

## PERFORMANCE OF JUVENILE TAMBAQUI IN CAGE, UNDER DIFFERENT FEED RATES\*

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### ABSTRACT

This study took place at the Federal University of Rondônia Foundation, at the Carlos Eduardo Matiaze Fish Farming Base, in Presidente Médici, state of Rondônia, Brazil, aiming to evaluate the performance of juvenile tambaqui fed with different feed rates in relation to body weight (BW), grown in cages. It was used 180 juvenile fishes, with mean initial weight of  $0.033 \text{ kg} \pm 0.001 \text{ kg}$  distributed in 20 cages with  $1 \text{ m}^3$  each arranged in a  $1000 \text{ m}^2$  ( $20 \text{ m} \times 50 \text{ m}$ ) hatchery and  $1.64 \text{ m}$  deep. The experimental design was randomized with five treatments in different feed rates (FR) and four replications (2, 4, 6, 8, and 10% of BW). The parameters were body length (m), head length (m), body height (m), BW (kg), and feed conversion. It was also performed the sensory evaluation of baby fish. The best performance under the different feed rates provided daily was 6%; we observed greater productivity in relation of time at this rate. On the other hand, the sensorial analysis of tambaqui baby fish cultivated in cages at 10% feed rate was the favorite of consumers because of the soft and succulent characteristic of the meat.

**Key words:** feeding; *Colossoma macropomum*; hedonic scale; nutrition; fish farming.

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### DESEMPENHO PRODUTIVO DE JUVENIS DE TAMBAQUI EM TANQUE-REDE, SOB DIFERENTES TAXAS DE ALIMENTAÇÃO

#### RESUMO

O estudo foi desenvolvido na Fundação Universidade Federal de Rondônia, na Base de Piscicultura Carlos Eduardo Matiaze, situada no município de Presidente Médici/RO com o objetivo de avaliar o desempenho produtivo de juvenis de tambaqui alimentados com diferentes taxas de alimentação em relação ao peso corporal (PC), cultivados em tanques-rede. Foram utilizados 180 juvenis, com peso médio inicial de  $0,033 \text{ Kg} \pm 0,001 \text{ Kg}$  distribuídos em 20 tanques - rede de  $1 \text{ m}^3$  dispostos em viveiro de  $1000 \text{ m}^2$  ( $20 \text{ m} \times 50 \text{ m}$ ) e profundidade de  $1,64 \text{ m}$ . O delineamento experimental foi ao acaso com cinco tratamentos com diferentes taxas de alimentação (TA) e quatro repetições (2, 4, 6, 8 e 10% do PC). Os parâmetros avaliados foram comprimento do corpo (m), comprimento da cabeça (m), altura do corpo (m), PC (Kg) e conversão alimentar. A avaliação sensorial do "baby fish" também foi realizada. Os resultados deste trabalho demonstraram que o melhor desempenho produtivo sob as diferentes TA fornecidas diariamente foi a de 6%, nesta taxa foi obtido maior produtividade em relação ao fator tempo. Já a análise sensorial do tambaqui baby fish cultivado em tanques-rede a TA de 10% foi o preferido dos consumidores pela característica macia e suculenta da carne.

**Palavras-chave:** arraçamento; *Colossoma macropomum*; escala hedônica; nutrição; piscicultura.

#### INTRODUCTION

Fish farming is the world's largest agrarian activity (PIANESSO *et al.*, 2013; XAVIER *et al.*, 2016). The harvest of aquatic organisms stands out as the fastest growing animal production sector in the world (CARVALHO *et al.*, 2013). The Food and Agriculture Organization of the United Nations (FAO) highlights Brazil as one of the world's largest fish producers, with an estimated 20 million tonnes by 2030 (FAO, 2015).

In the Brazilian Amazon region, fish is the main source of animal protein consumed by its inhabitants (ARAÚJO and FREITAS, 2009; PEREIRA JUNIOR *et al.*, 2013).

Because of the great population growth of the North region of the country, the demand for fish has increased and generated greater pressure on natural stocks, reducing the amount of fish and raising the price of the preferred species for consumption. Thus, regional fish farming is an activity with potential to minimize the effects of predatory exploitation of some fish species (PEREIRA JUNIOR *et al.*, 2013).

Tambaqui (*Colossoma macropomum*, Cuvier 1818) stands out among the native fish species with potential for captive cultivation. This fish has excellent performance for cultivation in different breeding systems, and it is the most cultivated one in northern Brazil (CHELLAPPA *et al.*, 1995; VAL *et al.*, 2000; CHAGAS *et al.*, 2006).

