), Mato Grosso (62 thousand tons) and Santa Catarina (44.5 thousand tons) (Table 3), respectively (PeixeBR, 2018).

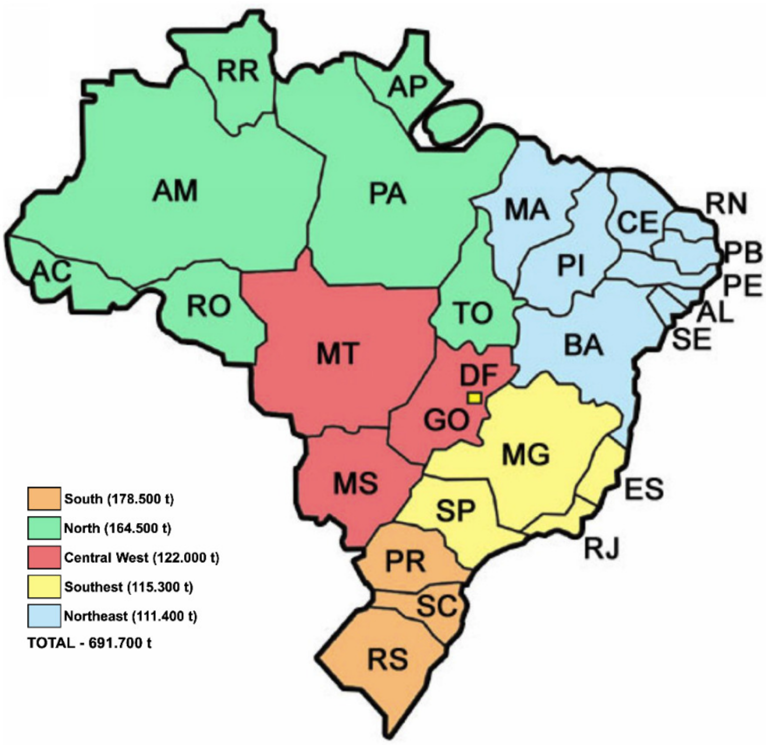

Figure 1. Production of fish from aquaculture in Brazil in tons per region. Font: PeixeBr (2018).

Table 3. Production of fish cultivated by the state in Brazil in 2017. Font: PeixeBR (2018).

Production of fish cultivated (Tons)				
State	**Tilapia**	**Native**	**Others (carp and trout, mainly)**	**Total**
Acre – AC	160	7,840	0	8,000
Amazonas – AM	0	28,000	0	28,000
Alagoas – AL	2,540	897	63	3,500
Amapá – AP	68	932	0	1,000
Bahia – BA	22,220	5,225	55	27,500
Ceará – CE	6,993	7	0	7,000
Distrito Federal – DF	1,500	0	0	1,500
Espírito Santo – ES	10,768	308	924	12,000
Goiás – GO	18,150	14,718	132	33,000
Maranhão – MA	2,650	23,850	0	26,500
Minas Gerais – MG	27,579	464	957	29,000
Mato Grosso do Sul – MS	17,850	7,599	51	25,500
Mato Grosso – MT	1,860	60,134	6	62,000
Pará – PA	560	19,440	0	20,000
Paraíba – PB	2,971	27	2	3,000
Pernambuco – PE	16,694	255	51	17,000
Paraná – PR	105,392	3,248	3,360	112,000
Piauí – PI	9,360	8,635	5	18,000
Roraima – RR	0	16,000	0	16,000
Rondônia – RO	0	77,000	0	77,000
Rio Grande do Norte – RN	2,231	62	7	2,300
Rio de Janeiro – RJ	3,768	590	442	4,800
Rio Grande do Sul – RS	4,158	1,778	16,064	22,000
Sergipe – SE	1,122	5,478	0	6,600
São Paulo – SP	66,101	3,128	271	69,500
Santa Cantarina – SC	32,930	2,136	9,434	44,500
Tocantins – TO	15	14,486	0	14,500
Total	**357,639**	**302,235**	**31,825**	**691,700**

