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Effect of the addition of poultry by-product meal on the zootechnical performance of Nile tilapia fingerlings

Efeito da adição de farinha de vísceras de aves sobre o desempenho zootécnico de alevinos de tilápia do Nilo

Misleni Ricarte de Lima[1*] (ORCID 0000-0001-6757-6395), Maria do Carmo Mohaupt Marques Ludke[1] (ORCID 0000-0003-4895-2599), Elton Lima Santos[2] (ORCID 0000-0002-0965-5332), César Antunes Rocha Nunes[3] (ORCID 0000-0001-7180-3829), Cláudio José Parro de Oliveira[4] (ORCID 0000-0001-5310-6923)

[1] Federal Rural University of Pernambuco, Recife, PE, Brazil. *Author for correspondence: misleniricarte@hotmail.com
[2] Federal University of Alagoas, Rio Largo, AL, Brazil.
[3] State University of Feira de Santana, Feira de Santana, BA, Brazil.
[4] Federal University of Sergipe, Nossa Senhora da Glória, SE, Brazil.

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ABSTRACT

This study has aimed to assess the inclusion of poultry by-product meal in the diets of Nile tilapia fingerlings on heterogeneous growth and zootechnical performance. We used 144 animals with a mean initial weight of 1.3 ± 0.02 g distributed in 24 polyethylene aquariums with a capacity of 80 L of water, connected to a recirculation system following a completely randomized experimental design with four treatments (0.0, 6.0, 12.0, and 18.0% of poultry by-product meal) and six replications. At the end of the experimental period, the following variables were evaluated: final weight, survival rate, weight gain, heterogeneous growth, average feed intake, feed conversion ratio, protein efficiency ratio, and hepatosomatic and liposomatic index. The treatments have had no effect on the variables analyzed in the performance test. Therefore, up to 18% poultry by-product meal can be included in Nile tilapia fingerling diets.

KEYWORDS: protein food; feed efficiency; *Oreochromis niloticus.*

RESUMO

O presente estudo teve como objetivo avaliar o efeito da inclusão da farinha de vísceras de aves em dietas para alevinos de tilápia do Nilo, sobre o crescimento heterogêneo (CHet) e desempenho zootécnico. Foram utilizados 144 animais com peso médio inicial 1,3 ± 0,02 g, distribuídos em 24 aquários de polietileno com capacidade para 80 L de água, interligados a um sistema de recirculação seguindo um delineamento experimental inteiramente casualizado, com quatro tratamentos (0,0; 6,0; 12,0 e 18,0% de farinha de vísceras de aves) e seis repetições. Ao término do período experimental foram avaliados: peso final, taxa de sobrevivência, ganho em peso, crescimento heterogêneo, consumo de ração, conversão alimentar aparente, taxa de eficiência proteica, índices hepatossomático e lipossomático. Não foram observados efeitos dos tratamentos sobre as variáveis analisadas no ensaio de desempenho. Sendo assim, a farinha de vísceras de aves pode ser incluída até 18% nas dietas para alevinos de tilápia do Nilo.

PALAVRAS-CHAVE: alimento proteico; eficiência alimentar; *Oreochromis niloticus.*

INTRODUCTION

Brazilian aquaculture is growing rapidly, and it is benefiting from the number of fish species that have shown potential for commercial farming, the availability of raw materials and market opportunities, and also the generation and dissemination of technology aimed at fish farming (LIMA et al. 2015).

Among the cultivated species, Nile tilapia stands out in the Brazilian scenario. The outstanding growth in the production of this species, among many other factors, is correlated to the professionalization of pisciculture in the country, the intensification of production systems, and the accumulation of knowledge about the species nutrition and feeding (PINTO et al. 2017). As for nutritional management, it is essential the use of balanced feed with highly digestible ingredients and a good amino acid profile to maximize the zootechnical indexes of confined animals.

Soybean meal is the main source of plant protein in fish diets, especially those with omnivorous eating habits. As soybean is a commodity, its price is strongly influenced by world demand, which makes its export more advantageous at times to the detriment of the domestic market (AZEVEDO et al. 2017).

