Residue from the extraction of oil from the Brazil Nut in diets for Tambaqui juveniles

Resíduo da extração do óleo da Castanha do Brasil em dietas para juvenis de Tambaqui

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ABSTRACT
The parameters of water quality, productive performance and economic viability were evaluated in tambaqui juveniles fed with different levels (0, 15, 25 and 35%) of Brazil nut meal (BNM). The water parameters measured were: surface temperature (TEMP), dissolved oxygen (OXY), hydrogenic potential (pH), total ammonia (AMO), alkalinity (ALK), hardness (HAR) and nitrite (NIT). Weight gain (WG), specific growth rate (SGR), feed intake (FI), apparent feed conversion (AFC), condition factor (K), daily feed intake (DFI) and daily weight gain (DWG) was avaluated. The cost of feed per kilogram consumed (CF US$/kg), cost of feed per kilogram of live weight gain (CF kg/LWG), economic efficiency index (EEI) and cost index (CI) were evaluated. TEMP, AMO, NIT, HAR did not differ (P>0.05), the means were 26.8°C, 0.16 mg L^{-1}, 0 mg L and 17.8 mg L^{-1}, respectively. The pH differed (P<0.05) and the treatment with 35% BNM was lower (6.5) when compared to the control (6.7). There was a decrease (P<0.05) in the levels of ALK and a linear increase (P<0.05) for the levels of OXY. The addition of BNM in the diet changed (P<0.05) the WG, SGR, FI, AFC, K, DFI and DWG. There was a downward trend (P<0.05) in the CF US$/kg, CF kg/LWG and CI and a linear increase (P<0.05) in the EEI. The BNM improved the production rates and changed the parameters of water quality, the inclusion of up to 35% of the BNM reduces the cost of production of feed and tambaqui juveniles.

Keywords: alternative food, food conversion, zootechnical performance, economic efficiency, feed.

RESUMO
Os parâmetros da qualidade da água, desempenho produtivo e viabilidade econômica foram avaliados em juvenis de tambaqui alimentados com diferentes níveis (0, 15, 25 e 35%) do farelo da castanha-da-amazônia (FCA). Foram mensurados os parâmetros da

água: temperatura superficial (TEMP), oxigênio dissolvido (OXI), potencial hidrogeniônico (pH), amônia total (AMO), alcalinidade (ALC), dureza (DUR) e nitrito (NIT). Avaliaram-se o ganho de peso (GP), taxa de crescimento específico (TCE), consumo de ração (CR), conversão alimentar aparente (CAA), fator de condição (K), consumo de ração diário (CRD) e ganho de peso diário (GPD). Avaliaram-se o custo da ração por quilograma consumido (CR US$/kg), custo da ração por quilograma ganho de peso vivo (CR kg/PV), índice de eficiência econômica (IEE) e índice de custo (IC). A TEMP, AMO, NIT, DUR não diferiram (P>0,05) as médias foram de 26,8°C, 0,16 mg L^{-1}, 0 mg L e 17,8 mg L^{-1}, respectivamente. O pH diferiu (P<0,05) e o tratamento com 35% de FCA foi menor (6,5) quando comparado ao controle (6,7). Houve diminuição (P<0,05) nos teores de ALC e aumento linear (P<0,05) para os teores de OXI. A adição do FCA na ração alterou (P<0,05) o GP, TCE, CR, CAA, K, CRD e GPD. Houve tendência de queda (P<0,05) no CR US$/kg, CR kg/PV e IC e aumento linear (P<0,05) do IEE. O FCA melhorou os índices produtivos e alterou os parâmetros da qualidade da água, a inclusão de até 35% do FCA reduz o custo de produção das rações e de juvenis de tambaqui.

Palavras-chave: alimento alternativo, conversão alimentar, desempenho zootécnico, eficiência econômica, ração.

1 INTRODUCTION

Tambaqui - *Colossoma macropomum* (CUVIER, 1816), is a native species of economic importance to the Amazon region, being the most cultivated species in Brazilian territory Associação Brasileira da Piscicultura (PEIXE BR) (2019). However, the high cost of food is a major obstacle in intensive fish production systems, reaching 80% of the total production costs.

Thus, research that seeks replacements for the main components of fish feed with lower economic value and that can provide the nutritional and sensory characteristics necessary to the fish are, according to Souza and Leite (2016) essential. These potential foods can be used as ingredients, reducing the cost of the feed and increasing the producer's profits.

