ZOOTECHNICAL PERFORMANCE OF NILE TILAPIA WITH DIETS BASED ON CASSAVA RESIDUES

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ABSTRACT – This research aimed to evaluate the use of residues from the processing of cassava, available in the North and Northwest Fluminense regions, replacing some traditional ingredients in the Nile tilapia diet. The experiment lasted 112 days. 840 tilapia fry were used, distributed in 12 hapas and divided into three treatments composed of different isoproteic and isocaloric diets, one control diet without inclusion of residue and two experimental diets, one with the inclusion of cassava peel flour and the other with inclusion of tapioca sweeping flour. The diet with the inclusion of cassava peel showed a zootechnical result similar to the control diet, and the inclusion of agro-industrial residue from tapioca dusting flour has been shown to provide this performance significantly superior. The evaluations carried out in this study indicate that the residues from the cassava processing are foods with potential for use in feed for Nile tilapia in partial replacement to energetic ingredients such as corn and wheat, without compromising the productive performance and reducing the cost of food, taking into account the use of agro-industrial waste present in the region.

Keywords: cassava peel, family farming, *Oreochromis niloticus*, sweep of tapioca.

DESEMPENHO ZOOTÉCNICO DE TILÁPIA-DO-NILO COM DIETAS A BASE DE RESÍDUOS DA MANDIOCA

RESUMO – Na presente pesquisa objetivou-se avaliar o aproveitamento de resíduos do beneficiamento de mandioca, disponíveis nas regiões Norte e Noroeste Fluminense, em substituição a alguns ingredientes tradicionais na dieta de tilápia-do-Nilo. O experimento teve duração de 112 dias. Foram utilizados 840 alevinos de tilápia distribuídos em 12 hapas e divididos em três tratamentos compostos por diferentes rações isoproteicas e isocalóricas, sendo uma ração testemunha sem inclusão de resíduo e duas rações experimentais, uma com inclusão de farinha de casca de mandioca e outra com inclusão de farinha de varredura de tapioca. A ração com inclusão de casca de mandioca apresentou resultado zootécnico semelhante à ração controle, e a inclusão de resíduo agroindustrial de farinha de varredura de tapioca demonstrou proporcionar esse desempenho de modo significativamente superior. As avaliações realizadas neste estudo indicam que os resíduos do processamento da mandioca são alimentos com potencial para utilização em rações para tilápia-do-Nilo em substituição parcial a ingredientes energéticos como o milho e o trigo, não gerando comprometimento do desempenho produtivo e reduzindo o custo da alimentação, levando-se em consideração o aproveitamento de resíduos agroindustriais presentes na região.

Palavras chave: agricultura familiar, casca de mandioca, Oreochromis niloticus, varredura de tapioca.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) is the sixth most cultivated fish species in the world (Michelato et al., 2013; Tacon and Metian, 2013). It is an important species in intensive aquaculture, it is among the main species cultivated commercially due to its good growth, potential for intensive fish farming, adaptation to different climates and environmental conditions and excellent quality meat

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(Scorvo et al. 2010; Ferreira et al. 2011; Melo, 2013; Vicente and Fonseca, 2013).

For Neu et al. (2012), this expansion is due to the capacity that the species has to adapt to the most diverse locations and the large amount of food ingredients that this fish can use in its diet. An option to replace animal protein sources for energy purposes in the diet of fish are ingredients of plant origin because they are rich in carbohydrates (Enes et al., 2011).

As an alternative to this nutritional demand, several alternative ingredients can be used in the feed in order to reduce costs and determine satisfactory growth, similar to that obtained with conventional foods. The use of some regional ingredients in fish feeds such as: cassava leaves, mesquite pods (Jesus et al., 2011), mango meal bran (Lima et al., 2011), coffee residue (Pimenta et al., 2011) among others are already being studied.

