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REPLACEMENT OF PROTEIN SOURCE IN PRACTICAL DIETS FOR AMAZON RIVER PRAWN

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ABSTRACT

The aim of this study was to evaluate the best level of substitution of fish meal (FM) by soybean meal (SBM), as protein source in practical diets for juveniles of *Macrobrachium amazonicum*. Juveniles, with initial mean weight of 0.16 ± 0.66 g, were stocked at a density equivalent to 150 juveniles m^{-2} in a recirculating aquaculture system. Treatments consisted of the proportions of fish meal and soybean meal (FM:SBM) in diets, namely: 0: 100, 20:80, 40:60, 70:30, 100:0 with five replicates per treatment. At the end of the 45 days trial, prawns were counted, measured, weighed, and the bromatological analysis of the whole body was performed. Survival remained above 94% in all treatments (p>0.05). A corporal bromatological analysis showed significant among treatments only for crude protein (p <0.05). The results of the production performance showed that the inclusion of up to 30% of SBM in replacement for FM (70:30) did not interfere, significantly, in the performance of the prawns (p>0.05), making possible the use of soybean meal in diets for juveniles of Amazonian river prawn.

Key words: freshwater; aquaculture; prawn culture; nutrition; plant protein.

SUBSTITUIÇÃO DE FONTE PROTEICA EM DIETAS PRÁTICAS PARA CAMARÃO-DA-AMAZÔNIA

RESUMO

O objetivo deste trabalho foi avaliar o melhor nível de substituição da farinha de peixe (FP) pelo farelo de soja (FS), como fonte de proteína em dietas práticas para juvenis de *Macrobrachium amazonicum*. Juvenis com peso médio inicial de 0,16 ± 0,66 g foram estocados em uma densidade equivalente a 150 juvenis m^{-2} em sistema de recirculação. Os tratamentos consistiram das seguintes proporções de farinha de peixe e farelo de soja (FP:FS): 0:100, 20:80, 40:60, 70:30, 100:0 com cinco repetições por tratamento. Ao final de 45 dias de experimento, os camarões foram contados, medidos e pesados, bem como foi realizada análise bromatológica corporal. A sobrevivência manteve-se superior a 94% em todos os tratamentos (p>0,05). A análise bromatológica corporal apresentou diferenças significativas entre os tratamentos apenas para proteína bruta (p<0,05). Os resultados da análise de desempenho zootécnico demonstraram que a inclusão de até 30% de FS em substituição a FP (70:30) não interferiu significativamente no desempenho dos camarões, possibilitando uso do farelo de soja em dietas para juvenis de camarão amazônico.

Palavras-chave: água doce; aquicultura; carcinicultura; nutrição; proteína.

INTRODUCTION

Worldwide, shrimp farming accounts for approximately 50% of the world's shrimp consumed (FAO, 2016). Within the world aquaculture scenario, freshwater prawn farming is one of the fastest growing sectors (VETORELLI, 2004; FAO, 2016) and, in addition, it is considered a sustainable activity, because it has low environmental impact (NEW *et al*., 2000). Moreover, the production of freshwater prawn has a high-added value, since it is considered a noble product, and also of great commercial importance, with thousands of tons being exported per year (PÉREZ-RAMIREZ and LLUCH-COTA, 2010).

The main species of freshwater prawns produced in the world are *Macrobrachium nipponense* and *Macrobrachium rosenbergii*, which together with the production of other species reach a volume of approximately 500 000 tons annually (FAO, 2016). In Brazil, *M. rosenbergii* is the main species reared in captivity. However, the native species *Macrobrachium amazonicum* presents high potential for production (MORAES-VALENTI and VALENTI, 2010) and is an important economic resource because it is one of the main fishing resources exploited artisanally in the northern region of the country (LUCENA-FRÉDOU *et al*., 2010).

Considering the expanding market for *M. amazonicum* and adversities in relation to extractivim, captive production may be an important alternative for the supply of this species to the market (MORAES-VALENTI and VALENTI, 2010). In prawn farming, the food strategy is fundamental to obtain good results. This involves some aspects such as nutrition, diet processing and food management (SMITH *et al*., 2002). Recently, studies have been performed to define the nutritional requirements for prawn of different species and stages of development (GLENCROSS *et al*., 2013; HAYD *et al*., 2016). However, for *M. amazonicum* there is little information in this regard, making it impossible to produce commercial feed and limiting its performance in production systems.

