EFFECT OF FOOD PROCESSING ON THE DEVELOPMENT OF PACAMÃ FINGERLINGS (*Lophiosilurus alexandri*)

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ABSTRACT: Although *pacamã* (*Lophiosilurus alexandri*), a fish species native to Brazil, is suitable for farming, it has been little investigated. The present experiment evaluates the effect of food processing on the performance and survival rate of *pacamã* fingerlings. An experiment in a completely randomized design was carried out with 48 *pacamã* fingerlings aged 45 days and weighing 1.94 ± 0.01 g. Fingerlings were assigned to three treatments with four repetitions. Each aquarium containing four fingerlings was considered one experimental unit. Fingerlings were submitted to feed treatments with 47.5% crude protein processed in bran, micro-pellet, and moist forms. The average final weight and apparent feed conversion were significantly (P<0.01) affected by food processing. *Pacamã* fingerlings that fed on moist food performed the best, such that moist food rather than bran or micro-pellet forms is recommended.
KEYWORDS: Carnivorous fish; Branny food; Micro-pelleted food; Moist food.

EFEITO DO PROCESSAMENTO DA RAÇÃO SOBRE O DESENVOLVIMENTO DE ALEVINOS DE PACAMÃ (*Lophiosilurus alexandri*)

RESUMO: Embora o pacamã (*Lophiosilurus alexandri*), uma espécie de peixe nativa do Brasil, seja apropriado para o cultivo, pouco se conhece a seu respeito. O presente experimento avaliou o efeito do processamento da ração no desempenho e na sobrevivência de alevinos de pacamã. O desenho experimental foi completamente casualizado, com 48 alevinos de pacamã com 45 dias de idade e peso de 1,94 ± 0,01 g distribuídos em três tratamentos com quatro repetições. Cada aquário com quatro alevinos foi considerado uma unidade experimental. Os alevinos foram submetidos a tratamentos com rações contendo 47,5% de proteína bruta, processadas na forma farelada, micropeletizada e úmida. O peso final e a conversão alimentar aparente apresentaram efeito significativo (P<0,01) para o processamento da ração. Os alevinos de pacamã alimentados com ração na forma úmida apresentaram melhor desempenho. Desse modo, recomenda-se a ração na forma úmida em vez daquelas nas formas farelada e peletizada.
PALAVRAS-CHAVE: Peixe carnívoro; Ração farelada; Ração micropeletizada; Ração úmida.

EFECTO DEL PROCESAMIENTO DE LA DIETA SOBRE EL DESARROLLO DE ALEVINES DE PACAMÃ (*Lophiosilurus alexandri*)

RESUMEN: Aunque el pacamã (Lophiosilurus alexandri), una especie de pez nativo de Brasil, es apto para el cultivo, poco se sabe acerca del mismo. En este estudio se evaluó el efecto del procesamiento del pienso en el rendimiento y la supervivencia de los alevines de pacamã. El diseño experimental fue completamente casualizado, con 48 alevines de pacamã con 45 días de edad y peso de 1,94 ± 0,01 g distribuidos en tres tratamientos con cuatro repeticiones. Cada acuario con cuatro alevines se consideró una unidad experimental. Los alevines fueron sometidos a tratamientos con piensos conteniendo 47,5% de proteína bruta, procesadas como harina, micro peletizado y húmedo. El peso final y la conversión alimentaria mostró efecto significativo (P <0,01) para el procesamiento de la ración. Los alevines de pacamã alimentados con la forma húmeda mostraron mejor rendimiento. Por lo tanto, se recomienda pienso en la forma húmeda en lugar de las formas en harina y micro peletizado.
PALABRAS CLAVE: Pez carnívoro; Pienso en harina; Pienso micro peletizado; Pienso húmedo.

Introduction

Pacamã (*Lophiosilurus alexandri* Steindachner, 1876) is a species endemic to the São Francisco River (TENÓRIO, et al., 2006). According to Godinho (2007), pacamã is a sedentary fish belonging to the same order as other important native carnivorous catfish (Siluriform) like surubim (*Pseudoplatystoma fasciatum*) and pintado (*P. coruscans*).

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Barros et al. (2007) place pacamã in the neotropical fresh water fish family (Pseudopimelodidae), which has been little studied and is endemic only to South America.

