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ECONOMIC EVALUATION OF TAMBAQUI "CURUMIM" PRODUCTION IN EARTH PONDS IN THE METROPOLITAN REGION OF MANAUS-BRAZIL

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ABSTRACT: Increasing demands for tambaqui curumim (350 - 700 g) has boosted its rearing in the metropolitan region of Manaus, thus this study aimed at performing an economic evaluation of this production. Seven fish farms that produce tambaqui curumim were selected and, by means of a semi-structured questionnaire, rearing stages were identified, such as production cycles, management methods, infrastructure, productive indexes and monetary expenses, which allowed the calculation of both the Total Operational Cost and profitability indicators. The results indicate a wide variation on productive indicators among the studied fish farms, with high indexes of apparent feed conversion (>2) and low productivities (<8 t. ha year^{-1}), which resulted in an average cost of R$5,37 kg^{-1}, with feed as the main cost. These factors, associated with a low marketing price (< R$ 3,76 kg^{-1}) of the tambaqui curumim, make this an unfeasible activity in 85,71 of the evaluated fish farms.
Keywords: fish farm, production cost, profitability.

AVALIAÇÃO ECONOMICA DA PRODUÇÃO DE TAMBAQUI CURUMIM EM VIVEIROS ESCAVADOS NA REGIÃO METROPOLITANA DE MANAUS-BRASIL

RESUMO: *A crescente demanda por tambaqui curumim (350 a 700 g) tem impulsionado seu cultivo, na região metropolitana de Manaus e este trabalho teve por objetivo avaliar economicamente esta produção. Foram selecionados sete empreendimentos que produzem tambaqui no padrão curumim e, por meio de um questionário semiestruturado, foram identificadas as fases de criação, ciclos de produção, manejos adotados, infraestrutura utilizada, índices produtivos obtidos e o desembolso monetário, que permitiram calcular o Custo Operacional Total e indicadores de rentabilidade. Os resultados indicam que houve ampla variação nos indicadores produtivos entre as pisciculturas estudadas, com elevadas Conversão Alimentar Aparente (>2) e baixas produtividades média (<8 t. ha ano^{-1}) que acarretaram, em custo médio de R$5.37 kg^{-1}, com a ração sendo o principal item. Estes fatores associados ao baixo preço de mercado (< R$ 3.76 kg^{-1}) pago pelo tambaqui curumim tornam essa atividade inviável em 85.71 dos empreendimentos avaliados.*
Palavras-Chave*: piscicultura, custo de produção, rentabilidade*

INTRODUCTION

In Manaus, capital of the Amazonas State, the consumption of tambaqui (*Colossoma macropomum*) is approximately 40.000 t year^{-1}, corresponding to a *per capita* consume of 17 kg habitant.year^{-1}, mostly deriving from fish farms (AMAZONAS, 2014). Such high

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consumption has increased with the birth of the Industrial Centre of Manaus, which intensified the people’s migration from rural areas to the capital, increasing the demand for high-quality food (GANDRA, 2010). However, the decline of natural fish stocks has led the government to regulate fishing activities by creating closed fishing seasons, diminishing the offer of fish to the population. In this sense, the “tambaqui curumim” (average weight from 350 to 700 g) has emerged as a good alternative to meet the demand created, due to the lack of small-sized fish during this closure period, supplying meal providers of the Industrial Centre of Manaus.

The tambaqui is a species native from the Amazon and Orinoco basins, with excellent production characteristics, such as rapid growth (VILLACORTA-CORREA, 1997), anatomical and physiological adaptation to low-oxygen environments (ARAUJO-LIMA and GOULDING, 1997) and tolerance to high densities (MELO et al., 2001; BRANDAO et al. 2004; GOMES et al., 2006; COSTA et al., 2016). Its rearing is performed in dams (MELO et al., 2001; GANDRA, 2010; LIMA et al., 2015), ponds (IZEL and MELO, 2004; GANDRA, 2010; LIMA et al., 2015; COSTA et al., 2016), streams or creeks (ARBELAEZ-ROJAS et al., 2002; LIMA et al., 2015) and net-tanks (BRANDAO et al., 2004; GOMES et al., 2006; GANDRA, 2010; LIMA et al., 2015). Rearing tambaqui in ponds is noteworthy, due to the high planktonic production verified in such environments (CAVERO et al., 2009; PAULA, 2009).