Brazil cultivates 64 species in aquaculture, where the main cultivated species are tilapia (*Oreochromis* spp.), common and Chinese carp (*Cyprinus carpio* Linneau, 1758), *Aristichthys nobilis* Richardson, 1845, *Hypophthalmichthys molitrix* Valenciennes, 1844 and *Ctenopharyngodon idella* Valenciennes, 1844, pacu (*Piaractus mesopotamicus* Holmberg, 1887), tambaqui (*Colossoma macropomum* Cuvier, 1816), surubim (*Pseudoplatystoma* sp.), sea prawn (*Litopenaeus vannamei* Boone, 1931) and molluscs (*Crassostrea gigas* Thunberg, 1793), *C. rhizophorae* Guilding, 1828, and *Perna perna* Linnaeus, 1758. Tilapia and round fishes (tambaqui, tambacu, pacu, and tambatinga) represent 83% of Brazilian fish farming, and the only tilapia contribute 47% of the national production (IPEA, 2017).

The tilapia ration in Brazil and worldwide and the current scenario of the national market of tilapia rations

Tilapiculture began in Brazil in the 1970s with the introduction of Nile tilapia (*Oreochromos niloticus*) by the National Department of Dry Works (DNOCS). In the 1980s, there was an increase in production from the pisciculture stations, with a production of fry for restocking and sales to rural producers (Kubitza, 2003). However, it was only in the 90s that production began to gain strength with the help of sexual reversion technology, initiating the industrial focus (Kubitza, 2003). Also, in the 90s, management research emerged, in addition to improving rations, allowing more states to adopt cultivation. The production of Brazilian tilapia increased from 12 thousand tons in 1995 to 219 thousand tons in 2015 (Figure 2) (FAO, 2016). The increase in the production of tilapia in Brazil put the country in the fourth-place world producer of tilapia, yielding a total of 8.8 billion in 2014 (IPEA, 2017).

Since the country's consolidation, one of the major's tilapia producers, the Brazilian market has been growing in exports, and this growth is forecast to continue (Embrapa, 2016). As reported by Embrapa (2016), the price of tilapia in large Brazilian cities varies between R$ 34 and R$ 44, which is a high value when compared to other meats on the market. Reducing the value of a kilo of tilapia would be necessary to develop production and processing technology, increasing efficiency and production costs, making the price more accessible.

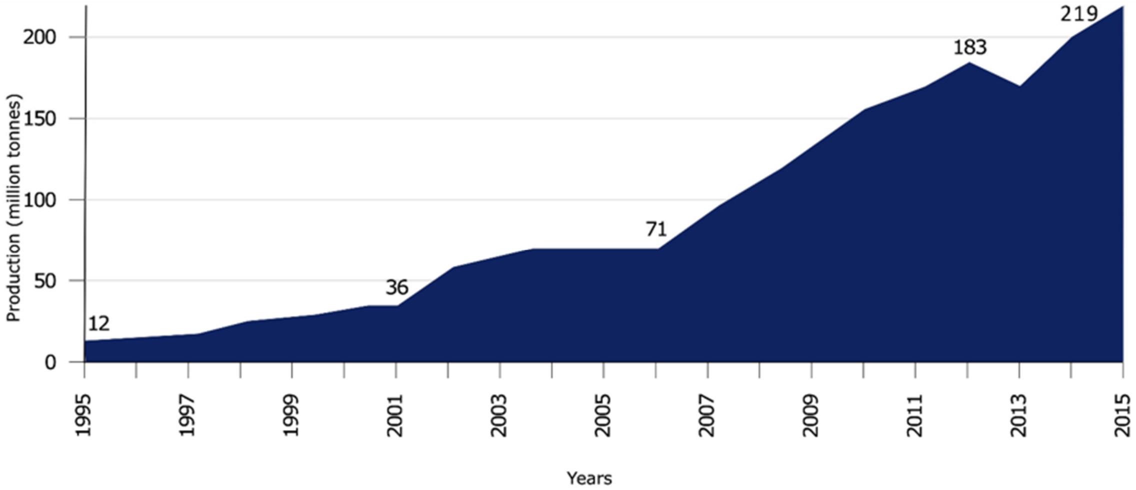

Figure 2. National tilapia production in 20 years (1995-2015).