In aquaculture, fish meal is used in diets as the main source of animal protein, having an amino acid profile closer to the needs of cultured fish and shrimp (PEZZATO *et al*., 2002). However, currently, due to the expansion of aquaculture and stagnation and/or a decrease in extractive fishery, fish meal is one of the costliest ingredients in shrimp diets, with around 68% of all fish meal produced in the world being destined to be used in aquaculture (TACON and METIAN, 2009). The high cost of fish meal emphasizes the importance of determining the nutritional requirements of farmed species, as well as alternative sources of ingredients, in order to promote sustainability in aquaculture with the rational use of this input. This strategy can reduce the excessive production of residues from feed wastage, as well as high feed frequency and high excretion of phosphorus (P) and nitrogen (N) in water, elements associated with eutrophication (HERBECK *et al*., 2013). In addition, the substitution of fish meal by a plant protein source could ease the pressure on fish stocks and would contribute to the reduction of production costs. (ABE *et al*., 2008; VALLE *et al*., 2015).

The production of soybeans (seed, oil and meal) is the main agricultural activity in Brazil, due to the territorial and economic-commercial importance (CONAB, 2014; SECEX, 2014). Brazil is the world's largest exporter of soybean seeds and, soybean meal is the main by-product obtained by the soybean oil extraction industry. Currently, soybean meal is the main protein ingredient used as a substitute for fish meal in the nutrition of monogastric animals, including fish (LIN and LUO, 2011). The widespread use of soybean meal is justified because its protein fraction has the best amino acid profile among protein feeds of plant origin, although it is deficient in sulfur amino acids, such as methionine and cystine (GATLIN *et al*., 2007).

Therefore, establishing the adequate level of substitution of fish meal by soybean meal may facilitate the preparation of commercial diets for *M. amazonicum* and contribute to the rational use of these ingredients. Therefore, the objective of the present study was to evaluate the best level of substitution of fish meal by soybean meal, and thus to determine the best proportion of fish meal and soybean meal to be used as a protein source in practical diets for juveniles of *M. amazonicum* during the nursery phase and its influence on performance and body chemical composition.

METHODS

The present study was carried out at the Federal University of Paraná (UFPR), Palotina Sector, in the Prawn Culture Laboratory. Post-larvae (PL) (from several spawnings) were obtained from the UNESP Aquaculture Center (CAUNESP), Campus de Jaboticabal, São Paulo. After the reception, the prawns were kept in polyethylene tanks with a volume of 200 L, provided with mechanical and biological filtration, at a density of 50 juveniles m^{-2}, where they remained for a period of 30 days to adapt to the experimental diets. Subsequently, they were submitted to biometrics and 17 juveniles with a mean weight of 0.16 ± 0.66 g were transferred to each experimental unit, where they remained for 45 days.

The experimental system consisted of 25 tanks (experimental units), with dimensions of 36 cm × 33 cm × 37 cm (length × width × height), with a capacity of 50 liters. The prawn density in the experimental units was equivalent to 150 juveniles m^{-2} (PENTEADO *et al*., 2007).

The tanks were connected to a closed water recirculating system with mechanical and biological filtration (BREGNBALLE, 2015), photoperiod (12:00h clear: 12:00h dark) and temperature control of the water through thermostat heaters. The dissolved oxygen levels were maintained by constant aeration, by radial compressor and distribution system by air hoses and diffusers, installed in each experimental unit.

The experimental diets were elaborated in order to present decreasing levels of inclusion of soybean meal in substitution of fish meal as a protein source, in this way the prawns were submitted to five treatments with five replicates each, containing different proportions of fish meal (FM) and soybean meal (SBM), as follows (FM:SBM): T1- 0:100, T2- 20:80, T3- 40:60, T4- 70:30, T5- 100:0, in a completely randomized design.

The experimental diets were formulated according to NRC (2011) data, using the software SuperCrac® versão 2.0. The diets were isonitrogenous with protein level of 35% and isocaloric containing 3600 kcal kg^{-1} of gross energy. As priority energy sources corn and fish oil and soybean oil were used (Table 1). The other ingredients were added in order to meet the nutritional requirements of prawns (NEW and KUTTY, 2010).

For the diets preparation, the ingredients were homogenized in an industrial mixer (G. PANIZ BP12C) followed by addition of oils and heated water (50 °C) until a consistent and homogeneous dough was obtained. Then, the it was processed in an experimental pelletizer to obtain 1.5 mm diameter pellets (ARAUJO and VALENTI, 2005).