An interesting management tool that have been adopted is the production cost, which is used to show the viability of rearing systems (SCORVO-FILHO et al., 1999; ZETINA CÓRDOBA et al., 2006; CAMPOS et al., 2007), potential species (DOMINGUES et al., 2014; BRABO et al., 2015), handling adequacy and technologies (ANDRADE et al., 2005; AYROZA et al., 2005; FURLANETO et al., 2006), impact of diseases (FARUK et al., 2004) and infrastructure optimization (VERA-CALDERÓN and FERREIRA, 2004). The elevated demand for tambaqui curumim, favors both the upsurge of new producers and the possibility of growing, considering the existing ones. However, this is a market that lacks information, enabling fish farmers to make assertive decisions, thus decreasing possible marketing vulnerabilities. In this sense, an economic evaluation regarding the production systems used for tambaqui curumim is an alternative to generate information about the behavior of these enterprises regarding the market. This study aimed at performing an economic evaluation of the production of tambaqui curumim in ponds, developed in the metropolitan region of Manaus.

MATERIAL AND METHODS

The metropolitan region of Manaus was created on May 30, 2007 by the Law Nº 52/2007 and consists of eight municipalities in the state of Amazonas (Novo Airão, Presidente Figueiredo, Manacapuru, Manaus, Iranduba, Itacoatiara, Rio Preto da Eva, Careiro da Várzea), which are currently going through a process of conurbation, representing about 49% of the state's population (GANDRA, 2010).

Initially, the Executive Secretariat of Fisheries and Aquaculture of the Amazon - SEPA/SEPROR was contacted, in order to obtain informations and indications of fish farms that represents the production technologies used for tambaqui rearing in the metropolitan region of Manaus. Seven farms that produce tambaqui curumim were selected, all of which sell to several sales channels and possess different scales of production. These scales are based on the Resolution/CEMAAM/Nº 01/08 - from July 03, 2008, which classifies the fish farms as: micro - ME (< 2 ha of water; one fish farm; ME), small - SSE (2 to 10 ha of water; three farms; P1c, P2c and P3c), medium - MSE (10 to 50 ha of water; three farms; M1c, M2c and M3c) and large - LSE (>50 ha of water; not collected for lack of availability of producers to provide data) enterprises. The last prerequisite of the chosen farms was the possibility of gathering informations directly from the producers, regarding their farms and the adopted production processes by them.

All data were obtained by means of a semi-structured questionnaire, regarding production stages, cycles, handling methods, infrastructure, productive indexes and monetary expense. The data about productivity, expenses, infrastructure, marketing channels, zootechnical performance and prices of factors and products allowed the calculation of production cost and profitability indexes. Costs were determined based on the structure of Total Operational Cost (TOC), adding the Effective Operational Cost (EOC) with other costs that are not effectively monetary expenses. In the EOC, all expenses were considered and, as for other costs, depreciation and family labor. The EOC was obtained by adding up the costs with fingerlings, feed, hired labor, infrastructure maintenance, energy, fuel, bank interests, repairs, rural taxes, fertilization, liming and operating license. The infrastructure depreciation, equipment and utensils were calculated by the linear method (MATSUNAGA et al., 1976).

The production indexes were production site, productivity (t ha^{-1} year), production (kg $year^{-1}$), average final weight, production cycle (days), apparent feed conversion (AFC), specific growth rate ($SGR = \frac{\ln(mean\ final\ weight) - \ln(mean\ initial\ weight)}{production\ cycle\ in\ days}$) and number of cycles per year. The considered economic indicators were Total Operational Cost (TOC), Gross Revenue (GR = price * production), Operational Profit (OP = GR - TOC) and Profitability Index ($PI = \frac{OP}{GR} * 100$) (MARTIN et al., 1995). In order to determine the revenue, operational profit and profitability index, the proportion of fish destined to each marketing channel was considered. All used values in this study refers to January 2015. Regarding the fish farms that possesses more than one activity or product, costs were defined singularly to the production of tambaqui curumim, so that only the costs referring to this product were accounted.

RESULTS AND DISCUSSION

It was observed that the production of tambaqui curumim (350 to 700 g), was developed simultaneously with tambaqui "roelo" (> 1,5 kg) in the same pond, in 44.4% of the sampled farms (P1c, P2c, P3 and M2c). In these production systems, fish are reared until curumim pattern and, in average, 67% of fish are harvested, while the rest are kept in the pond and sold at a bigger size. The concomitant production (curumim plus roelo) is an interesting way of increasing productivity, reducing costs and meeting the demand for tambaqui curumim. However, this strategy was not sufficient to make the activity viable, considering the conditions it is performed.