In Brazil, cage fish farming is in rapid expansion; it is considered an investment alternative with lower cost and faster implementation (ONO and KUBITZA, 2003). Tambaqui breeding in cages in Central Amazonian lowland lakes have reached high yield (CHAGAS *et al.*, 2005, 2007), being pointed as a promising alternative activity for the riverside Amazon populations.

Despite the understanding on the adequate stocking density in the rearing tambaqui phase and cage volume towards higher yield, information on feed rate for improved food use and yield, in this system, is still scarce (BRANDÃO *et al.*, 2004; GOMES *et al.*, 2004; SANTOS *et al.*, 2013).

Feed is one of the most costly items in the various fish production systems, with 50 to 90% of the total cost (ANDRADE *et al.*, 2005). The adoption of measures aimed at reducing this cost is necessary an adequate feed management.

Tambaqui growth is directly related to the diet used in the cultivation of the species. The nutritional value of the feed is not only the nutrient content but also the ability of the animal to assimilate the nutrients.

Therefore, this work aimed to evaluate the performance of juvenile tambaqui fed with different feed rates in relation to body weight, grown in cages.

## METHODS

### Study area

The study was carried out at the Federal University of Rondônia Foundation, Presidente Médici Campus, at Carlos Eduardo Matiaze Fish Farming Base, in Presidente Médici, state of Rondônia, Brazil, from December 2013 to February 2014, amounting to 60 days of assessment. The Committee of Ethics in the Use of Animals approved the research – protocol PP 018-2014.

### Experimental design

The study was conducted on 20 cages of 1.0 m<sup>3</sup> (1.0 m x 1.0 m x 1.0 m) with 2.0 mm mesh size. The cages were installed in a 1000 m<sup>2</sup> (20 m x 50 m) hatchery and 1.64 m deep. We distributed 180 juvenile fishes of the *C. macropomum* species, with initial mean weight of 0.033 ± 0.001 kg, in a completely randomized design with five treatments in different feed rates and four replications; the stocking density was eight juvenile fishes per m<sup>3</sup>. Commercial feeding (Table 1) had 40% crude protein (EL-SAYED and TESHIMA, 1992), offered daily in the proportions of 2, 4, 6, 8, and 10% of BW distributed in three daily feeding times at 8 a.m., 12 p.m., and 6 p.m.

Adjustment of feed rates in relation to BW was performed by means of intermediate weighing at 25 days of experimentation and at the daily growth rate of 2.5% of BW.

**Table 1.** Guarantee levels per kilogram of feed.

Nutrient	Amount	Nutrient	Amount
Ethereal extract (min), g	80.0	Choline (min), mg	300.0
Crude fiber (max), g	40.0	Biotin (min), mg	60.0
Mineral matter (max), g	150.0	Niacin (min), mg	52.0
Crude protein (min), g	400.0	Pantothenic Acid (min), mg	4.0
Humidity (max), g	90.0	Vitamin A (min), IU	30.0
Calcium (min), g	20.0	Vitamin B1 (min), mg	2.0
Calcium (max), g	35.0	Vitamin B12 (min), mg	5.0
Phosphorus (min), g	15.0	Vitamin B2 (min), mg	4.0
Zinc (min), mg	180.0	Vitamin B6 (min), mg	2.1
Iron (min), mg	98.0	Vitamin D3 (min), IU	6.000
Copper (min), mg	10.0	Vitamin E (min), IU	50.0
Manganese (min), mg	10.5	Vitamin K3 (min), mg	2.5
Selenium (min), mg	0.6	Vitamin C (min), mg	550.0
Iodine (min), mg	0.4		

Ingredients: transgenic ground whole maize (*Bacillus thuringiensis*), transgenic soybean bran (*Agrobacterium tumefaciens*), meat and bone meal, fish meal, calcitic limestone, poultry viscera oil, wheat bran, rice bran, sodium chloride (common salt), vitamin and mineral premix (vitamins, niacin, choline chloride, copper sulfate, iron sulfate, cobalt sulfate, manganese sulfate, calcium iodate, sodium selenite, fungistatic (propionic acid), antioxidant (BHT)).

Biometric assessments were performed every 25 days for body length (m), head length (m), body height (m), and BW (kg).

Fish seeds were weighed every 25 days to calculate the average daily weight that is obtained by the difference between the final BW and the initial BW divided by the number of assessment days.