There are several possibilities for using materials that already exist on the same rural property, which are normally discarded. In Rio de Janeiro, tilapiculture represents approximately 70% of the total production of fish grown in the North and Northwest regions of the state (IBGE, 2018). Considering the relevant tilapia production in these regions, the present study aimed to evaluate the zootechnical performance of Nile tilapia with diets based on residue from cassava processing in food.

MATERIAL AND METHODS

The experiment was carried out at the Federal Institute of Education, Science and Technology Fluminense Advanced Campus Cambuci (IFF-Cambuci), in the municipality of Cambuci / RJ, in partnership with the State University of the North Fluminense Darcy Ribeiro (UENF), from January to May 2017, totaling 112 days.

To feed the fish, three rations were made, one with traditional ingredients only, without including cassava residues (control; T1) and two with alternative ingredients (residues obtained in agro-industries in the region): cassava peel flour 24% (T2) and tapioca sweeping flour (T3). The formulations of the three diets, shown in Table 1, are isoproteins (36% crude protein), isocaloric (3,100 Kcal).

In order to carry out the experiment, 1,200 fingerlings of the Nile tilapia variety Gift were purchased from a private fish farm, sexually inverted for males and with an average weight of approximately two grams. The animals were divided into 12 lots with 100 fish each, each lot housed in a hapa with a mesh of 7 mm and a useful volume of 6 m³ (2.0 x 2.0 x 1.5 m), covered with plastic mesh for protection against birds. The hapas were fixed suspended by wire inside a pond excavated with water renewal, measuring 50.0 x 20.0 x 2.0 m and protected against terrestrial predators by an electrified fence. Two rows were formed with six hapas on each side of the tank.

Table 1 - Formulation in percentage of the ingredients of the experimental and control diets

Ingredients (%)	Treatments		
	T1 (WAR)	T2 (ARMPF)	T3 (ARTSF)
Corn meal	19.08	2.00	1.00
Wheat bran	8.00	2.00	2.00
Soybean meal	54.92	38.09	28.00
Fish's flour	15.00	30.91	42.00
Premix	2.00	2.00	2.00
Fish oil	1.00	1.00	1.00
Residue 1 (RAFCM)	0.00	24.00	0.00
Residue 2 (RAFVT)	0.00	0.00	24.00
Total	100	100	100

T1 - WAR - without agro-industrial residue; T2 – ARMPF - agro-industrial residue from manioc peel flour; T3 - ARTSF - agroindustrial residue from tapioca sweeping flour.

NOTE: all diets were formulated with 3,100 Kcal/kg of digestible energy and 36% crude protein.

Initially, the fish underwent a period of adaptation to the experimental conditions in order to avoid that a possible mortality and stress generated by the transport and change of environment could interfere in the studied variables. The adaptation period lasted two weeks and during this time all animals received only the control diet in two daily offers, at 8 and 16 hours. On the 15th day, the batches underwent a selection with removal of different animals (very small or very large), so that each batch was as homogeneous as possible and remained with 70 fish each. Then the lots were divided between the 3 treatments, with 4 repetitions each, and each treatment started to receive its corresponding ration, also in two daily offers and at the same times.

Two weeks after the start of the experimental rations supply, each batch was weighed, defining an initial average weight (AWi) for the fish in each sample unit. From then on, the weighings were carried out every two weeks until the end of the experiment, obtaining in each weighing the biomass of each hapa and adjusting the amount of feed to be supplied (8% of the biomass, divided into two daily offers).

The experiment lasted 112 days and at the end all animals were fasted for a period of 24 hours, and then passed through the last weighing to determine the final average weight (AWf) of each batch. A sample corresponding to 10% of each batch was slaughtered after being anesthetized with Eugenol-based solution, measuring the total length (TL - measured from the mouth to the tip of the caudal fin) and standard length (SL - measured from the mouth) to the base of the caudal fin). These animals were then eviscerated and the carcass frozen for further analysis of the proximate composition.