In the Amazon region, the residues from the oil industry of the Brazil nut (*Bertholletia excelsa*, also known as Amazon nut) stand out, which can be an alternative in food formulations, with ecological and economic purposes, reducing the cost of food without causing disturbances in the metabolism of fish (SILVA; PINTO & CARVALHO, 2016).

The Brazil nut meal (BNM) has great nutritional value with high values of lipids (35.33%) and proteins (37.54%) (SOUZA et al., 2016). In addition, it is a product of plant origin, which does not incur a health risk, as observed with products of animal origin, such as bone meal and blood meal (BEZERRA et al., 2014).

Given the benefits of this alternative ingredient, combined with its easy acquisition in the region of Sena Madureira-Acre, the objective was to evaluate the productive performance, parameters of water quality and the economic viability of diets containing different levels of inclusion of BNM in the diet of tambaqui juveniles.

2 MATERIAL AND METHODS

All management practices involving animals were approved by the Ethics Committee on the Use of Animals/IFAC (CEUA) (Process Nº. 005/2018).

The research was carried out on a rural property in the municipality of Sena Madureira - Acre, Brazil, located in the Southwest of the Amazon, at an altitude of 150m, between the coordinates of 68°39'25" south latitude and 68°39'5" west longitude. The region has an Am climate, defined as tropical, an average annual temperature of 24.5 °C, annual rainfall above 1,600 mm, the rainy season comprises the months from November to April, and a less rainy season from June to September. (ACRE, 2020).

The experiment lasted 90 days, with seven days for acclimatization and adaptation of the animals to the diet and experimental conditions. The experimental design used was completely randomized, with four levels of BNM inclusion (0, 15, 25 and 35%) and five replications per treatment, totaling 20 experimental units.

After initial weighing, 1,000 tambaqui juveniles (initial average weight of 11±08 g) were distributed in 20 experimental units; each experimental unit consisted of 50 juveniles housed in a polyethylene box with a capacity of 1000 liters, in na area covered and protected from weather conditions, with a daily water renewal rate of 10% of the volume and constant aeration by means of a mechanical blower. The water supply was carried out with water from a 2 ha reservoir supplied by rainwater.

Every two days, in situ measurements of temperature (TEMP), dissolved oxygen (OXY) and hydrogenic potential (pH) of the water in the boxes were carried out, with a frequency of 3 times a day at different times (09:00, 12:00 and 17:00 hours), the water temperature was measured at the same moment of the OXY collection using an Oxymeter-Thermometer, introducing the probe in the central part of the boxes at a depth of 50 cm, and moving it on one side to the other for 2 minutes.

For the determination of the hydrogen potential (pH) a portable pHmeter was used, with automatic temperature compensation, precision: ± 0.06, resolution: 0.01 and working temperature range of 5-35°C. The equipment probe was introduced on the side of the boxes until its complete immersion, for a time of 10 seconds, as described in the user manual, to measure this parameter.

Water samples for the evaluation of AMO, ALK, HAR and NIT were collected weekly, at a depth of 65 cm, and the evaluations were performed using the colorimetric method according to the Alfakit instruction manual.

The diets were designed to be isoenergetic and isonitrogenous (36% PB, 3500 kcal ED/kg of feed). Composed of corn-based concentrate, soybean meal, meat and bone meal, mineral supplement and Brazil nut meal at different inclusion levels (15, 25 and 35%). The feeds was offered three times a day (09:00, 13:00 and 17:30 h) until apparent satiety.

To make the feeds, the ingredients were ground in a knife mill, with a 0.5 mm sieve and mixed homogeneously. The rations were pelleted by moistening (25% of the dry weight of the feed) with water at a temperature of 65 °C, and then they were pelleted with the aid of a meat grinder adapted for this purpose, dried under forced ventilation at 55°C for 12 hours and shortly after stored in identified plastic bags and placed in a freezer (-20°C).

The pellets were disintegrated and separated to obtain particles with a diameter suitable for the size of the animals' mouths. The proportion of ingredients and chemical-bromatological composition are described below (Table 1).