To produce a large amount of tilapia, it is necessary an excellent investment in the ration. Not to mention the numerous small producers, which are not registered/listed in the Associação Nacional dos Fabricantes de Rações – ANFAR (Brazilian foundation). According to the "Sindicato Nacional da Indústria de Alimentação Animal" (Brazilian Corporation) Sindirações (2017), in 2016, Brazil produced 70 million tons of feed for animal feed, with an expected increase of 1.4 million tons for the year of 2017. Of this total (70 million tons), aquaculture accounted for 1.33% (0.93 million tons), while feed production for poultry accounted for 54% (37.8 million tons). The forecast for feed production and percentage of production growth for 2017 compared to 2016 was 0.99 million tons and about 7%, respectively (Sindirações, 2017). According to (Firreti et al., 2007), the analysis of the behaviour of feed prices over the years shows that this input has increased. The price of the kilo of the ration, which was R$ 0.76 in 1996, reached R$ 0.88 in 2006, an increase of 15.81%. It is worth noting that in 1999 the price of the ration was even higher when the kilo of the ration was sold for R$ 1.25. In the following years, the price still rising with almost R$ 2.00 in 2012 and a low in 2015 with a value of around R$ 1.50 (França, 2016).

The final price of the feed depends on the type of processing received. Depending on the processing, the feed may be more expensive or cheaper. According to (Borges-Neto & Prado, 2017), there are different ways to produce and provide fish feed, which is: (i) the ingredients of the ration are only ground and mixed. This process is not recommended since the nutrient losses are enormous, causing not only problems to the fish but also the water pollution of the tanks; (ii) pelleted feed, that is, through the combination of moisture, heat, and pressure, the smaller particles are agglomerated, giving rise to larger particles. Its stability on the water surface should be around 15 minutes, which ensures its quality. This type of feed reduces nutrient losses in water, can eliminate some toxic compounds, decrease food selection by fish, and reduce the volume of feed transport and storage. However, it has a higher cost of production when compared to the first fish feed method; (iii) using extruded ration, which consists of a process of cooking at high temperature, pressure, and controlled humidity. Its stability on the water surface is about 12 hours, making food management with this type of feed easier and more efficient. Nowadays, it has been the most suitable form of ration for fish farming.

Discussion

Current aquaculture scenario in Brazil and worldwide: data and trends

Brazil presents two positive points when we compare it with the main producing countries of the aquaculture sector in the world, which are the similarity between the aquaculture factors (species cultivated, technology, perspectives), and the diversity of cultivated species (64 species). In general, it is currently unanimous in the sector to give priority to the productive chains of tilapia, sea prawn and mollusks and, in parallel, to stimulate new research projects in areas that may, in the future, form new productive chains, such as the pirarucu, surubins and other native fish, as well as trout and freshwater prawns; and also of fish species for sport fishing, which are often strongly linked to regional demands. In particular, we can confirm the consolidation of tilapia, carp and some other native fish species in the South; round and surubins in the Southeast; native fish in the Midwest; tilapia and surubins in the Northeast; and tambaqui and pirarucu in the North (Kubitza et al., 2012).

Regarding trends, we can see that in the publication "Fish to 2030" (FAO, 2015), it is estimated that in 2030 aquaculture will account for more than 60% of the world's production of fish for human consumption. Thus, it is clearly seen that the upward trend seen in the last few years should continue in the coming decades, with aquaculture being the most responsible for meeting the growing demand for fish worldwide. In Brazil, the Peixe Br (2019) intends that aquaculture production will surpass the capture fish production in 2020. Brazil is one of the countries with great potential for expansion of aquaculture, since it has one of the extense coastal strips in the world with more than 8,500 km of extension, covering an area of more than 3.5 million km^2 of Exclusive Economic Zone. Also, Brazil is the holder of the most substantial amount of water with the potential for continental aquaculture in the world (Itaipu Binacional, 2010).

Among the specific demands placed, also consensual of the national aquaculture sector, increasingly visible in the discussions related to the sustainability and competitiveness of production systems, is the environmental issue, due to its characteristic of direct users of water resources captured or even by use of the environment in production. Some sustainable practices are being adopted in aquaculture in order to reduce the impacts caused, such as new methods to reduce chemical and biological pollution by controlling the stress of cultivated organisms; application of integrated pest management; and use of vaccines as a substitute for the use of antibiotics for disease control (SEBRAE, 2015).