A carnivorous fish rather appreciated by the local population for the taste of its meat, it is one of the local species with the highest commercial value. It is also used in aquariums due to its exotic external anatomy. Because of this, it has become rare in street markets in recent years, as reported by Lins et al. (1997), and it is one of the endangered species in the Minas Gerais State portion of the São Francisco basin.

Partial spawning occurs naturally in nests built on sandy bottoms with parental care (LOPEZ; SAMPAIO, 2000). Eggs and larvae as considered large by Sato et al. (2003), with the living adult weighing over 8 kg (CARDOSO, et al., 1996). Although the literature on its farming is scarce, several authors consider it a species with aquaculture potential (SATO, et al., 2003; BARROS, et al., 2007; GODINHO, 2007; PEDREIRA, et al., 2008).

Pedreira et al. (2008) observed that the zooplankton size influences the performance and survival rates of post-larval pacamã. Nevertheless, feed treatment did not improve performance and worsened water quality. In contrast, Meurer et al. (2010) found that pacamã fingerlings fed with post-larval Nile tilapia (*Oreochromis niloticus*) at a ratio of 30% live weight achieved good growth.

The initial development phases are extremely important in fish farming as it affects the supply of quality fish in quantity for the later farming phases (HAYASHI, et al., 2002). The consumption of inert artificial food is one of the hindrances in carnivorous fish farming in the initial phases, as artificial feed training may result in significant death rates (LUZ, et al., 2002). Studies on the use of inert foods in carnivorous species are relevant for the development of sustainable farming programs.

The literature on pacamã is scarce (TENÓRIO, et al., 2006) and many experiments report on live food. Knowing the behavior of pacamã towards inert food is very important for the development of rational farming strategies as well as the research of the species itself.

The use of processing technologies in the production of commercial aquaculture foods aiming to improve the nutritional and physical characteristics of ingredients has increased (BOOTH, et al., 2000). According to Ensminger and Olentine (1980), processing aims to improve particle size, change moisture, acceptability, nutritional content, increase availability, remove anti-nutritional factors, and reduce shipping/storage costs and pathogenic microorganisms.

The development of rational technologies for farming endangered fish species may have a double benefit. First, by reducing predatory fishing with the sale of farmed fish, and second, by means of rational farming technology in government fish farms to maintain breeding stocks for re-population programs of natural environments.

The present study aimed to evaluate the performance and survival rate of pacamã fingerlings fed inert artificial food in bran, micro-pellet, and moist forms.

Material and Methods

The experiment was carried out at the Aquaculture Sector of the Agrarian Sciences campus of Universidade Federal do Vale do São Francisco (UNIVASF), Pernambuco State (PE), Brazil, over a period of 45 days. Forty-eight pacamã (*L. alexandri*) fingerlings aged 45 days and weighing 1.94 ± 0.1 g were used in the experiment. Fingerlings were assigned to twelve 60 L aquariums in a fully random design with three treatments and four repetitions. An aquarium with four fingerlings was considered the experimental unit.

The fingerlings from a same spawn used in the experiment were supplied by the Bebedouro Fish Farm (3rd Regional Superintendence of CODEVASF, Petrolina, PE). Fingerlings were fed at will until the day of transportation to the UNIVASF Aquaculture Laboratory, where they were kept in a 1,000 L tank for one week without food. Afterwards, the fishes were weighed and assigned to the experimental units. No specific handling was used for fish adaptation to inert food consumption.

The experimental units were continuously aerated by contact with a porous stone connected to a mini air compressor. Every morning (7h00) and afternoon (16h00), 20 and 40% of the tank water was siphoned, respectively, to remove feces and leftover food. The water temperature of each aquarium was measured before siphoning, and the other water physical-chemical parameters, such as pH, electrical conductivity, and dissolved oxygen, were measured weekly before the morning siphoning.

Although there is no data in the literature on the nutritional requirements of pacamã, a 47.5% crude protein food was prepared. The food ingredients were ground and sieved through a 1.0 mm mesh according to Hayashi et al. (1999). Due to the high fat content in viscera and tilapia meals, the ingredients were ground manually and sieved through a 1.0 mm mesh first, and next mixed with the ground and sieved fraction.

The foods were mixed according to the experimental food formulations in Table 1. Fingerling treatment involved giving one of the three food processings, bran, micro-pellet, or moist.