Apparent feed conversion was evaluated by dividing the amount of feed supplied daily by the daily weight gain of the fish.

Limnological data (temperature, dissolved oxygen, pH, and conductivity) were measured in a multiparameter probe (PRO PLUS, YSI, Derry, UK) and later used to maintain the water quality of the cage.

## Sensory analysis

The design was entirely randomized at the feed rates of 2% and 10% of BW and ten replications.

At 60 days, the juvenile fishes (Baby fish, weight  $\pm$  0.250 to 0.500 kg) were killed by thermal shocks in a Styrofoam box with water and ice (5°C), followed by evisceration. Baby fish is a denomination used for fish of up to 0.5 Kg. We used pliers to remove the leather and scales; this was a fast and efficient procedure in order not to damage the fillet or expose the fish as much as possible to higher temperatures. The removed carcasses were frozen at -20°C until analysis.

Sensory analysis took place at the Fish Farming Laboratory (LPA). The carcass trays from each treatment were thawed under refrigeration and roasted (George Foremann grill), concomitantly, for 20 minutes. The roast trays were offered to 40 tasters related to the fish farming activity; 55% of them were female and 45% male, aged between 19 and 38 years.

The tests occurred in a white light benchtop and the analysis was done using the methodology of Stone and Sidel (2004). The evaluators answered a questionnaire in which they evaluated the following items: flavor, aroma, texture, and overall impression. The items

were evaluated in a hedonic scale of 9 points (9 for “I liked it very much”, 8 for “I liked it a lot”, 7 for “I liked it moderately”, 6 “I liked it slightly”, 5 for “I neither liked nor disliked”, 4 for “I disliked it slightly,” 3 for “I disliked it moderately,” 2 for “I disliked it very much”, and 1 for “I disliked it extremely”) and followed by justification.

## Statistical analysis

The treatments averages were analyzed by analysis of variance and regression, using linear (L), quadratic (Q), and cubic (C) orthogonal contrasts, with  $p=0.05$ . We used the SAS 9.0 Statistical Program. The statistical analysis of the data of the sensory analysis occurred in a descriptive way, with the grouping of the characteristics of preference according to frequency.

## RESULTS

### Performance

The final BW, head length, final body length, and weight gain variables showed a linear effect ( $p<0.05$ ) in relation to feed rates (FR). However, the final BW showed a decrease from the FR of 6%. The gain BW was significant when compared 2 to 6% FR. The gain BW is lower when compared FR of 6% to 10%. The other biometric variables were not influenced ( $p>0.05$ ) by the increase in feed supply in relation to BW (Table 2).

The average daily gain increased as the increase of FR showed a linear increasing effect ( $p<0.05$ ). However, this increasing effect had reduced intensity at 6% of BW; the linear equation shows that for every 1% increase in FR, there was an increase of 0.0003 kg in the average daily gain of the fish. With the increase of 66.70% in FR from 6% to 10%, the growth related to the average daily gain of the fish was only 5.8% (Table 2).

**Table 2.** Means of initial and final body weight, head and body length, initial and final height, average daily gain, contrasts, and coefficient of variation (CV) for different feed rates.

Variable	Feed rate (%) <sup>1</sup>					Contrast <sup>2</sup>			CV (%)
	2	4	6	8	10	L	Q Q	C	
Initial body weight (kg)	0.034	0.032	0.033	0.032	0.034	-	-	-	-
Final body weight (kg) <sup>3</sup>	0.17	0.233	0.297	0.287	0.315	*	ns	ns	14.37
Initial head length (m)	0.038	0.037	0.037	0.036	0.037	-	-	-	-
Final head length (m)	0.059	0.062	0.066	0.065	0.067	*	ns	ns	5.52
Initial body length (m)	0.101	0.099	0.099	0.098	0.1	-	-	-	-
Final body length (m)	0.186	0.204	0.217	0.215	0.223	*	ns	ns	4.2
Initial body height (m)	0.048	0.047	0.047	0.048	0.047	-	-	-	-
Final initial body height (m)	0.08	0.87	0.094	0.094	0.098	ns	ns	ns	5.03
Average daily gain (kg)	0.002	0.003	0.004	0.004	0.005	ns	ns	ns	17.61

<sup>1</sup>Feed rate in relation to body weight of juvenile tambaqui; <sup>2</sup>L = linear effect, Q = quadratic effect, and C = cubic effect significant at 1% (\*) or 5% (\*\*); ns = non-significant at 1 or 5%; <sup>3</sup>Final body weight (kg) =  $0.157 + 0.017 \text{ FR}$  ( $R^2 = 83.37$ ); Final head length (m) =  $0.058 + 0.0009 \text{ FR}$  ( $R^2 = 82.62$ ); Final body length (m) =  $0.183 + 0.043 \text{ TA}$  ( $R^2 = 82.53$ ); Final body height (m) =  $0.078 + 0.002 \text{ FR}$  ( $R^2 = 86.65$ ); Average daily gain (kg) =  $0.002 + 0.0003 \text{ FR}$  ( $R^2 = 85.78$ ).