One way to control environmental impacts is groundwater recirculation systems, along with offshore aquaculture (in deep ocean waters). Some tendencies of improvement and expansion of the agricultural sector can be mentioned, like system of recirculation and control of effluents; multitrophic cultivation, aquaponics and groundwater; use of new technologies such as biofloc (see particular discussion below in "Biofloc system production for tilapia") and probiotic system; investment in filtering organisms, such as oysters and mussels, and autochthonous organisms, such as algae; development of more efficient feeds, alternative protein sources (e.g., algae) and integration and higher efficiency between production, commercialization, and distribution.

Therefore, aquaculture trends are the real progress of this activity, but so that social, economic, and environmental aspects are interconnected and progressing concomitantly. In Brazil, Plano de Desenvolvimento da Aquicultura Brasileira 2015/2020 (2015), objective to promoting between 2015-2020 new assignments of aquaculture areas with capacity to produce more than one ton of fish a year; support productive chain projects that aim at integrated and sustainable development; finance actions for Technical Assistance and Aquaculture Extension to 50,000 aquaculture farmers per year; Deploy 20 Demonstration Units (UDs) of new technologies for fish farming and shrimp farming with little use of water, bioflocs and alternative energy sources (more details in Plano de Aquicultura Brasileira 2015).

The current scenario in Brazil regarding the problems faced in cultivation and nutrition of tilapia

Several factors may interfere with and contribute to fish nutrition, such as the environmental conditions in which they live. Cold-water fish, for example, require an optimum development temperature below 18°C, and, on the other hand, hot water requires an optimum temperature above 18°C. Another critical factor that directly interferes with fish development is the diet. Studies have shown that diet can influence behaviour, structural integrity, health, physiological functions, reproduction, and fish growth (Borges-Neto & Prado, 2017). Together with these positive characteristics related to diet, the increase in production areas in aquaculture, mainly in fish farming, makes producers search for higher yields and the development of production techniques, especially those related to water quality and nutritional and food management. It leads to an increase in the demand for better quality food, directly influencing feed manufacturers to present better products. From this, there was a representative increase in the number of factories producing fish feed, which diversified the product options available in the market (Kubitza et al., 1998; Moro & Rodrigues, 2015).

High quality extruded feeds are more digestible, therefore less polluting compared to pelleted feeds. It allows an increase in productivity with a lower environmental cost (Kubitza et al., 1998). A process that submits the mixture to higher humidity, temperature, and pressure obtains the extruded pellets. As a result, practically all of the starch is gelatinized, and the pellet exits the partially expanded extruder, which gives it water stability for up to 24 hours. Moro & Rodrigues (2015), as well as several other authors, have presented a compilation of types and forms of feed processing and, therefore, more details about such information are discussed internally.

Despite the many technological advances related to genetic improvement, biology, reproduction, disease prevention, nutrition and management in tilapia production (El-Sayed & Teshima, 1992), the main issue in Brazil is the management of adequate nutrition, combined with a correct food management, since food expenses can reach 65% of the total cost of production (Firreti et al., 2007). As it is a model based on the use of balanced rations, the cost can influence the production and, consequently, the provision of resources to pay the production falls on the fish farmer. Thus, several types of feed emerge, as it is the case of the biofloc system, which is considered a more sustainable technique because it does not carry out changes throughout the fish production. Tilapia, for instance, is omnivorous, but have a strong tendency toward vegetarianism. The physiological and biological structure of tilapia is shaped to graze algae and other aquatic plants. Accelerated growth of fingerlings is observed when they are placed in an aquarium with a high concentration of algae near a site with high solar incidence. In many "nurseries" (places destined to the treatment of the new-born tilapia) the fingerlings are fed exclusively through this process; therefore, they grow faster. The smaller the fish (in size and grams), the more delicate it is and the more susceptible to diseases.