The production of tambaqui curumim is performed with the initial stocking of 0,5 g fish, originating either from the private production sector or from fingerlings donations by the state government. After a period that varies from 180 (ME, P2c, M1c and M2c) to 330 days (P1c), fish are harvested with an average final weight between 450 g (P2c) and 700 g (M2c and M3c), with productivities ranging from 2,84 to 17,50 t ha^{-1} year (Table 1). The farms M1c and M2c presented the lowest means for AFC, but the average prices paid for feed (R$ kg^{-1}) were high, thus being a possible indicative of using feed of better quality. However, it is possible to observe that the price paid for feed is also a limiting factor for the activity's development in this region. In the region of Alta Floresta-MT, Munoz et al. (2014) observed that the production of tambaqui was not feasible, due to the region's geographic isolation, which does not have feed factories nearby, increasing feed costs.

Table 1. Production costs and profitability indexes for tambaqui curumim production, performed in ponds in the metropolitan region of Manaus, Amazonas, regarding January 2015.

Costs	**ME**	**SSE**			**MSE**			**Mean**
		P1c	**P2c**	**P3c**	**M1c**	**M2c**	**M3c**	
Effective Operational Cost (R$ kg^{-1})	**4,84**	**5,60**	**6,21**	**3,99**	**3,33**	**3,84**	**4,20**	4,57
Feed	3,34	4,61	5,28	3,58	2,88	2,68	3,17	3,65
Permanent Labor	0,62	-	-	0,14	0,23	0,38	0,63	0,28
Day Laborer	-	-	0,11	0,03	-	0,08	0,05	0,04
Fingerlings	-	-	0,13	-	0,06	0,13	0,14	0,07
Maintenance of Infrastructure	0,02	0,02	0,06	0,06	0,02	0,20	0,01	0,06
Energy	0,03	0,31	0,04	0,01	0,00	0,04	0,09	0,08
Fuel	0,01	0,47	0,38	0,09	0,06	0,28	0,05	0,19
Operating License	-	-	0,01	0,00	0,01	-	-	0,00
Repairs	-	-	-	-	0,00	-	-	0,00
Rural Land Tax	-	0,00	0,00	-	0,00	-	-	0,00
Fertilization	0,11	0,01	0,03	0,00	0,03	-	-	0,03
Liming	0,71	0,18	0,09	0,09	0,03	0,05	0,06	0,17
Bank Interests	-	-	0,08	-	-	-	-	0,01
Other Costs (R$ kg^{-1})	**1,19**	**1,00**	**1,32**	**0,09**	**0,33**	**1,41**	**0,22**	**0,79**
Depreciation	0,74	0,42	0,54	0,09	0,33	0,76	0,22	0,44
Family Labor	0,45	0,58	0,78	-	-	0,65	-	0,35
Total Operational Cost (R$ kg^{-1})	**6,03**	**6,60**	**7,53**	**4,08**	**3,66**	**5,25**	**4,42**	**5,37**
Water Blade Area (ha)	0,34	2,10	4,50	1,60	16,00	2,28	6,00	4,69
Density (fish m^{-2})	0,63	1,20	0,60	1,50	1,50	0,70	1,00	1,02
Production Cycle (days)	180	330	180	240	180	240	180	218,57
Productivity (t ha^{-1} year)	6,68	6,43	2,84	5,63	17,50	6,91	7,00	7,57
Average Final Weight (g)	500	550	450	500	500	700	700	557,14
Apparent Feed Conversion	2,25	3,23	2,96	2,43	1,74	1,46	2,15	2,32
Specific Growth Rate (%)	3,84	2,12	2,67	2,88	3,07	3,02	4,02	3,09
Average Sales Price (R$ kg^{-1})	4,00	3,50	3,50	3,50	3,80	3,80	4,25	3,76
Operational Profit (R$ kg^{-1})	-2,03	-3,10	-4,03	-0,58	0,14	-1,45	-0,17	-1,60
Profitability Index (%)	-	-	-	-	3,65	-	-	-
Breakeven Productivity (t ha^{-1} year)	10,07	9,41	3,87	6,55	16,86	9,54	6,24	8,93

Legend: ME: micro enterprise; SSE: small-sized enterprise; MSE: medium-sized enterprise. The dashes indicate a “zero” value. The values 0,00 are different than zero, but very close to zero.