The variables of carcass, organ and viscera, and head weight, and carcass yield showed a linear effect ( $p < 0.05$ ) in relation to FR. However, carcass, organ and viscera, and head weight decreased when FR increased from 6% to 8% and had a sudden increase when FR increased from 8 to 10% in relation to BW (Table 3).

Feed conversion had an increasing linear effect ( $p < 0.05$ ). As increased of one percentage unity in the feed rate, there was a 0.0002 kg increase in daily fish feed consumption; for 2% (BW) FR, feed conversion was 0.0006 kg kg<sup>-1</sup>, that is, food intake was low, indicating high participation in total diet of the primary production, comprised by zoo- and phytoplankton, with more FR, increased food intake, reaching 0.0024 kg<sup>-1</sup> apparent feed conversion with 10% (BW) FR, because of the fed leftover in the cages (Table 4).

That also happened with food intake in kilograms per fish, which showed a linear increasing effect ( $p < 0.05$ ), indicating that for each percentage unit of increase in the feed rate there was a daily increase of 0.0012 kg of feed per individual. At 2% (BW) FR individuals had an average consumption of 0.0013 kg, while at 10% (BW) FR the average consumption of the fish was 0.0113 kg feed day<sup>-1</sup>.

Sensory analysis

The acceptability of baby fish tambaqui was high among the tasters regardless of the adopted food system (Figure 1), with a preference of 87.5% and 92.5% for the feed rates of 2% BW day<sup>-1</sup>

**Table 3.** Means for the variables of carcass, organ and viscera, and head weight, and carcass yield, contrasts, and coefficient of variation (CV) for juvenile tambaqui fed with different feed rates.

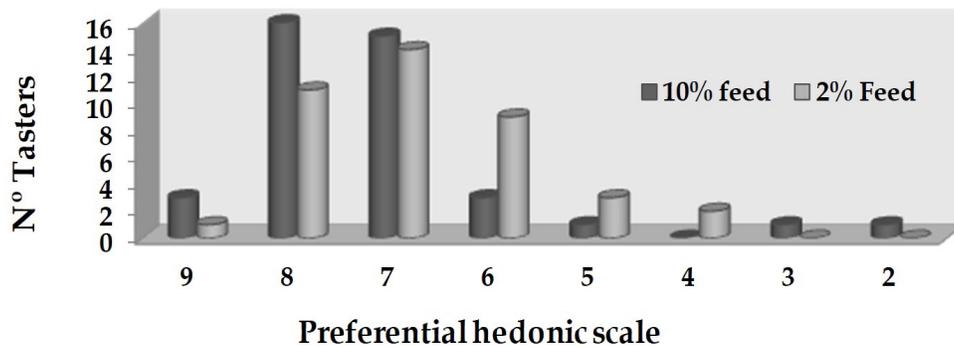
Variable	Feed rate (%) <sup>1</sup>					Contrast <sup>2</sup>			CV(%)
	2	4	6	8	10	L	Q	C	
Carcass (kg) <sup>3</sup>	0.102	0.142	0.185	0.177	0.198	*	ns	ns	14.24
Organs and viscera (kg) <sup>3</sup>	0.011	0.016	0.021	0.019	0.021	*	ns	ns	15.23
Head (kg) <sup>3</sup>	0.043	0.058	0.071	0.068	0.075	*	ns	ns	16.07
Carcass yield (%) <sup>3</sup>	64.77	65.85	66.8	66.9	67.27	*	ns	ns	1.83

<sup>1</sup>Feed rate proportional to the body weight of juvenile tambaqui; <sup>2</sup> L = linear effect, Q = quadratic effect, and C = cubic effect, significant at 1% (\*) or 5% (\*\*); ns = non-significant at 1 or 5%; <sup>3</sup>Carcass (kg) = 0.092 + 0.011FR (R<sup>2</sup> = 81.92); Organs and Viscera (kg) = 0.011 + 0.001 FR (R<sup>2</sup> = 76.87); Head (kg) = 0.041 + 0.004 FR (R<sup>2</sup> = 79.72); Carcass Yield (%) = 0.065 + 0.0003 FR (R<sup>2</sup> = 90.48).