Table 1: Composition of experimental diet offered to pacamã fingerlings.

Ingredient	Amount	Nutrient	Amount
Poultry by product meal	49.88 %	Crude protein	47.50 %
Nile tilapia meal	20.00 %	Crude energy[2]	3,774
Soybean meal	14.11 %	Phosphorus	1.03 %
Mineral and vitamin suplement1	5.00 %	Calcium	1.86 %
Corn	5.00 %	Crude fiber	1.87 %
Soybean oil	5.00 %		
Salt (NaCl)	0.50 %		
Ascophyllum nodosum	0.50 %		
BHT	0.01 %		

[1]Levels by kilogram of product: Vit. A, 1,200,000 UI; Vit. D_3, 200,000 UI; 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; Pantotenato Ca, 12,000 mg; Vit. C, 48,000 mg; Bio-

tin, 48 mg; Colin, 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. [2] kcal kg^{-1}.

The branny food was considered as the food obtained by the previously described processes. To produce the moist food, the branny food was wetted at grinding with 1.3 and 1.5 parts of water to one part of dry food (ENSMINGER; OLENTINE, 1980) and given to fingerlings as four small balls.

The micro-pelleted food was obtained from the branny food wetted at 50°C, pelleted in an experimental electric pelleter, and later dried in a forced air oven at 50°C for 24 hours. The pellets were then ground and graded with several mesh sieves (LOVELL, 1988). Fingerlings were fed pellets equal to or smaller than 2 mm.

Pacamã fingerlings were given food at the ratio of 10% live weight twice a day at 07h30 and 17h00. Every 15 days, the fishes of each experimental unit were weighed to determine feeding amounts, the calculation of weight, and apparent feed conversion rates. Apparent feed conversion rate (FCa) was estimated using the equation: FCa = feed offered/weight gain.

At the end of the experimental period, the pacamã fingerlings were counted and weighed to evaluate the final average weight and FCa. The evaluation parameters were submitted to variance analysis at 5% probability and to the Tukey test when the difference was significant using software SAEG (Sistema para Análises Estatísticas e Genéticas, Statistical and genetic analysis system) (UFV, 1997).

Results and Discussion

The mean values of water physical-chemical parameters pH, dissolved oxygen, electrical conductivity, and morning and afternoon temperatures were 7.4 ± 0.1, 5.1 ± 0.4 mg L^{-1}, 71.71 ± 6.2 µS m^{-1}, 24.4 ± 0.6ºC, and 25.5 ± 0.6ºC, respectively.

The average weight at 15, 30, and 45 days are given in Figure 1. Pacamã fingerling weight was affected by food processing ($P<0.01$). Moist food results were better at 30 and 45 days of the experiment.

The mean fortnightly FCa and the mean FCa in the experimental period are given in Table 2. FCa was the best for moist food in relation to the first ($P<0.02$), second ($P<0.05$), and third ($P<0.01$) fortnights, as well as the period mean FCa ($P<0.01$).

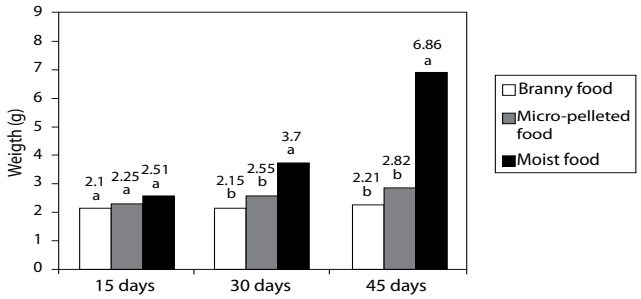

Figure 1: Weight of pacamã (*Lophiusilurus alexandri*) fingerling given different food processing at 15, 30, and 45 days (means in the same period (days) followed by different letters are significantly different by Tukey's test at $P<0.05$).

The survival rates of pacamã fingerling given branny, micro-pellet, and moist foods in the experimental period were 75, 87.5, and 100%, respectively. Despite the large numerical difference, survival was not influenced by treatments ($P>0.05$).

Water physical-chemical parameters remained within the values recommended for fish farming (BOYD, 1990; SIPAÚBA-TAVARES, 1995); that is, it was suitable for the fish species farming and not affected by treatments.