Faced with the various obstacles existing in pisciculture, the high feed cost is still a great challenge to overcome. This can be specially seen in the Brazilian Northeast with its low production of grains, and the fact that traditional sources commonly used in the feed of these animals, such as corn, fish meal, and soybean meal, are considered commodities in the agroindustry sector, which makes most of them expensive.

In an attempt to reduce the high cost of feed, several studies have been conducted to replace traditional ingredients with alternative sources. A poultry by-product meal is a great option among the ingredients with potential for this replacement. This ingredient is a by-product of the poultry slaughterhouse industry that results from the cooking, pressing, and grinding of poultry offal, and the inclusion of heads and feet is allowed (HENRIQUES et al. 2017).

Poultry by-product meal has good nutritional value and can be an excellent protein source in fish feed. It has the following nutritional composition: dry matter (93.90%), crude protein (53.30%), fat (20.60%), and gross energy (5343 kcal/kg) according to ROSTAGNO et al. (2017).

In addition to having a good nutritional composition, this ingredient has excellent digestible coefficients for Nile tilapia: 93.13% for dry matter digestibility coefficient, 92.98% for protein, and 97.26% for energy (PINTO et al. 2017). Therefore, poultry by-product meal has excellent potential to be included in diets of Nile tilapia.

Previous studies have shown that the use of poultry by-product meal as a protein source improves the productive performance of fish in different farming stages. The following studies stand out: HASSANI et al. (2021) for sturgeon juveniles, RANDAZZO et al. (2021) and SABBAGH et al. (2019) for gilt-head bream juveniles, KPOGUE et al. (2019) for *Parachanna obscura* fingerlings, YONES & METWALLI (2015) for Nile tilapia juveniles, and CAVALHEIRO et al. (2014) for catfish juveniles.

Based on the above, the objective of this study has been to assess the parameters of productive performance, heterogeneous growth, and digestive indexes of Nile tilapia fingerlings fed with poultry by-product meal in their diet.

MATERIAL AND METHODS

This research was conducted in the Non-Ruminants Digestibility Sector, located in the Animal Husbandry Department of the Federal Rural University of Pernambuco (UFRPE), Brazil.

The ingredients used in the manufacture of the feed were analyzed regarding their chemical composition, according to the methodology described by DETMANN et al. (2012). The chemical composition of poultry by-product meal is described in Table 1.

Table 1. Determined chemical composition of poultry by-product meal (dry matter basis).

Nutrients and Energy	(%)
Dry matter[1]	95.34
Crude protein[1]	60.18
Ether extract[1]	21.58
Mineral material[1]	11.74
Calcium[2]	5.54
Phosphorus[2]	0.79
Sodium[2]	0.28
Gross energy[1]	5521kcal/kg

[1]Analysis performed at the Animal Nutrition Laboratory of UFRPE.
[2]Analysis performed at the EMBRAPA Laboratory for swine and poultry (Concórdia/SC/Brazil).

The animals used in the research were acquired from a commercial producer, and before the initial biometry all the animals were acclimated for a period of 10 days in a 1000 L tank with a recirculation system with biofilter and constant aeration. During this period, a multiparameter probe monitored the water quality parameters (dissolved oxygen, temperature, and pH) daily. Fish were fed three times a day with commercial extruded feed (30% crude and species-specific protein).

After the period of adaptation and biometrics, the animals were placed in 24 polyethylene aquariums with a capacity of 80 L of water connected to a recirculation system using a biofilter (consisting of sand, gravel, and bio ball) and constant aeration. The system water renewal rate was 1 L per minute.

For the performance testing, four diets formulated to meet the species' nutritional requirements according to NRC (2011) were assessed, being these diets isoproteic and isoenergetic (Table 2).

Table 2. Formulation and chemical composition of experimental diets.