Table 1. Proportion and chemical-bromatological composition of the ingredients of the diets of tambaqui juveniles with diferente levels of inclusion of the Brazil nut meal used in Sena Madureira-AC

Ingredients	Levels of Brazil nut meal			
	0%	15%	25%	35%
Soybean meal	35.6	55.5	49.3	43.7
Meat and bone meal	24.0	0.0	0.0	0.0
Corn bran	32.0	23.9	22.9	18.8
Brazil nut meal	0.0	15.0	25.0	35.0
Soy oil	5.9	3.1	0.3	0.0
Common salt	0.5	0.5	0.5	0.5
Mineral supplement	2.0	2.0	2.0	2.0
	100	100	100	100
Chemical-bromatological composition of the ingredients				
Ingredients	EE (%)	PB (%)	FB (%)	U (%)
Soybean meal	2.6	44.4	7.3	11.6
Meat and bone meal	11.6	56.3	0.8	5.3
Corn bran	4.1	7.9	1.7	12.8
Brazil nut meal	35.3	37.5	9.6	5.3

EE = Ethereal extract, PB = Crude Protein, FB= Crude Fiber, U= Moisture

In biometrics, weight and morphometric characteristics were measured; data were obtained at the beginning of the experiment and at intervals of thirty days, with a total of four measurements (initial, 30, 60 and 90 days) in the proportion of 20% of the amount of fish in each repetition; a digital electronic scale with 0.5 g precision was used to evaluate the weight. The body measurements of the fish were taken from the anterior extremity to the beginning of the caudal fin using a digital caliper with a precision of 0.1 mm.

Feed consumption was monitored throughout the whole experimental period, enabling the evaluation of feed intake and feed efficiency parameters. Feeding adjustments and corrections were calculated as a function of the weight obtained during the biometrics.

The following performance parameters were analyzed: weight gain (WG), specific growth rate (SGR), feed intake (FI), apparent feed conversion (AFC), Fulton condition factor (K), daily feed intake (DFI) and daily weight gain (DWG). Data were calculated as follows: WG (g) = final weight - initial weight; SGR = 100 x (final weight 1/3–initial weight 1/3)/t; where t is the duration of the feeding trial (t = 90 days); FI (g) = (total intake / final weight), AFC = feed intake (g) / weight gain (g), K = (P / C-3) x 100, where P is the weight in kg and C is the length in cm daily; DFI = (total consumption / final weight)/ 90 days of experiment and DWG (g) = final weight - initial weight/90 days of experiment.

To verify the economic viability of using BNM, the average cost of the feed per kilogram (kg) of live weight (PV) gained (Yi) was determined, according to Silva et al. (2008): Yi = (Qi x Pi) / Gi, where Yi = average feed cost per kg gained in the i-th treatment; Qi = average amount of feed consumed in the i-th treatment; Pi = average price per kg of feed used in the i-th treatment and Gi = average weight gain in the i-th treatment.

Next, the Economic Efficiency Index (EEI) and the Average Cost Index (ACI) proposed by Silva et al. (2008): EEI = (LAc /ACtei) x 100 and ACI = (ACtei/LAc) x 100, where LAc = lowest average cost observed in feed per kg of LWG between treatments and ACtei = average cost of treatment i considered.

Data were collected regarding the prices of inputs, practiced in the year 2019, used in the companies supplying the ingredients. The cost of the rations used in this experiment was calculated based on retail prices (Table 2) and these values were converted into current dollars at the price of US$ 3.85 at the time.

Table 2. Cost of ingredients used in experimental diets to formulate different diets with the inclusion of Brazil nut flour in Sena Madureira-AC

Ingredients	Price per kg (US$)
Soybean meal	9.63
Meat and bone meal	6.93
Corn bran	4.50
Brazil nut meal	3.85
Soy oil	19.25
Common salt	5.78
Mineral supplement	77.0

Source: Personal File

To evaluate the effects of treatments, regression analysis was performed using the statistical software Sisvar 5.0. Different regressions were tested and the one that resulted in the highest coefficient of determination (R^2) and significance level was chosen.

3 RESULTS AND DISCUSSION

The mean values obtained for TEMP, AMO, HAR and NIT showed no significant difference (P>0.05), the values were 26.8°C, 0.16 mg L^{-1}, 17.8 mg L^{-1} and 0 mg L^{-1}, respectively. No differences were observed between treatments, in relation to water quality, that could affect the welfare of animals in the experimental units during the assessment period (Table 3).