In view of the fact that the tank was supplied by a single point located at the head and the drainage occurred from the point on the opposite bank, with the water flow occurring in this direction, the haphas arranged at the beginning of the rows (close to the supply point of the tank) could be exposed to a higher level of dissolved oxygen. On the other hand, the hapas arranged at the end of the rows (close to the drainage point of the tank) could be exposed to a higher level of nitrogenous waste eliminated by the fish and carried in the direction of the first to the last hapas.

Due to this heterogeneity of environmental characteristics between the different hapas fixation points in the tank, the design was carried out in randomized blocks (DRB). The tank was virtually divided into 4 blocks and 3 randomized treatments in each block, preventing these environmental differences to which each experimental unit was exposed from influencing the statistical analysis of the studied performance variables.

To assess the possible differences in these variables as a result of the treatments, analysis of variance (ANOVA) was performed at the level of 5% of probability in the F test. When this was significant, the Tukey test was also applied at the level of 5% of probability for partition of treatments into similar groups.

The survival rate is expressed as a percentage and was calculated using the equation:

$$SR = 100 \times \left(\frac{Q_f}{Q_i}\right)$$

Where: SR = survival rate; Qf = quantity of fish surviving at the end of the experiment; Qi = quantity of fish housed at the beginning of the experiment;

The specific growth rate (SGR) is expressed as a percentage and was calculated using the formula suggested by Bagenal and Tesch (1978):

$$SGR = 100 \times \left(\frac{\ln Wf - \ln Wi}{t}\right)$$

Where: TCE = specific growth rate; Pf = final weight (g); Pi = initial weight (g);

ln = natural logarithm; t = days of experiment;

In the country, the feed industry certifies the quality of the feed by the performance responses obtained mainly by weight gain and apparent feed conversion (Silva et al., 2013). The feed conversion represents how much the animal converts from food to kilogram of live weight, disregarding losses with excretion and leftovers. However, the experimental conditions of this study did not allow to assess how much of the food provided was excreted or lost. Therefore, the apparent feed conversion index (AAC) was used as a parameter, which does not take into account the amount of food used by the animal, but the amount supplied and the weight gain obtained during the cycle, as shown in the formula:

$$AFC = \frac{AA}{AW}$$

Where: AFC = apparent feed conversion; AA = average amount of feed provided per animal in the experimental unit; AW = average weight gain per animal in the experimental unit.

The feed efficiency index (IEA), equivalent to the efficiency to convert the feed into live weight, was determined using the equation:

$$FEI = \frac{AW}{AF}$$

Where: FEI = feed efficiency index; AW = average weight gain per animal in the experimental unit; AF = average amount of feed provided per animal in the experimental unit.

The carcass samples of each treatment were crushed, and the proximate composition was defined by determining the moisture, ash, protein and lipid content in each sample pool. The methodology used is in accordance with that provided by AOAC, the acronym in English for “Association of Analytical Communities” (AOAC 2005).

The moisture content was measured by means of the sample weight difference before and after drying in an oven regulated at 105 ° C until constant weight was obtained. This difference in weight represents the losses of moisture and volatile substances that occurred during the process.

The fixed mineral residue (ash) was measured by weight loss after incineration, in a muffle furnace at 500-550 ºC, with destruction of the organic matter without appreciable decomposition of the constituents of the mineral residue or loss through volatilization.

The protein content was determined by the Kjeldahl method, which is based on the determination of total nitrogen. First, digestion and distillation with sulfuric acid was performed to collect the ammonium sulfate, which was then titrated with 0.1N hydrochloric acid solution.

The fat content was determined by means of hot ethereal extraction (Goldfish method). The petroleum ether is heated and begins to wash the sample, dragging the lipids and depositing them at the bottom of the used glassware. The extracted lipids are determined by the difference between the glassware weight with the deposited lipid and the glassware weight before analysis.

RESULTS AND DISCUSSION

Regarding the survival rate, it was observed that none of the diets with residue significantly affected the animals' survival. The survival rate obtained was 92%, 94% and 93%, for treatments T2, T3, T1, respectively.