Ingredients (%)	LEVELS OF POULTRY BY-PRODUCT MEAL			
	0%	6%	12%	18%
Soybean meal	60.14	51.94	43.75	35.55
Corn	32.49	35.78	39.08	42.34
Test ingredient	-	6.00	12.00	18.00
Dicalcium phosphate	2.79	2.01	1.23	0.45
Common salt	0.50	0.50	0.50	0.50
Mineral and vitamin supplement*	0.50	0.50	0.50	0.50
Limestone	0.92	0.61	0.29	-
Vitamin C	0.10	0.10	0.10	0.10
Soybean oil	2.04	2.20	2.36	2.52
BHT**	0.02	0.02	0.02	0.02
L-lysine	0.28	0.19	0.09	-
L-threonine	0.04	0.02	0.01	-
DL-methionine	0.18	0.12	0.06	-
CALCULATED COMPOSITION				
Digestible energy kcal/kg^{-1}	3036	3036	3036	3036
Crude protein (%)	30.00	30.00	30.00	30.00
Ether extract (%)	4.17	5.00	5.83	6.66
Crude fiber (%)	3.81	3.51	3.21	2.91
Calcium (%)	1.20	1.20	1.20	1.20
Available phosphorus (%)	0.65	0.65	0.65	0.65
Total lysine (%)	1.97	1.97	1.97	1.97
Total met + cys (%)	1.05	1.05	1.05	1.05
Total threonine (%)	1.20	1.20	1.20	1.20

*Mineral and vitamin supplement (Composition/ kg of product): vit. A = 900,000 IU; vit. D3 = 50,000 IU; vit. E = 6,000 mg; vit. K3 = 1200 mg; vit. B1 = 2400 mg; vit. B2 = 2400 mg; vit. B6 = 2000 mg; vit. B12 = 4800 mg; folic acid = 1200 mg; calcium pantothenate = 12,000 mg; vit. C = 24,000 mg; biotin = 6.0 mg; choline = 65,000 mg; nicotinic acid = 24,000 mg; Fe = 10,000 mg; Cu = 600 mg; Mn = 4000 mg; Zn = 6000 mg; I = 20 mg; Co = 2.0 mg; and Se = 25mg. **Butylated hydroxytoluene (antioxidant).

The experimental feed was prepared as follows: the ingredients were ground in a Wiley mill, with a 1.0 mm sieve, then homogenized and moistened with water (at temperature ± 50 ºC) and pelleted in a screw feeder. Subsequently, the diets were sent to a forced air oven at a temperature of ± 55 ºC for a period of 24 hours.

For the performance testing, 144 male Nile tilapia fingerlings were used with a mean initial weight of 1.3 ± 0.02 g. A completely randomized design was used consisting of four treatments (0.0, 6.0, 12.0, and 18.0% of by-product meal inclusion) and six replications with six animals per experimental unit.

The aquariums were siphoned daily (before the first feeding) to remove feces and any feed leftovers, and approximately 15% of the water was removed. The fish were fed four times a day (8:00 AM, 11:00 AM, 02:00 PM, and 05:00 PM) until apparent satiety for 60 days.

The water quality indicators of pH, oxygen, and temperature were monitored daily using a multiparameter probe. In addition, total ammonia (NH_3 + NH_4) was measured with the aid of a spectrophotometer, using HI93700-01 model reagents. Nitrite (NO_2^-) was analyzed with the same equipment, using the HI93705-01 reagent. The means of the water quality parameters monitored throughout the experimental period were: dissolved oxygen (6.0 ± 0.9 mg/L^{-1}), temperature (27.02 ± 0.4 ºC), pH (6.28 ± 0.2), nitrite (0.03 ± 0.08 mg/L^{-1}), and ammonia (0.002 ± 0.001 mg/L^{-1}). The values obtained corroborate those recommended by SÁ (2012) for aquaculture.

The animals were submitted to biometric measurement every 15 days, for 60 days, to monitor performance and heterogeneous growth (HetG), which were assessed by the coefficient of variation of weight [CV = 100 (standard deviation/mean weight)] (BARBOSA et al. 2006).

At the end of the research, the animals were fasted for 24 hours for complete emptying of the digestive tract. Then, they were anesthetized with clove oil in water (10 ml/L^{-1}) and they were later weighed to evaluate final weight (g), heterogeneous growth, and survival rate (%).

Then, two fish from each experimental plot were necropsied to remove the offal, liver, and visceral fat to determine the following digestive indexes: hepatosomatic index (liver weight ÷ body weight) x 100 and liposomatic index (weight of the coelomic fat ÷ body weight) x 100.