The survival rates found for pacamã fingerlings agree with the values reported by Rodrigues and Fernandes (2006), Bombardelli et al. (2004), and Furuya et al. (1998), who found that food processing did not influence survival rates. In contrast, Meurer et al. (2003) reported that micro-pelleted food resulted in a significantly lower survival rate than branny and moist food. We point out the resistance of the species to fasting periods, which may be related to the fact that the species is sedentary and possibly given to low energy consumption, as the fish remain on the bottom of the tank.

Table 2: Fortnightly and final apparent feed conversion of pacamã (*Lophiusilurus alexandri*) fingerlings given different food processing.

Food	Apparent Feed Conversion			
	1st fortnightly	2nd fortnightly	3rd fortnightly	Total period
Branny	20.89a	36.09a	12.25a	16.81a
Micro-pelletized	18.14a	25.39a	5.58a	10.49a
Moist	2.55b	1.61b	1.75b	1.79b
CV1	56.63	82.76	49.74	44.17

Means in the same column followed by different letters are significantly different by Tukey's test ($P<0.05$); [1] Coefficient of variation.

As to the final weight, Rodrigues and Fernandes (2006) evaluated acará-bandeira (*Pterophyllum scalare*) fingerlings and observed that food processing affected the fish final weight. Extruded and pelleted foods afforded better results than branny food. Our results disagree with those on Nile tilapia by Bombardelli et al. (2004) and Meurer et al. (2003) in the sexual reversal period, whose final weight was affected by food processing. In addition, Furuya et al. (1998) also found distinct values. Food processing did not influence Nile tilapia final weight during the growth phase.

Like performance, feed conversion was affected in the studies reported by Rodrigues and Fernandes (2006) and Furuya et al. (1998). The former demonstrated that extruded food resulted in higher FCa than that of branny food and a similar FCa to that of pelleted food. The latter found higher FCa for extruded food than for pelleted food.

The distinct results of the present study are due to the distinct species and development phase investigated. Few studies in the literature report on food processing for carnivorous fish and none on the species investigated here. Among the works discussed, a few investigated moist diets comparatively to other food processings. Most research compared extruded and pelleted foods, many times in relation to the influence of processing on nutrient availability or the reduction of anti-nutritional factors (DREW, et al., 2007).

In the case of carnivorous species, particularly Brazilian native species, moist food is commonly used in the feed training phase, as in the case of the study of Luz et al. (2002) on trairão (*Hoplias lacerdae*) fingerlings. Treatment without feed training led to low survival rates.

The present study demonstrates the best performance of fingerlings fed moist food. The impossibility or the low consumption of other food processings is confirmed by the low growth and FCa of fingerlings fed micro-pelleted and branny foods.

Pedreira et al. (2008) reported that pacamã has a large mouth, as confirmed by Meurer et al. (2010); the pacamã fingerling mouth is 56.7% as long as the head. Along with the lack of adequate gill rakers, which help in the best use of particulate foods, such as branny or micro-pelleted food, the results obtained with moist food may be more related to the supply of this food in ball form.

Another important factor found in this experiment is the good performance of the species when fed with inert artificial food, as although it is known that the species consumes inert foods, it is not known when it may be used. Pedreira et al. (2008) pointed out that the use of inert food did not afford an improvement in performance for species in the beginning of the post-larval phase. The good performance of fingerlings fed moist food may be related to the use of food suitable to the nutritional requirements of the species despite the lack of reference values in the literature.

It has been observed that the importance of processing food appropriately to fish species and developmental phase, as well as the nutritional balance for a given species, has little impact if the food is not provided in a form that fish may consume. The present results on fingerlings fed moist food corroborate those reported by Rodrigues and Fernandes (2006), who stated that food processing aims at facilitating the animal's feed intake, thus increasing feed efficiency and reducing losses to the aquatic system.

Moist food reduces food selectivity to an extent when compared to branny food (ENSMINGER; OLENTINE, 1980) and is "softer" and more palatable than the dry food (LOVELL, 1988). Generally, grinding is the first food processing step and it involves only the physical reduction of food particle size and an increase in surface area (MONTICELLI, et al., 1996), which increases nutrient leaching into the water and allows for food selectivity. However, a decisive factor in the present work was the feed intake capacity. Further investigation is required to compare particles with similar sizes.

Conclusion

It is recommended to provide moist food to pacamã fingerlings (*L. alexandri*) rather than micro-pelleted or branny foods.

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