After pelleting, the diets were submitted to oven drying with air recirculation (SOLAB, SL-102) at 55 °C for 24 hours. After drying, the pellets were ground and then classified into sieves for reduction and standardization of the diameter of 0.1 mm, adapted from the methodology used by PEZZATO *et al*. (2002). They were

Table 1. Composition of experimental diets with different proportions of fish meal and soybean meal (FM:SBM) used in feeding of *Macrobrachium amazonicum* juveniles during the experimental period.

FM:SBM Ingredients[1] (%)	0:100	20:80	40:60	70:30	100:0
Fish meal	0.00	12.50	25.00	37.50	50.00
Soybean meal	72.57	53.58	35.22	16.86	0.00
Ground corn	9.21	19.68	26.28	32.88	31.53
Inert[2]	2.11	0.65	1.12	1.58	8.48
Dicalcium phosphate	8.38	7.62	6.90	6.18	5.53
Limestone	4.40	3.94	3.45	2.97	2.43
Mineral and vitamin supplement[3]	2.00	2.00	2.00	2.00	2.00
Fish oil	0.65	0.00	0.00	0.00	1.30
Soybean oil	0.65	0.00	0.00	0.00	1.30
BHT[4]	0.01	0.01	0.01	0.01	0.01
Vitamin C	0.02	0.02	0.02	0.02	0.02
Nutrients[5]					
Calcium (%)	4.00	4.00	4.00	4.00	4.00
Ash (%)	19.57	17.63	17.57	17.52	21.22
Gross energy (Kcal .kg^{-1})	3,600	3,600	3,600	3,600	3,600
Crude fiber (%)	4.48	3.55	2.60	1.64	0.59
Total Phosphorus (%)	2.00	2.00	2.00	2.00	2.00
Crude fat (%)	3.34	3.34	4.47	5.59	8.89
Dry matter (%)	92.90	92.28	91.94	91.60	91.78
Crude protein (%)	35.00	35.00	35.00	35.00	35.00

[1]All ingredients were obtained from commercial premises; [2]Inert used: Caolin; [3]Vitamin and mineral supplement levels guarantee per kilogram of product:vit. vit. A – 1,200,000 IU; vit. D3 – 200,000 IU; vit. E – 12,000 mg; vit. K3 – 2,400 mg; vit. B1 – 4,800 mg; vit. B2 – 4,800 mg; vit. B6 – 4,000 mg; vit. B12 – 4,800 mg; folic acid – 1,200 mg; calcium pantothenate – 12,000mg; vit. C – 48,000 mg; biotin – 48 mg; hill – 65,000 mg; Niacin – 24,000 mg; Fe – 10,000 mg; Cu – 6,000 mg; Mn – 4,000 mg; Zn – 6,000 mg; I – 20 mg; Co – 2 mg; Se – 20 mg; [4]BHT = butyl hydroxy toluene; [5]Values determined at Animal Nutrition Laboratory (UFPR – Palotina, PR, Brazil).

then packaged, identified and stored in a freezer until their use (OLIVEIRA FILHO and FRACALOSSI, 2006).

Feeding was performed four times daily (07h30, 11h30, 15h30 e 19h30) up to apparent satiation, diets were weighed at the beginning and at the end of the day to quantify the daily consumption. Before the first feeding each experimental unit was siphoned for the removal of feces and occasionally leftover feed. Daily, dissolved oxygen (mg L^{-1}), pH and temperature (°C) of water were measured with an oximeter (Alfakit® AT160), pH meter (Alfakit® AT315), and thermometer (Incoterm®), respectively. Weekly, total ammonia concentration, nitrite, nitrate (APHA, 2005), orthophosphate, alkalinity and hardness (WALKER, 1978) were monitored.

Survival was determined by the difference in prawn numbers at the beginning and at the end of the experiment. At the end of the experiment, all animals were euthanized by termonarcose (1 °C) and were weighed and measured. After that, all the prawns were used for analysis of the body chemical composition. The animals were ground in a meat grinder until homogeneity, then samples were used to determine the levels of moisture, crude protein, crude fat and ash, according to the methodology described by SILVA and QUEIROZ (2002).

The following parameters were evaluated: final weight (FW): body mass obtained at the end of the experiment; weight gain (WG) = final body mass - initial body mass; Total length (TL) = measurement of the tip of the rostrum to the end of the telson; Standard length (SL) = post-orbital margin length the dorsal mid-posterior margin of the cephalothorax; Specific growth rate (SGR) = [(In final body mass - In initial body mass)/days] x 100; Apparent feed conversion (AFC) = feed supplied/gain by weight and protein efficiency rate (TEP) = gain in weight/crude protein consumed, as described by SEENIVASAN *et al*. (2012) and NRC (2011).