The zootechnical performance parameters assessed in this study were: final weight, survival rate (SR = number of final fish ÷ number of initial fish x 100), weight gain (WG = final biomass – initial biomass), average feed intake (FI = 100 (amount of feed (g)/fish biomass (g)), feed conversion ratio (FCR = amount of dry feed offered (g)/wet weight gain (g)), and protein efficiency ratio (PER = weight gain (g)/protein consumed (g)).

Statistical analyses were performed using the Statistical Analysis System (SAS 2000) program and the data were submitted to regression analysis at a 5% significance level.

RESULTS AND DISCUSSION

The inclusion of up to 18% of poultry by-product meal in the diets of Nile tilapia fingerlings did not significantly influence (p>0.05) the results of the variables analyzed (Table 3).

Table 3. Performance of Nile tilapia fingerlings fed diets containing levels of poultry by-product meal.

Variables analyzed	Inclusion levels					
	0%	6%	12%	18%	P*	CV
Initial weight (g)	1.3±0.02	1.3±0.02	1.3±0.02	1.3±0.02	-	-
Final weight (g)	17.51±1.48	20.02±0.85	17.90±1.83	20.14±1.98	0.0686	9.64
WG (g)	16.21±1.48	18.72±0.85	16.60±1.83	18.84±2.36	0.0686	10.35
FI (g)	18.27±1.80	21.99±1.88	21.49±2.75	22.12±3.14	0.0721	11.56
FCR	1.13±0.13	1.14±0.08	1.32±0.29	1.30±0.15	0.2641	15.14
PER	2.96±0.33	2.94±0.19	2.58±0.55	2.66±0.35	0.4046	15.29
SR (%)	86.67±13.61	93.33±9.62	93.33±9.62	86.67±13.61	0.6661	13.09
HSI	0.21±0.03	0.37±0.08	0.29±0.07	0.28±0.08	0.0723	27.42
LSI (%)	0.08±0.05	0.17±0.08	0.18±0.04	0.16±0.05	0.0653	37.52

WG: weight gain; FI: average feed intake; FCR: feed conversion ratio; PER: protein efficiency ratio; SR: survival rate; HSI: hepatosomatic index; LSI: liposomatic index; P*: probability; CV: coefficient of variation.

Final weight and weight gain were not influenced by the levels of inclusion of poultry by-product meal, as shown in Table 3. A similar result has been obtained by RANDAZZO et al. (2021) for the final weight parameter of juvenile gilt-head bream in their study that has assessed the replacement of protein from plant ingredients with protein from poultry by-product meal. SABBAGH et al. (2019) have also found no statistical difference with gilt-head bream juveniles for weight gain when they replaced fish meal with poultry by-product meal.

SCHWERTNER et al. (2013), when assessing the replacement of fish meal with poultry by-product meal in the diets of *Leporinus macrocephalus* fingerlings, have also not found a significant effect for these analyzed variables. However, FARIA et al. (2002) found divergent results from his research, who, when assessing this ingredient in the diets of Nile tilapia (*Oreochromis niloticus*) fingerlings, have found a linear increase in weight gain. BOSCOLO et al. (2005), when testing the diets of post-larvae Nile tilapia during the sex reversal phase, have also found a linear increase in final weight. SIGNOR et al. (2007), when analyzing *Leporinus macrocephalus* fingerlings, have also found a linear increase in final weight and weight gain.

Fingerlings have a greater requirement for nutrients because of their high growth rates during this stage. According to MORGAN et al. (2000), protein metabolism refers to a permanent cycle of synthesis and degradation, where growth is essentially an addition of proteins because the rate of synthesis is greater than the rate of degradation. Therefore, animals that receive feed formulated with ingredients of animal origin, whose amino acid profile tends to be higher, when compared to plant ingredients, have better zootechnical indexes, as the animals have a better use of the diet.

Feed consumption was also not significantly influenced by changes in the diet's by-product meal levels. However, this may have occurred because the feed was isoenergetic, since energy is one of the factors limiting consumption.