Depending on the production system adopted, the rations can comprise 40 to 70% of the cost of production, representing the main cost item in intensive tilapia fish farming. Therefore, one of the most effective ways for producers to minimize this cost is to adequately adjust feed quality and feed management to the different stages of production and the fish production system used. According to Kubitza (1999), adequate nutrition and food management: allows the best use of fish growth potential; accelerates fish growth, increasing the number of annual life cycles; improves food efficiency, minimizing production costs; reduces the polluting impact of effluents from intensive fish farming, contributing to the increase of productivity per area of production; provides adequate health and tolerance to diseases and parasitic diseases; improves fish tolerance to handling and live transport; increases the reproductive performance of the matrices and the quality of the post-larvae and fingerlings and, therefore, makes possible to optimize the production and to maximize the revenues of the fish culture. Also, Kubitza (1999) showed several basic information on tilapia rations considering development stages, production sites (nurseries, net tanks, and raceways), restrictions on the use of some ingredients, nutrition and food management during sexual reversion, and feed conversion of tilapia (Furuya, 2010; Pezzato, 1995).

FAO states that Brazil has climatic conditions and natural resources to support one of the largest industries based on aquaculture. Much of the growth in this sector must be credited to the efforts of feed manufacturers who have put a great diversity of products on the market in a short period, thus encouraging production (Kubitza et al., 1998). Virtually all feed manufacturers are located in the states of the southeast region, and outside of these states, the price of feed is high because of the additional cost of transportation, fees, and taxes. Feed manufacturers should consider the growth of aquaculture and the lower costs of the primary raw materials in a given region when they start planning studies for new factories. Manufacturers should also pay more attention to the production of nutritionally complete rations to meet the nutritional requirements of fish under intensive cultivation conditions in tanks and raceways, production systems increasingly used. High-quality feeds are also necessary for the cultivation of carnivorous fish, increasingly popular among fish farmers. Also, there is a need to diversify the composition and size of the products to meet the needs and maximize the production of various fish species at different stages of production.

In this way, Brazil has been searching for improved tilapia strains aiming at better zootechnical performance and better utilization of food, thus reducing consumption. Also, more improved rations are being researched and produced, that is, with better digestibility, because rations more efficient, even with higher prices, can allow a lower cost of production (Kubitza et al., 1998). In general, what can be seen is a concern and an improvement on the part of the manufacturers of rations: in the quality control of raw materials; in the use of information available to formulate rations that meet the nutritional requirements of fish, rather than using tables of nutritional requirements for poultry or pigs; in the use of adequate technology to process the rations; in the knowledge of the losses of vitamins during the processing, stocking, and use of the rations; in the implementation of the quality control of its products, through laboratory analyses and biological tests; in the provision of technical support to fish farmers (and customers), through an open line for consultation, holding of lectures and field days, publication of practical production manuals and feeding guides; in developing agreements with research institutions and producers to establish the nutritional requirements of potential native fish and to evaluate the performance of their products; and in the search for experienced nutritionists for the development of new products. Also, fish farmers should be responsible for proper storage and correct use of feed; for evaluating the quality of the rations on the farm; by recording fish production and performance data, sharing this information with other fish farmers and feed manufacturers.

Biofloc system production for tilapia

The search for better cost-benefit and higher productivity means that aquaculturists consider several factors in the cultivation of their creations, such as good management practices, in order not to make aquaculture a possible source of environmental impact. In this way, we can perceive that it is quite relevant to implement sustainable production systems, capable of minimizing damages to the environment, with particular emphasis on closed production systems (Colt et al., 2006). Among these, the biofloc system has become popular in recent years and has recently been considered as a more sustainable technique because it does not carry out water changes throughout the animal life cycle (Avnimelech, 2007; Azim & Little, 2008; Crab et al., 2009; Kubitza, 2011). This system has been used in aquaculture since the beginning of the 1990s and consists of low or even non-renewal water used in production systems (Kubitza, 2011).

The biofloc system is based on the recycling of nutrients through a high carbon/nitrogen ratio in the water, in order to stimulate the growth of microalgae, various microscopic organisms (protozoa, rotifers, fungi, oligochaetes), among other microorganisms, especially a vast diversity of heterotrophic bacteria, which convert ammonia into microbial biomass, which will supplement the feeding of cultivated organisms (Avnimelech, 2007; Kubitza, 2011). Bioflocs can reach crude protein levels of up to 50% (Azim & Little, 2008), which makes them attractive food for animals in the production system, with the possibility of reducing feed rates and, consequently, feed cost (see Avnimelech, 1999).