Table 3. Means of the values obtained for the physical and chemical parameters of the water during the experimental phase of the use of different levels of Brazil nut meal bran in the feeding of tambaqui juveniles in Sena Madureira-AC

Variable	Levels of Brazil nut meal (%)				
	0	15	25	35	p-value*
AMO	0.17 (0.17-0.18)	0.17 (0.14-0.18)	0.17 (0.15-0.17)	0.16 (0.15-0.16)	0.10
NIT	0 (0-0.08)	0 (0-0)	0 (0-0.03)	0 (0-0)	0.28
HAR	18.6 (17.1-18.8)	17.5 (16.7-18.8)	17.1 (15.7-17.5)	18.6 (15.7-18.6)	0.44
pH	6.7 (6.6-7.2) ^{a}	6.6 (6.6-6.6) ^{ab}	6.6 (6.5-6.6) ^{b}	6.5 (6.5-6.6) ^{b}	0.01**
TEMP	26.9 (26.9-27.3)	26.8 (26.7-26.8)	26.8 (26.7-26.8)	26.7 (26.7-26.8)	0.21

AMO - ammonia mg L^{-1}; NIT - nitrite mg L^{-1}; HAR – total hardness mg L^{-1}; pH - hydrogenic potential and TEMP - surface temperature °C
*Kruskal Wallis test ** Means followed by distinct letters oin the line represent difference by Dunn's test (p<0.05).

There was no significant difference (P>0.05) between the treatments for TEMP, and a range of 26.7 to 26.9°C was established, suggesting that temperature did not influence the experimental parameters, as it was within the ideal range for the farming of

C. macropomum, as established by Faria and Morais (2013) where values between 25 and 32ºC are considered optimal for growth, temperatures below 22ºC reduce their metabolic activity and can lead to death when lower than 16ºC.

The mean concentration of AMO in the treatments was 0.17 mg L^{-1} ($P>0.05$), suitable values of ammonia for fish farming are around 0.05 mg L^{-1}; values above 0.2 mg L^{-1} can induce toxicity leading to a decrease in growth and resistance to diseases, which can be lethal for most fish species, even for a short period of time (FARIA AND MORAIS, 2013).

HAR values did not show statistical differences ($P>0.05$) in relation to treatments. The results showed that the hardness remained within the limits favorable to the cultivation of freshwater fish (0-75 mg L^{-1}), being classified as water with low levels of hardness (KUBITZA, 2017). This way, the effect of the water renewal rate may have favored the lower levels of hardness, due to the possible decrease in the amount of salts in the water, which would tend to precipitate carbonates.

During the experimental period, values for nitrite concentration were not recorded (Table 3). According to Leira et al. (2017) poisoning can occur when fish are exposed to concentrations of 0.3 to 0.5 mg L^{-1} of nitrite, the heme-iron group of hemoglobin is oxydized by nitrite and converted to meta-hemoglobin, which cannot transport oxygen. Thus, the oxygen diffusion capacity was not altered in this experiment and, consequently, there was no influence of this measured variable.

The values for the pH variable differed ($P<0.05$) between treatments (Table 3). The average pH results (6.5) found for the experimental treatments are favorable for the farming and good development of *C. macropomum*, which in general are more tolerant to the acidic freshwater environment, as they have adaptive physiological strategies that involve hematological adjustments, ion regulation and mucus production (STACHIW et al., 2013).

Alkalinity means showed a significant effect ($P<0.05$) with a decreasing trend ($Y= 22.11-0.06x$). The alkalinity values observed in the treatment without the inclusion of BNM were 22.4 mg L^{-1} $CaCO_3$, whereas in the treatment with 35% BNM the value was 20.6 mgL^{-1} (Table 4).

Table 4. Mean values and regression equations obtained for alkalinity in mg L^{-1} $CaCO_3$ and dissolved oxygen in mg L^{-1} during the experimental phase of the use of different levels of Brazil nut meal in the feeding of tambaqui juveniles in Sena Madureira-AC

Variable	Levels of Brazil nut meal (%)				CV (%)	R^2 (%)	Equation
	0	15	25	35			
ALK	22.4	20.1	20.0	20.6	6.6	94.50	Y = 22.11 – 0.06 x*
OXY	2.4	2.6	2.1	3.0	8.9	86.73	Y = 2.4 +0.02x*

CV (%) = Coefficient of variation; R² = Coefficient of determination; * Significant equation (p <0,05).