The result obtained in this research's apparent feed conversion ratio was similar to that found by PIÑEROS-ROLDAN et al. (2014) with Pirapitinga (*Piaractus brachypomus*) juveniles, as these authors have also not obtained a significant effect when replacing fish meal with poultry by-product meal. However, different results have been obtained by HASSANI et al. (2021), who have found a higher rate for this variable by replacing 100% fish meal with poultry by-product meal in the diets of sturgeon juveniles. FARIA et al. (2002), when analyzing (0, 4, 8, 12, 16, and 20%) the inclusion of poultry by-product meal in the diets of Nile tilapia fingerlings, have obtained a quadratic effect, which shows a better conversion for the level of 20% of inclusion. SIGNOR et al. (2007) have found (for 0, 5, 10, 15, and 20% of this same ingredient) a linear decrease, and the level of 20% of inclusion of poultry by-product meal resulted in the best feed conversion for *Leporinus macrocephalus* juveniles.

Another parameter that was not influenced by the treatments was the protein efficiency ratio, which represents the animal's ability to transform protein into body mass. A similar result has been found by YONES & METWALLI (2015), who have replaced fish meal with poultry by-product meal for Nile tilapia juveniles. In addition, ADAM SULIEMAN & KHAMIS AHMED (2011) have also found a similar result with the inclusion of 10% of poultry by-product meal in the diet of Nile tilapia fingerlings. On the other hand, KPOGUE et al. (2019) have found a quadratic effect when replacing fish meal with poultry by-product meal for *Parachanna obscura* fingerlings. FARIA et al. (2002) have found an increasing linear effect for Nile tilapia fed diets with poultry by-product meal.

The average mean survival rate was above 86%, and the inclusion of poultry by-product meal in the diets did not influence it. This result corroborates those of SIGNOR et al. (2008), in which the authors have found no significant effect on the survival rate for *Astyanax altiparanae* fingerlings fed with poultry by-product meal. In addition, FARIA et al. (2002) have also found no significant effect for Nile tilapia fingerlings fed with increasing levels of poultry by-product meal. On the other hand, KPOGUE et al. (2019) found a linear reduction when replacing fish meal with poultry by-product meal for *Parachanna obscura* fingerlings. FINKLER et al. (2010), when evaluating the replacement of fish meal with poultry by-product meal in the diets of *Leporinus macrocephalus* X *Leporinus elongatus* fingerlings, have also obtained a linear reduction in the survival rate of these animals.

The hepatosomatic index obtained in this study ranged from 0.21 to 0.37%. A similar effect has been obtained by BOSCOLO et al. (2010), who have also found no significant effect when evaluating this index in Nile tilapia juveniles, and their results ranged from 2.30 to 2.59%.

The percentages of liposomatic index found ranged from 0.08 to 0.18%. A similar effect has been obtained by BOSCOLO et al. (2010), who have also not found a significant effect for Nile tilapia juveniles, and their results ranged from 3.82 to 4.25%

In nutritional assays for the assessment of ingredients in fish diets, hepatosomatic and liposomatic evaluation is essential. According to SANTOS et al. (2015), this evaluation is an important tool for zootechnical performance and animal welfare, since the organs of the gastrointestinal tract and the liver are sensitive to the type of food because of metabolic transformations and nutrient absorption. FURUYA & FURUYA (2005) report that the changes that may occur in hepatosomatic and liposomatic indexes may be directly associated with the accumulation of energy reserves or with some disturbance in the protein and lipid metabolism, or even an imbalance in the energy:protein ratio of the diet. For example, in feed with low energy in relation to protein, the amino acids in the diet will be used as a source of energy or for the deposition of body fat.

Regarding body fat deposition, LIMA et al. (2012) report that the accumulation of fat is proportional to the growth of the fish, being this more evident in animals in the termination phase. Thus, this confirms the low percentages obtained by our research for the liposomatic index, since the animals evaluated were in the nursing phase.

BOSCOLO et al. (2010) report that the main fat deposit site in lean fish, as in the case of tilapia, is the viscera. According to SOARES JÚNIOR et al. (2013), the inclusion of lipids in the diet of fish leads to an increase in the level of body fat, and this increase is related to the level of inclusion, thus, the higher the level of dietary lipid, the greater the fat deposit in this animal.

Although the levels of inclusion of the test ingredient provided an increase in the ether extract in the diets (4.17 to 6.66%), this increase did not result in a difference in the deposition of fat in the viscera, and this resulted in values below those found in the literature.

This is a positive effect on the carcass characteristic, since a high percentage of fat can influence the metabolism and nutritional composition of the muscle with the accumulation of fat, which for the consumer market is not feasible, because more and more people are looking for a higher fillet yield with a lower deposition of fat in the carcass.