This technology allows the use of high storage densities and high productivities (10 to 40 kg m^{-3}) (Avnimelech, 2005). A study of Widanarni et al. (2012) with red tilapia under different densities (25, 50, 100 fish m^{-3}) showed better survival rates using the biofloc system. Another study showed that the storage density of 45 fish m^{-3} in biofloc tanks presented the best response, reaching a productivity of 16.57 kg m^{-3} and survival of 91%, besides to obtaining fish major than 400 g in 128 days of cultivation (Lima et al., 2015), tilapias are adapted to the biofloc system, since they are able to feed by filtration of the water, allowing the absorption of biofloc in suspension. Also, being a robust fish and presenting a rapid rate of growth, it is adapted to well-formed systems.

Kubitza (2011) observed a high potential of the use of the technology of bioflocs in the creation of tilapias, which also was found in other experimental studies realized in other countries. The author also states that Brazil has a substantial availability of area and water for the implantation of conventional fish farming systems (dams, nurseries, and net tanks) in several regions and the implementation of compact and intensive production enterprises with the biofloc technology. Therefore, it is an alternative to be considered, primarily when the cultivated species (in this case tilapia) benefits from bioflocs as a food source.

In order to employ the biofloc system and to increase the fish development, especially tilapia, several parameters of water quality must be analysed. Silva & Costa (2013) showed a detailed approach of these parameters, including experiments of the evolution of water with biofloc system. Among the parameters are temperature - fish are ectothermic organisms, and their body temperature is directly linked to the variation of the ambient temperature. It may result in metabolic changes induced by elevation or reduction in temperature; dissolved oxygen - according to Kubitza (2003), some variations in the concentrations of dissolved oxygen can cause stress, risk of mortality, delay in growth and reduction in food efficiency; alkalinity - for the adequate development of the fish, as well as for the formation of bioflocs, water must have an alkalinity equal to or greater than 20 mg L^{-1}. It is because the ideal alkalinity of the culture medium, allowing the proliferation of the heterotrophic bacteria, which are desirable to the system, must be kept high in order to avoid significant pH variations (Ostrenskv & Boeger, 1998); pH - pH is one of the parameters that is directly linked to the ideal environment for the proliferation of heterotrophic bacteria, and its control is of fundamental importance for the formation of bioflocs. These bacteria need a culture medium that meets the basic needs for their proliferation; ammonia - it is known that one of the objectives of fish and shrimp farming in the biofloc system is the non-renewal of the culture water. In the case of ammonia, not performing the water exchange and using a high density in the tanks can be an aggravating factor; nitrite - is a highly toxic component for fish. High levels cause stress and affect the red blood cells reducing their respiratory capacity, which can lead to death from anoxia. A recent study developed with the growth performance of Nile tilapia in a biofloc system and different salt concentrations (Alvarenga et al., 2018), showed that concentrations between 4 and 8.g L^{-1} increase the developmental performance of the individuals during the initial phase of culture. Thus, this study provides new evidence of parameters that can be used in the biofloc system, especially with tilapia production.

Finally, in the case of tilapia, the main advantage is that this species benefits from bioflocs as a source of food, making it possible to reduce feed use and consequently reduce production costs (Silva & Costa, 2013). It is important to emphasize that the various parameters must be analysed quickly and correctly since the organisms are in an environment rich in residues and microorganisms, which can cause damages and losses to fish farmers.

Conclusion

Aquaculture is one of the fastest-growing activities in the world and in Brazil, which has excellent potential to increase and improve its production efficiency. Nowadays, it can be seen that it is unanimous in the sector to prioritize the productive chains of tilapia, marine shrimp and mollusks and, in parallel, stimulate the development of new research projects and new technologies in areas that may in the future create new productive chains, for example, from other species of fish. Also, the issue of environmental impacts related to fish production in all areas and phases of the production process seems to be well known.

Specific demands are increasingly visible in the discussions related to sustainability, the competitiveness of production systems, and especially to the environmental issue, due to its characteristic of direct users of water resources captured or the use of the environment in production.

Trends in aquaculture are the real progress of this activity, but so that social, economic, and environmental aspects are interconnected and progressing concomitantly.

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