The decline in ALK may be associated with the dilution of the bases by the increase in the rainfall regime in the reservoir and with the process of decomposition of organic matter. Despite this small decline, according to Rodrigues et al. (2013) the ALK levels obtained in this study were kept within acceptable limits (20 to 300 mg L^{-1}), with an adequate buffering power, for a good performance for fish.

For dissolved oxygen there was an increasing linear effect (Y=2.4+0.02x) (P<0.05). The OXY values observed in this study (Table 4) proved the water to be poorly oxygenated; however, according to Pereira Junior et al. (2014) tambaqui tolerates low levels of dissolved oxygen in the water of approximately 0.5 mg L^{-1}, suggesting that the low OXY content observed in the confinement environment may have been due to the water residence time, probably due to increase in biomass and in the amount of feed supplied.

There was a significant effect (P<0.05) for the variables evaluated weight gain (WG), specific growth rate (SGR), feed intake (FI), apparent feed conversion (AFC), condition factor (K), daily feed intake (DFI) and daily weight gain (DWG) (Table 5). The highest values of productive performance obtained are in the treatments where the juveniles were fed with 35% BNM, followed by the level of 25% BNM.

Table 5. Zootechnical performance parameters of tambaqui juveniles (*Colossoma macropomum*) fed with different levels of inclusion of Brazil nut meal in the diet in Sena Madureira-AC

Variable	Levels of Brazil nut meal (%) (%)				CV (%)	R^2 (%)	Equation
	0	15	25	35			
WG (g)	24.9	31.0	40.2	50.5	5.7	95.43	Y= 22.96 +0.73X*
SGR (%)	0.6	0.6	0.7	0.9	3.8	93.51	Y=0.53+0.01X*
FI (g)	27.7	33.8	45.5	60.8	4.1	92.03	Y=24.35+0.94X*
AFC (g)	1.2	1.1	1.1	1.2	4.8	55.24	$Y=1.1-0.004x+0.002x^{2*}$
K %	2.6	2.6	4.1	4.7	7.4	84.70	Y=2.28+0.06X*
DFI (g)	0.8	0.9	0.1	1.1	3.3	87.56	Y=0.82+0.001X*
DWG (g)	1.0	1.2	1.6	2.0	5.7	95.3	Y=0.92+0.003X*

CV (%) = Coefficient of variation; R² = Coefficient of determination; * Significant equation (p <0.05); WG = Weight Gain; SGR = Specific Growth Rate; FI = Feed Consumption; AFC = Apparent Food Conversion; K = Condition Factor; DFI = Daily Feed Consumption; DWG = Daily Weight Gain

The results for the WG suggest that tambaqui is a fish capable of making good use of feeds containing BNM inclusion, it was observed that fish submitted to treatment with 35% BNM, the SGR was influenced, reaching up to 0.88%, and the biomass doubled, with a general mean WG of 50.5 g in relation to the control treatment. This result may have occurred due to the higher feed consumption in relation to the fish in the treatments (0, 15 and 25%).

All treatments showed good levels of AFC and there was no decrease in FI between treatments, it is believed that this result is due to good conditions of water quality, food management and the quality of experimental diets.

The values for AFC found in this study were 1.1 to 1.2, similar to that reported by Pereira Junior et al. (2013) who observed values of 1.1 ± 0.2 for AFC in the cultivation of tambaqui juveniles fed with increasing levels of crueira flour (made from cassava, *Manihot esculenta*) as a substitute for corn (*Zea mays*), demonstrating that *Colossoma macropomum* has great ability to make good use of plant-based foods.

There was an effect ($P<0.05$) of the levels of BNM and the animals fed with 35% BNM had higher K, DFI and DWG and presented K = 4.7%, DFI = 1.1 and DWG = 2.0 g/day, obtaining higher values when compared to fish fed with the control diet.

These results corroborate those reported by Rodrigues et al. (2013) when stating that tropical species have better AFC rates, and the increase in temperature promotes an increase in the growth rate, while the requirements for maintenance remain constant, allowing the energy income to be used for growth.

The average values for the variable K in the treatments with 25% and 35% BNM were 4.07% and 4.66%, respectively, higher values than those obtained by Silva and Fujimoto (2015) evaluating the growth of tambaqui in different densities of storage in net-tanks in a lake supplied with rainwater and finding values for K of 3.6% and 3.8%.

In the present study, the absence of significant alterations in the productive performance variables suggests that the BNM does not have a quantity of anti-nutritional factors in a way that affects the tested índices; the processing to obtain the BNM or the feed processing may have destroyed such substances, and the BNM supplied the essential aminoacid requirements for tambaqui juveniles.