For the statistical analysis, the data were submitted to the verification of normality by the Kolmogorov-Smirnov test and the homogeneity by the Levene test. Subsequently, analysis of variance (ANOVA) was performed and in the case of statistical difference, the results were submitted to the Tukey test. All analyzes were performed at a significance level of 5% (SOKAL and ROHLF, 1995).

RESULTS

The different levels of substitution of fish meal by soybean meal did not affect the limnologic parameters (p>0.05). The pH levels remained close to 8 ± 0.10, dissolved oxygen 5.93 ± 0.63 mg L^{-1}, temperature 29 ± 1.24 °C, alkalinity 40 ± 0.67 mg L^{-1} $CaCO_3$, hardness 20 ± 0.27 mg $L^{-1}CaCO_3$, total ammonia nitrogen 0.005 ± 0 mg L^{-1}, nitrite 0.02 ± 0.02 mg L^{-1}, nitrate 0.41 ± 0.36 mg L^{-1}, and orthophosphate 0.18 ± 0.11 mg L^{-1}.

All the production parameters evaluated were affected by the treatments (p<0.05) (Table 2), except for survival (p>0.05), which remained above 94% for all treatments.

The weight gain and total length presented an increase proportional to the increment of fishmeal levels in the diet, in which treatments 70:30 and 100:0 (FM: SBM) presented the highest values (p<0.05) for these parameters (Table 3). The specific growth rate and protein efficiency rate also showed a proportional decrease with the increase of SBM levels in the diet, treatments with ratios of 0: 100, 20:80 and 40:60 (FM: SBM) showed smaller indices.

As shown in Table 3, the lower inclusion levels of soybean meal in substitution of fish meal (70:30, 100:0 FM:SBM) provided lower feed conversion rates (p<0.05). In contrast, total replacement (0:100) in the diet resulted in higher feed conversion rate (p<0.05).

The substitution of fish meal for soybean meal caused a significant alteration of the body crude protein levels (p<0.05), for other parameters of the body chemical composition, no effects of the treatments were observed (p> 0.05), as can be observed in the Table 3. There was a higher deposition of crude body protein in prawn fed the diet containing only fish meal as a protein source (p <0.05), compared to animals fed the diet containing only soybean meal (Table 3).

DISCUSSION

During the experimental period, the water quality parameters analyzed remained at levels adequate to the cultivation of freshwater prawns, according to the parameters established by MORAES-RIODADES *et al*. (2006).

In the present study, the weight gain and total length of the prawns were negatively influenced by the inclusion of soybean meal in substitution to fish meal in the diets, and a better weight gain was observed in the treatments with proportions of 70:30 and 100:0 FS: SBM. These results did not corroborate the results obtained for *M. rosenbergii* by HASANUZZAMAN *et al*. (2009), which reported better weight gain in the treatment with higher FM replacement by SBM (20:80) and lower weight gain for juveniles of *M. rosenbergii* fed diets without or with low inclusions of soybean meal. Also, ROZIHAN *et al*. (2012), obtained better growth for post larvae of *M. rosenbergii* with the diet containing the ratio of 40:60 (FM: SBM).

Regarding the specific growth rate, the results obtained in the present study were similar to those reported for *M. rosenbergii* where values ranged from 1.87 to 3.72% (GUPTA *et al*., 2007;

Table 2. Performance of prawns (*Macrobrachium amazonicum*) fed with isoprotein and isoenergetic diets containing different proportions of fish meal and soybean meal (FM:SBM).

	Trataments (FM:SBM)					
Parameters	0:100	20:80	40:60	70:30	100:0	**CV (%)***
S(1)%	94.12	96.47	98.82	95.29	97.65	5.56
FW(2) (g)	0.44^{d}	0.51^{cd}	0.58^{bc}	0.65^{ab}	0.68^{a}	8.04
TL(3)(mm)	38.81^{d}	40.46^{cd}	42.26^{bc}	44.74^{ab}	44.61^{a}	11.55
SGR(4)	2.21^{c}	2.50^{bc}	2.81^{ab}	3.06^{a}	3.17^{a}	14.87
WG(5) (g)	0.28^{d}	0.35^{cd}	0.42^{bc}	0.49^{ab}	0.52^{a}	7.76
AFC(6)	5.43^{d}	4.54^{cd}	4.30^{bc}	4.65^{ab}	4.18^{a}	16.06
PER(7) %	1.28^{c}	1.61^{bc}	2.00^{ab}	2.28^{a}	2.47^{a}	26.59

Means followed by different letters in the same line differ (P <0.05) by the Tukey test; *Coefficient of variation; (1)Survival; (2)Final weight; (3)Total length; (4)Specific growth rate; (5)Weight gain; (6)Apparent feed conversion; (7)Protein efficiency rate.