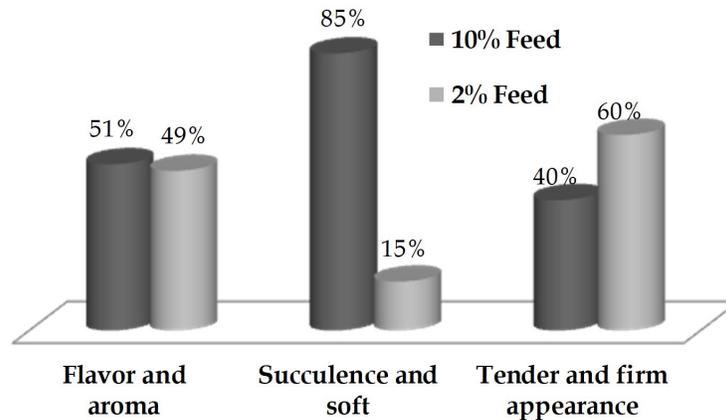
**Table 4.** Means of apparent feed conversion and supply of feed, orthogonal contrasts, and coefficient of variation (CV%) for juvenile tambaqui fed with different feed rates.

Variable	Feed rate (%) <sup>1</sup>					Contrast <sup>2</sup>			CV (%)
	2	4	6	8	10	L	Q	C	
Apparent feed conversion <sup>3</sup>	0.59	1	1.28	1.85	2.42	*	ns	ns	15.22
Supply of feed in grams per fish per day <sup>-1 4</sup>	1.32	3.32	5.65	7.83	11.3	*	ns	ns	14.57

<sup>1</sup>Feed rate proportional to body weight of juvenile tambaqui; <sup>2</sup>Significant at 1% (\*) or 5% (\*\*); ns = non-significant at 1 or 5%; <sup>3</sup>Apparent feed conversion = 0.2234 + 0.1835 FR (R<sup>2</sup> = 100); <sup>4</sup> Supply of feed in grams per fish per day<sup>-1</sup> = -1.4643 + 1.2297 FR (R<sup>2</sup> = 100%).



**Figure 1.** Assessment of the acceptance of consumers of baby fish tambaqui at different feed rates. Items were evaluated in a 9-point hedonic scale: 9 for “I liked it very much”, 8 for “I liked it a lot”, 7 for “I liked it moderately”, 6 “I liked it slightly”, 5 for “I neither liked nor disliked”, 4 for “I disliked it slightly”, 3 for “I disliked it moderately” 2 for “I disliked it very much”, and 1 for “I disliked it extremely”.



**Figure 2.** Proportion of tasters assessing taste, texture, and overall appearance of the meat.

and 10% BW day<sup>-1</sup>, respectively, with opinions concentrated in the hedonic scale of score 6 to 9.

For feed systems, most tasters scored 6 to 9, with “I liked it very much” to “I liked it slightly”, for baby fish fed with 10% BW day<sup>-1</sup>, accounting for 85% of the opinions compared to 65% for taste, which received 2% of BW (Figure 2). The justification of preference ranked the meat as softer, tastier, and more succulent.

On the other hand, the sensorial preference for baby fish fillet in the FR 2% BW day<sup>-1</sup> showed a high number of tasters who liked it slightly, compared to the preference for the fish fed with a higher feed supply (2% vs. 10%), justifying more tender characteristic (Figure 2), a more tambaqui characteristic taste.

## DISCUSSION

Food management is very important in fish farming. The adoption of adequate feeding strategies at different stages of fish life improves their growth, survival rate, and feed conversion, thus contributing to reduce feed waste which impairs the quality of the culture water and production (CHO *et al.*, 2003; CHAGAS *et al.*, 2007).

Feed rate influences both the growth and feed efficiency of farmed fish and their growth is directly proportional by the feed rate (NG *et al.*, 2000; MIHELAKAKIS *et al.*, 2002; EROLDogan *et al.*, 2004).

Tambaqui final weight showed a linear increasing effect ( $p < 0.05$ ) as the feed supply increased. The productive efficiency was higher in pacus (*Piaractus mesopotamicus*) at the feed rate of 5%, compared to the rates of 1% and 3% BW day<sup>-1</sup> (BORGHETTI and CANZI, 1993). That is, the higher the nutrient input, especially energy and protein, the greater weight gain for fish.