Heterogeneous growth (HetG) had no effect among treatments (Figure 1).

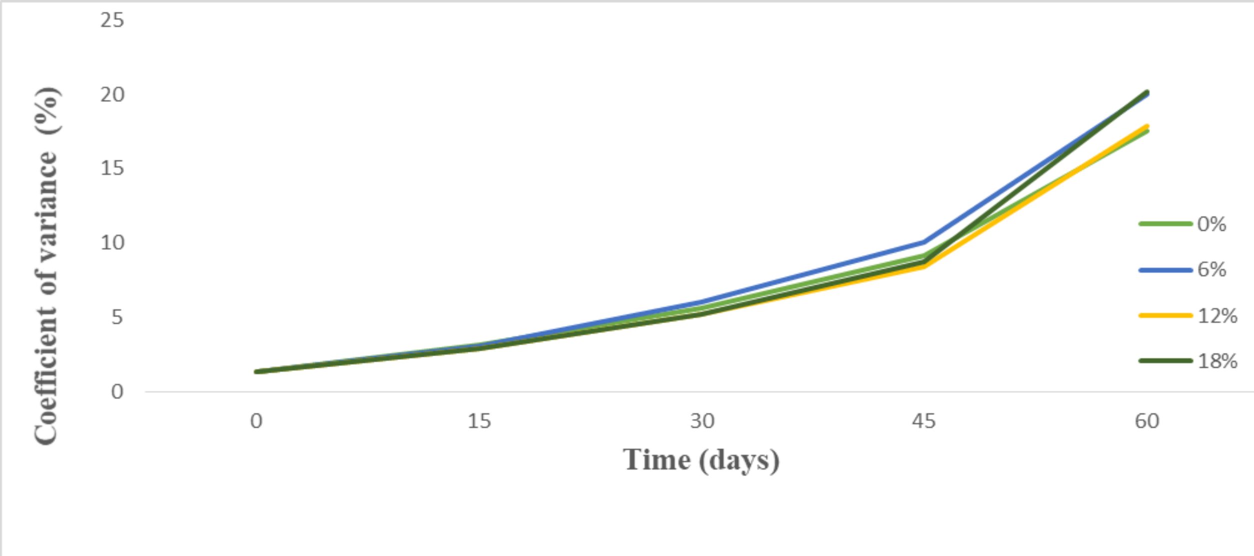

Figure 1. Heterogeneous growth (HetG) of Nile tilapia fingerlings fed diets containing different levels of poultry by-product meal.

Throughout the entire experimental period, there was no exacerbation of the heterogeneous growth of the animals between the different treatments assessed; that is, all the animals presented very similar weights during the 60 days of evaluation of the research. However, there was an increase in HetG as the animals increased in weight in all treatments. This is a natural fact in the case of Nile tilapia, as this is a territorial and aggressive species.

During the experimental period, we could observe that the animals showed territorial behavior, which is characterized by aggressiveness between individuals and social stress. This may have driven growth variations between dominant and submissive fish in the group; however, these variations had no significant effect between treatments. This may have occurred because of the stocking rate, which was approximately 13.33 L of water for each fish, which gives the animals space to move around within the experimental units. According to BARBOSA et al. (2006), tilapia with low initial weight variability and high stocking densities show an exacerbation of heterogeneous growth. The individuals in this study presented low initial weight variability (1.3 ± 0.02 g) and a low stocking rate, and this may have contributed to the non-exacerbation of HetG.

Based on the data obtained from the assessment of HetG in this study, it can be inferred that the levels of inclusion of poultry by-product meal in the analyzed diets provided a more homogeneous batch at the end of the experimental period. This is a positive point, as this is what is expected in tilapia farming. It is worth noting that HetG is one of the parameters used to assess the uniformity of the batch; it can be used as an assessment measure: the stocking density rate, feeding frequencies, type of food, etc. (SEABRA et al. 2020, SIGNOR et al. 2020).

CONCLUSION

Based on the results obtained in this study, it can be concluded that poultry by-product meal can be included in Nile tilapia diets up to the level of 18% without affecting the zootechnical performance of the animals.

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