Table 3. Body chemical composition (in dry matter) of *M. amazonicum*, fed with isoprotein and isoenergetic diets containing different proportions of fish meal and soybean meal (FM:SBM).

	Trataments (FM:SBM)					
Variable (%)	0:100	20:80	40:60	70:30	100:0	**CV (%)***
Moisture	70.24	70.38	71.12	71.18	71.90	0.95
Ash	13.54	13.78	13.82	15.18	14.99	7.97
Crude protein	54.09^{b}	58.73^{ab}	60.98^{ab}	59.21^{ab}	63.94^{a}	7.16
Crude fat	1.42	1.27	0.65	1.06	1.15	27.80

Means followed by different letters in the same line differ significantly (P <0.05); *Coefficient of variation.

AMARAWEERA *et al*., 2014). The reduction of the specific growth rate observed in this experiment when higher SBM levels were included in the diet, are in agreement with the results presented by DU and NIU (2003), which tested the effect of the replacement of fish meal by soybean meal for juveniles of *M. rosenbergii*, and observed a gradual decrease of the specific growth rate with the increase of SBM in the diet. In both studies, it was possible to observe an inverse relation between the growth rate of prawn and soybean meal inclusion in the diet. The replacement of fish meal by soybean meal can provide a reduction in the concentrations of amino acids and essential fatty acids (TIDWELL *et al*., 1993), justifying the reduction of the weight gain and the growth (TL) observed at extreme levels of substitution.

Several factors like amino acid profile of the protein sources used, reduction of food intake, digestibility of ingredients and the high metabolic cost may have influenced the lower performance of prawns fed diets containing higher levels of soybean meal. Generally, ingredients such as soybean have low digestibility (GONÇALVES and CARNEIRO, 2003), although it is the product among the sources of vegetable protein with better amino acid profile, presenting deficiency only in sulfur amino acids (KROGDAHL *et al*., 2010). These factors may be related to lower weight gain and lower final total length in prawns fed diets containing higher amounts of soybean meal.

Total replacement of fish meal by soybean meal (0: 100; FM:SBM) in the diet resulted in higher feed conversion rate, possibly due to the lower capacity of utilization of plant protein sources by *M. amazonicum* in the absence of an animal protein source (HARDY, 2008; KROGDAHL *et al*., 2010). The deficiency of some essential nutrients in soybean meal, especially n-3 highly unsaturated fatty acids when compared to fish meal (BROWDY *et al*., 2006), may have compromised growth and, consequently, the feed conversion rate obtained, thus preventing the possibility of total replacement of fishmeal by soybean meal. Another factor that may be related to the reduction of growth and weight gain in the treatments with higher levels of soybean meal is, possibly, the reduction of methionine in the diets. This amino acid is scarce in soybean meal and its supplementation is indicated in the formulation of the diets (DERSJANT-LI, 2002; GATLIN *et al*., 2007).

The feed frequency in the present study was four times a day and feed conversion ratio ranged from 4.18 to 5.43. ARAÚJO and VALENTI (2005) studied food frequencies for post-larvae of *M. amazonicum* and found results similar to the present study, with a feed conversion ratio ranging from 3 to 10, without significant differences, when tested up to eight daily feeds. Feed conversion ratio provides an overview of feed utilization and its physiological phenomena such as: gastrointestinal motility, absorption and energy use; however, a non-acceptance of the feed may occur, or even low intake, due to the feed competition in the intake, causing a worsening of the value obtained and masking the result of feed utilization (ARAÚJO and VALENTI, 2005). Another important factor to consider is the contact of the inert diet with the water, that can provide the physical disintegration, making it difficult the ingestion by the prawn, since the feed is handled by them before the ingestion and they locate the feed exclusively by smell and taste and not by sight, such process may take minutes or hours (NUNES, 2001).