The initial average weight did not differ statistically between treatments (Table 2), reflecting the correct homogenization of the batches before starting to supply the experimental diets and measurements. The performance variables "final average weight", "total length", "standard length" and "height" showed a statistical difference between treatments, with the diet with the inclusion of the cassava sweep (T3), the treatment with the greatest difference.

The higher performance obtained with the inclusion of tapioca flour (T3), may have occurred due to the need to use a higher concentration of fish meal in this formulation. It is worth noting that as the agro-industrial residues used are of high energy value and low in protein, there is a need to balance the diet by adding other ingredients with a better profile of amino acids and nutrients (Cyrino et al., 2010). It should also be noted that fish meal and oil, sources traditionally used in the formulation of feed for aquatic organisms, tend to increase production costs (Azevedo et al., 2013). Therefore, the use of these alternative ingredients in feed formulations is one of the alternatives to lower the cost of feed, as pointed out by Carvalho et al. (2012).

Table 2 - Average values of the zootechnical data of Nile tilapia farming fed with feed formulated with traditional ingredients only (T1) and fed with feed formulated with the inclusion of agro-industrial residues (T2 and T3)

Variables	Treatments		
	T1 (WAR)	T2 (ARMPF)	T3 (ARTSF)
AW_i (g)*	4.62	4.28	5.14
AW_f (g)	45.70^b	39.08^b	59.10^a
Total length (cm)	13.01^b	12.54^b	14.76^a
Standard length (cm)	10.89^b	10.53^b	12.42^a
Height (cm)	4.13^b	3.97^b	4.70^a

* There is no statistically non-zero contrast between the means by the F test at the 5% probability level. ^{abc} Means followed by at least one equal letter on the same line do not differ at the level of 5% probability by the Tukey test.

Pereira da Silva and Pezzato (2000) when evaluating the attractiveness and palatability of various ingredients for Nile tilapia classified ingredients derived from cassava as of low palatability, reinforcing the need to use a higher proportion of fish meal in diets with inclusion of residues when compared to the control diet, which in turn increases the palatability of the feed and the attraction of fish, ensuring greater consumption. The results also match the omnivorous eating habit of tilapia, suggesting the ability to make good use of rations containing flour from cassava residue or flour from tapioca sweeping (Oeda et al., 2013).

The means of specific growth rate (SGR) showed no statistical difference between treatments. As for the apparent feed conversion (AFC) and feed efficiency índices (FEI), T2 and T3 differed, with T3 showing results zootechnically superior to T2, which may suggest a better digestibility of the tapioca sweep in relation to the peel. cassava (Table 3). The data found corroborate with Boscolo et al. (2002) who state that the cassava residues can be included in the feed for Nile tilapia fry up to the level of 24%, replacing cornmeal entirely, without compromising the development of fish.

The AFC and FEI of diets with inclusion of cassava peel and tapioca sweep did not differ from the control diet formulated only with traditional ingredients. This result suggests an incomplete use of the food provided, which may have occurred due to the use of dense pelleted feeds, that is, pellets that sink in contact with the water due to their high density. Similar results to the experiment were found by Melo et al. (2015), with the substitution of corn for mango bran in the feeding of Nile tilapia.

Table 3 - Average values of the zootechnical indexes of Nile tilapia rearing fed with feed formulated with traditional ingredients only (T1) and fed with feed formulated with the inclusion of agro-industrial residues (T2 and T3)

Variables	Treatments		
	T1 (WAR)	T2 (ARMPF)	T3 (ARTSF)
SGR*	2.67 %	2.57 %	2.90 %
AFC	3.52[ab]	4.21[a]	2.60[b]
FEI	0.30[ab]	0.25[b]	0.39[a]

* There is no statistically non-zero contrast between the means by the F test at the 5% probability level.

[abc] Means followed by at least one equal letter on the same line do not differ at the level of 5% probability by the Tukey test.