However, despite the linear increasing effect with feed supply, the magnitude of the final weight begins to decrease from the FR of 6% of supply relative to BW. Our data corroborates with literature, in which a 5% (BW) FR of is recommended for juvenile tambaqui, ensuring final weight consistent with the potential production of tambaqui (CHAGAS *et al.*, 2005, 2007). A study on the effect of different feed rates on carp fish seeds (*Ctenopharyngodon idella*)

has concluded that the supply of food at 6% of BW is better suited for improved performance and survival (MARQUES *et al.*, 2004).

In farming environments, production depends on balanced feed (TAKAHASHI, 2005); however, expenditure with them represents 50-80% of production cost (PEREIRA FILHO, 1995). Therefore, experiments related to feed use should take into account the performance (CHAGAS *et al.*, 2005) and, especially, carcass yield, which compensates the feed costs. The evaluation of fish carcasses is one of the great economic and production importance; it is possible to estimate the yield for the fish farmer and for the fish processing industry. The useful part of the fish, also called carcass or eviscerated fish, is the body part ready for consumption and/or industrialization, given by the slaughtered animal, after bleeding, skinning, and scaling, being eviscerated and without the head. Carcass yield at the tested FR were approximately 60 to 70%; these results corroborate the literature (FERNANDES *et al.*, 2010).

Growth is not the only variable that should be considered in determining optimal feed rate. Feed conversion efficiency is also a good indicator; the percentage of feed conversion efficiency decreases with increasing feed rates (NG *et al.*, 2000; EROLDogan *et al.*, 2004). Feed conversion has a direct effect on production costs because feeding represents approximately 30-60% of the operational costs of fish farming in cages (HUGUENIN, 1997).

Feed conversion is an index that can be used as an indicator of feed quality (KUBITZA, 2003), because it represents the efficiency of the conversion of feed into fish biomass. Therefore, the apparent feed conversion rate (AFC) close to 2 is a good reference standard (ARBELÁEZ-ROJAS *et al.*, 2002). Apparent feed conversion was low in this study and showed a linear increasing effect, according to each 1% of increase in FR, with AFC from 0.64 to 2.06% of the FR used, being below the indexes obtained by FERNANDES *et al.* (2010).

CHAGAS *et al.* (2007) have observed in tambaquis cultivated for 150 days a conversion of 1.98 for 1% BW day<sup>-1</sup>, 4.86 for 3% BW day<sup>-1</sup>, and 7.07 for 5% BW day<sup>-1</sup>. These values for conversion were very high and are not indicated for fish culture.

Fish consumption is one of the fastest growing food segments in Brazil (BORGES *et al.*, 2013). To improve the sensorial quality

of food products, the evaluation of the acceptance of consumers is important, as well as the identification of the sensory characteristics of products that influence preference (HOUGH *et al.*, 2006; BORGES *et al.*, 2013). The analysis allows us to know the degree of acceptance or preference of a group of tasters using a hedonic scale of nine points, which is the most applied scale, given its simplicity and reliability and the validity of the results. Thus, we can transform subjective data into objective data and obtain important information from the consumer market of a given product (STONE and SIDEL, 2004).

Through the hedonic scale, the tasters accepted tambaqui Baby Fish, and the results are concentrated between the 6 and 9 scale. BORGES *et al.*, (2013), indicates the preference in the scale 6.

Tambaqui Baby Fish, having good acceptance by the consumers, is very important for tambaqui chain production, because it is an alternative commercialization niche for the fish farmer and the industry. Studies on tambaqui acceptance, and even about freshwater fish acceptance in general are scarce in the literature.

Thus, the results of this study have great importance directly about product yield and acceptability. Correct feed handling is essential to optimize yield. In addition to causing metabolic-digestive changes, excess feed implies of the water quality deterioration, while underfeeding results in low growth rate with a marked variation in fish size (CYRINO *et al.*, 2010). There are many factors that influence feed intake rate; therefore, feed rates must be adjusted according to the individual conditions of each culture unit (RODRIGUES, 2014). The preference of consumers is necessary to understand the market and to have greater profitability.

## CONCLUSIONS

The best performance under different daily feed rates was 6% of BW. At this rate it was obtained higher yield in relation to time for fish farmed at the density of eight fish per m<sup>3</sup> in cages.

Tambaqui Baby Fish cultured in cages at the feed rate of 10% BW day<sup>-1</sup> was preferred by consumers because of the soft and succulent characteristic.

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