Regarding protein efficiency, the proportions of 40:60, 70:30 and 100:0, had statistically equal results, i.e. it is possible to use up to 60% of soybean meal without adversely affecting this parameter. HASANUZZAMAN *et al*. (2009) obtained protein efficiency rates for *M. rosenbergii* between 0.95 and 1.51% and the best efficiency rate was observed for the treatment with higher substitution of fish meal by soybean meal (20:80; FM:SBM). Similar values were found in the present study with the ratio of 20:80 (1.61%), but the best results were for the proportions (FM:SBM) of 70:30 and 100:0 where the protein efficiency rates were 2.28% and 2.47%, respectively.

The moisture values in the present study are fairly below those found by SEENIVASAN *et al*. (2012) and GUPTA *et al*. (2007) who obtained body composition values for *M. rosenbergii* with variations of moisture between 75.1 and 76% and 74.2 and 76.8, respectively. Considering that, there is not much scientific data on *M. amazonicum*, comparison with other species, but, in this present study, we could determine that *M. amazonicum* presents lower levels of body moisture, and therefore higher dry matter, compared to *M. rosenbergii*.

For the crude protein levels, SEENIVASAN *et al*. (2012) found values from 57 to 62.88%, which are similar to those found in the present experiment, ranging from 54 to 63%. On the other hand, GUPTA *et al*. (2007) obtained higher crude protein contents: 69.18%, 71.32% and 72.25%, respectively, in the treatments (FM:SBM) 90:10, 67:33 and 20:80, with juveniles of *M. rosenbergii*. The differences found between the present study and the GUPTA *et al*. (2007), besides the difference of the species used, occurred possibly, due to differences in experimental diets composition, but also because the aforementioned authors performed a 135-day experiment, in which the animals reached a mean final weight of 22g. It is expected that larger animals deposit higher levels of body protein than smaller animals, such as those of the present experiment.

The highest body crude protein levels in *M. amazonicum* fed with fish meal (100: 0) compared with the animals fed the diet containing only soybean meal (0: 100) as a protein source, occurred due to the supply of protein of better biological value, the fish meal, with consequent better utilization and deposition of the protein when compared to a source of protein with amino acid deficiency. In the data obtained by GUPTA *et al*. (2007), there was greater deposition of body crude protein in prawns fed with the diet with 67:33 (FM: SBM) compared to a 90:10 diet. This effect was not observed in the present experiment in which close proportions (70:30 and 100: 0) were not different.

As previously reported, in addition to the fact that GUPTA *et al*. (2007) used a wide range and variation of ingredients among diets, they also used experimental diets with variation in protein and energy levels. On the other hand, NAIK and MURTHY (2000) observed that diets with different sources of protein, such as fish meal and soybean meal, did not affect the protein content in body composition of *M. rosenbergii,* but no increased levels of substitution were tested.

In the analysis of ash content, KIRSCHNIK and VIEGAS (2004) found an average value of 1.26% for *M. rosenbergii*, based on a sample of muscle tissue, a result lower than those found in the present study, which analyzed the whole body (integrally). SANTOS *et al*. (2007) also obtained lower ash values (0.68%) for post larvae of *M. rosenbergii*. On the other hand, GODA (2008) in an experiment with post-larvae of *M. rosenbergii*, analyzing the whole animal, obtained values of superior ashes, ranging from 4.9 ± 1.1 to 6.7 ± 1.3%. The high levels of chitin and inorganic salts contained in the carapace of crustaceans (TOLAIMATE *et al*., 2003; SHAHIDI and SYNOWIECKI, 1991), may explain the high ash levels observed in the present study. Another determinant factor may be related to the use of prawn in juvenile phase, presenting higher incorporation of chitin and inorganic salts in relation to post larvae (SANTOS *et al*., 2017).

The results obtained for total body fat of the prawn are lower than those found for post larvae of *M. rosenbergii* (1.66 to 1.96%) by GUPTA *et al*. (2007). The literature cites values ranging from 1.5 to 12.4% and points out that *M. amazonicum* has potential as a source of essential fatty acids, especially EPA (eicosapentaenoic) and DHA (docosahexanoic) which is used both in human feeding and in the incorporation of fish diets (FURUYA *et al*., 2006; SEENIVASAN *et al*., 2012). Further studies are needed so that inferences such as these can be made for *M. amazonicum*.

CONCLUSION

It is possible to include up to 30% of soybean meal in substitution of fish meal as protein source in practical diets for juveniles of *M. amazonicum* in the nursery phase without compromising the production performance of the prawns.

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