The effective operational cost (EOC) represented, in average, 86.42% of the total operational cost (TOC). Feed was the most representative item in TOC, with a participation ranging from 51.09% (M2c) to 87.75% (P3c), followed by labor costs (12.11% in average) and fixed capital depreciation (8.03% in average). The feed participation in TOC obtained in this work, also were observed in other studies that reported variations from 62% to 84% on cost, due to costs' structure, production stage and density (MEROLA and PAGANFONT, 1988; MELO et al., 2001; CASTRO et al., 2002; BARROS and MARTINS, 2012; COSTA et al., 2016). In this study, M2c and ME were two exceptions; regarding M2c, feed participation was 51.09% and depreciation 14.44% in TOC. As for ME, feed participation was 55.45% in TOC and 12.25% of depreciation in TOC. These results indicate that the farmer is working with a high degree of idleness, confirmed by the fact that the minimum necessary production to match the gross revenue with the TOC (9.45 t ha^{-1} year for M2c and 10.07 t ha^{-1} year for ME) were higher than the obtained productivity (M2c: 6.91 t ha^{-1} year; ME: 6.68 t ha^{-1} year).

Despite having the best AFC, the prejudice observed in M2c is related to the sales weight of fish, because this enterprise sells its fish with 700 g, but at the price of smaller fish. Regarding tambaqui production, negative results have been associated to low technological levels, mainly related to the absence of specific feeds and improved lineages (PEDROZA FILHO et al., 2016). These factors minimize the feed utilization, increasing AFC, directly affecting production costs and, consequently on the enterprise's profitability (PEDROZA FILHO et al., 2016), as observed in P1c and P2c, as both presented the lowest values of SGR, high values of AFC and also the greatest losses (R$ -3.10 kg^{-1} in P1c and R$ -4.03 kg^{-1} in P2c), indicating that a more efficient feed management can revert these results.

The greatest production cost was observed for P2c, which had an AFC above two, lower productivity and stocking density. The observed differences in stocking density, rearing period and mean final weight reflected in a wide variation of both specific growth rate and AFC values. The M1c was the only viable enterprise, despite selling all its production to a fish processing plant, which is the marketing channel with the lowest remuneration. Moreover, this enterprise has the largest area destined to the production of the pattern curumim. In this farm, it was possible to observe both greatest stocking densities and productivities, such as lowest cycles, AFC and TOC. Its production is staged, which allows periodic harvests throughout the year. This positive economic result was achieved by its technical result, not by sales price. The manager of this propriety is a formed professional with fish farming experience, who managed to convert this knowledge into the highest productivity (17.50 kg ha^{-1} year) and the second better feed conversion (1,74), due to a staggered production and sufficient use of aerators and high quality feed.

The wide variation in productive and economic data among the enterprises, evidences the existing diversity of handling methods and the singularity that exists in each fish farm.

Considering the studied region, where fish farming is typically familiar and the used areas are smaller than 5 ha of water blade (GANDRA, 2010; LIMA et al., 2015), it is possible to affirm that the production of tambaqui curumim was not viable in small and medium production scales, thus bringing the need for improvements in production processes, aiming at decreasing prices and increased profitability. These improvements can be achieved by obtaining a better AFC, when using a specific feed for this species; using aerators correctly; adopting a staggered production, as observed in M1c; having more control of the production process, specially related to daily handling and water quality and adequately determining production costs with an effective control of expenses. Increasing production scales have been reported as a way of increasing profitability in aquaculture (SCORVO FILHO et al. 1999; ASCHE et al. 2008; ILIYASU et al. 2014; YIN et al. 2014; SABBAG and COSTA, 2015), as well as the activity's professionalization, by means of exploring the manager's previous experiences (SCORVO FILHO et al. 1999; VERA-CALDERÓN and FERREIRA 2004).

In 85.71% of the farms, the amount paid for the generated product was not sufficient to cover the total operational cost (Table 1). The two enterprises (P1c and P2c) that suffered the greatest losses were the same that presented the lowest values of SGR and final sales prices, besides having the highest values of AFC. In order for the enterprises to present positive operational profits, it would be necessary to increase productivity by an average of 7.93%. Asche et al. (2008) reported that one of the ways of increasing productivity and reducing costs consists in the use of technological innovations, improving the productive process. However, the lack of knowledge, resources and credit restrictions are limiting factors, especially for small or family productions, for the adoption of new technologies, or singularly using adequate technology.

CONCLUSION

The production of tambaqui curumim in the metropolitan region of Manaus has been shown to be a high-risk activity, since only a medium-sized company (M1c) obtained profit (3.65%), which is associated to a staggered production, efficient use of aerators and high quality feed. The other two medium-sized enterprises, despite having an AFC below average, sells a product of 700 g by the price of 500 g fish, which led to a financial prejudice. On the other hand, micro and small-sized companies uses low quality feed, increasing feed conversion to values superior to 2.3, which when associated to low productivity, leads to great losses

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