There was a decrease ($P<0.05$) in the cost of production of the feeds with the inclusion of BNM, as shown in Table 6. It happened because BNM is a more economical ingredient in relation to corn bran and soybean meal, necessary to adjust the energy and protein level in the feed formulation.

Table 6. Economic performance of tambaqui juveniles (*Colossoma macropomum*) fed with different levels of inclusion of Brazil nut meal in the diet in Sena Madureira-AC

Variableável	Levels of Brazil nut meal (%)				p- value	R^2 (%)	Equation
	0	15	25	35			
FC (US$/kg)	8.07	7.57	6.49	5.81	0.02	95.0	Y=8.24-0.07X
FC (kg/LWG)	9.3	8.24	7.36	7.00	0.01	98.0	Y=9.04-0.06X
EEI (%)	81.41	86.79	101.2	113.1	0.04	0.93	Y=78.29+0.92X
CI (%)	138.9	130.3	117.7	100.0	0.03	0.94	Y=142.26-1.09X

FC = Feed Cost; FC (kg/LWG) = Feed cost per kilogram of live weight gain; EEI = Economic Efficiency Index; CI= Cost Index; R^2 = Coefficient of determination. Dollar value at the time: R$ 3.85.

The most expensive feed was the control (US$ 8.07/kg), followed by the feed with 15% BNM (US$ 7.57/kg), the feed with 25% BNM (US$ 6.49/kg), and the one with 35% BNM (US$ 5.81/kg), respectively. This was due to the high cost of soybean meal when compared to the value of BNM, which is a by-product.

There was also a downward trend ($P<0.05$) in the production cost per kilogram of fish with the inclusion of BNM in the diets. The cheapest kilogram of fish was the feed with 35% BNM inclusion (US$ 7.00). The most expensive kilogram was the control feed (US$ 9.03), followed by the feed with 15% BNM (US$ 8.24), respectively.

In commercial fish farming, feeding expenses correspond to most of the production costs, reaching 80% of the total costs. This is due to the high value that ingredients and feeds reach in the market. This is very evident in the Amazon region, where there is a need to import these products, due to the low regional agricultural productivity (PEREIRA JUNIOR et al., 2013).

If a rural producer in the Amazon region opted for the intensive tambaqui farming system, the expected average productivity would be around 10 tons of fish per hectare per year. Under these conditions, the expenditure on feed necessary to produce the fish would be US$ 90,300.00 for the control feed, US$ 82,400.00 for the feed with 15% BNM, US$ 73,600.00 for the feeds with 25% of BNM and US$ 70,000.00 for the feed with 35% BNM.

Comparing the cost of control feed and feed with 35% BNM, savings up to US$ 20,300.00 per hectare of water blade are observed. This corresponds to a 22.48% reduction in the cost of tambaqui production, referring to feed. This advantage will allow the producer to offer a more competitive product in the market.

The results for the production cost observed in this study were higher than those obtained by Pereira Junior et al. (2013) who used cassava (*Manihot esculenta*) flour to feed tambaqui, and observed a 12% reduction in production cost.

The economic efficiency index showed an increasing linear effect ($P<0.05$), as the levels of BNM in the feed were increased; according to the regression analysis, it was observed that at each increment of one percentage point of the BNM there was an increase of 0.92%.

The lowest cost index ($P<0.05$) was in the treatment with the inclusion of 35% BNM, followed by the one with the addition of 25%. These results corroborate those found by Silva et al. (2020) who verified, based on the economic indicators evaluated, that a replacement of 25% of corn with palm kernel meal is viable in the feeding of tambaqui, especially considering that at certain times of the year corn has a price increase.

However, it disagrees with the results obtained by Ferreira et al. (2021) for juvenile tambaqui and did not find a decrease in economic efficiency with increasing levels of inclusion of buriti pie in experimental diets. Thus, it is important to study alternative ingredients with potential for use in fish feed in the Amazon, which contribute to the development of an economically and environmentally viable regional fish farming.

4 CONCLUSIONS

The addition of Brazil nut meal improved significantly the production rates and altered the water quality parameters of tambaqui juveniles production, without compromising the evaluated variables. The inclusion of up to 35% of the Brazilian nut meal reduced the production cost of feed and tambaqui.

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