Due to this characteristic, the time that the ration remains in suspension in the water and available for seizure by the fish is reduced, decreasing its use. The present study used food in a fixed quantity, making it impossible to visually assess the degree of apprehension of the feed provided, which may justify a low utilization and high apparent feed conversion values.

Excessive feed supply can result in food waste, increased production costs and worsening water quality, consequently impairing the zootechnical and economic performance of the activity (Santos et al., 2013). A greater amount of daily offers in smaller portions can contribute to loss reduction, resulting in a more efficient AFC. Santos et al. (2015) recorded an increasing trend in weight gain with an increase in food frequency to up to four times a day.

Boscolo et al. (2002) observed that the alternative ingredient is well used by the species, and also highlights the agglutinating characteristic of cassava residues, which provides less leaching of nutrients from the feed and, consequently, better use of the diet.

With the exception of the mineral content (ash) of the fish, all other variables showed a significant difference between treatments (Table 4). The group that received the diet with the inclusion of tapioca dusting flour (T3) presented a carcass with a higher dry matter content than the control group (T1). The T2 group, on the other hand, which received a diet with the inclusion of manioc peel flour, did not differ from any of the other two treatments.

Table 4 - Body composition of Nile tilapia fed with feed formulated with traditional ingredients only (T1) and fed with feed formulated with the inclusion of agro-industrial waste (T2 and T3)

Variables	Treatments		
	T1 (WAR)	T2 (ARMPF)	T3 (ARTSF)
Dry matter	24.69[b]	25.63[ab]	26.55[a]
Ashes *	17.95	19.73	19.80
Crude fat	9.42[b]	9.01[b]	12.81[a]
Crude protein	70.55[a]	68.56[a]	64.52[b]

* There is no statistically non-zero contrast between the means by the F test at the 5% probability level.

[abc] Means followed by at least one equal letter on the same line do not differ at the level of 5% probability by the Tukey test.

The highest dry matter content T3 is also accompanied by the highest fat content, while the protein content of the T3 group was the lowest among the treatments. In turn, the levels of fat and protein in treatment 2 did not differ from the control treatment. According to Pereira Junior et al. (2013), the higher crude fat content in the carcass can be explained by the increased concentration of fat in the diet. Therefore, the higher fat content observed in treatment 3 may also be related to the higher level of inclusion of fish meal in the diet of this treatment.

Similar to the results obtained, Gonçalves et al. (2009) found an increase in the fat content of Nile tilapia fed diets containing increases in the energy: protein ratio. Boscolo et al. (2002) observed a decrease in the percentage of fat in the carcass of Nile tilapia due to the lower inclusion of vegetable oil in diets with higher concentrations of manioc sweepings.

Excess energy in the feed can cause a worse use of the other nutrients in the feed due to the satiety generated in the animals, or the excess energy consumed can be anabolized for energy purposes through lipogenesis, causing an increase in the deposition of body fat (Pereira Junior et al. (2013).

The results obtained are also in agreement with those found by Torelli et al. (2010) when evaluating the use of agro-industrial residues in the feeding of different fish species, including Nile tilapia. These authors observed a lower deposition of crude protein in the tilapia carcass fed with feed formulated with alternative ingredients, one of these ingredients being cassava zest.

CONCLUSION

The evaluations carried out in this study indicate that the residues from the cassava processing are foods with potential for use in feed for Nile tilapia in partial replacement to traditional ingredients, without compromising the productive performance. Studies are also needed to investigate a way to increase the use of these rations without the need for extrusion, such as, for example, a greater number of daily offers and in smaller quantities, in order to reduce losses from pellets that sink without time for capture. In this way, it would be possible to improve the rates of apparent feed conversion and feed efficiency.

ACKNOWLEDGMENT

This article is the result of research funded by the Pescarte Environmental Education Project (PEA) which is a mitigation measure required by the Federal Environmental Licensing, conducted by IBAMA.

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Recebido para publicação em 20/10/2020, aprovado em 27/04/2021 e publicado em 13/05/2021.