PRODUCTIVE PERFORMANCE OF THE "GREEN TERROR" *(Andinoacara rivulatus)* FISH DURING THE FATTENING STAGE WHEN FED DIETS WITH PASSION FRUIT CAKE *(Passiflora edulis)*

RENDIMIENTO PRODUCTIVO DE LA ESPECIE DEL PEZ NATIVO "TERROR VERDE" (*Andinoacara rivulatus*)" DURANTE LA ETAPA DE ENGORDE CUANDO SE ALIMENTA CON DIETAS CON TORTA DE MARACUYÁ *(Passiflora edulis)*

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ABSTRACT

The objective of the present work was to evaluate the effect of diets containing passion fruit cake on the productive performance of the "green terror" (*Andinoacara rivulatus*)". Fish were fed four passion fruit diets (T1: 0%, T2: 3%, T3: 6%, T4: 9%) for 30 days. The weight increase (WI), relative weight increase (RWI), growth rate (GR), incremental growth rate (IGR), feed conversion ratio (FCR), dry matter digestibility, gross protein digestibility (GPD), gross energy digestibility (GED), protein efficiency rate (PER), productive value of protein (PVP), and feed cost were assessed. There were no differences in the final weight, WI, RWI, GR and IGR values between T1 and T2; only the diet in T3 and T4 showed poorer results than the T1 diet. FCR was higher in the control diet (T1) and in T4 than in T2 and T3. As the percentage of passion fruit increased, the cost of the diet decreased. GPD and GED did not exhibit differences in T1, T2 and T3, only DT T4 had lower digestibility values. PER of control DT T1 had a better coefficient than T2, T3 and T4. Significant differences were found in PVP between the control DT, T2 and T4. However, the lowest values were obtained with this latter DT. The addition of up to 3-6% passion fruit did not affect the yield, and the cost of the diet was significantly reduced.

Key words: *Andinoacara rivulatus*; apparent digestibility; fattening stage; experimental diets; *Passiflora edulis*

RESUMEN

El objetivo fue evaluar el efecto de las dietas, que contenían maracuyá, en el rendimiento productivo del "terror verde". Los peces fueron alimentados con cuatro dietas de torta de maracuyá (T1: 0%, T2: 3%, T3: 6%, T4: 9%) durante 30 días. El aumento de peso (WI), aumento de peso relativo (RWI), tasa de crecimiento (GR), tasa de crecimiento incremental (IGR), conversión de alimento (FCR), digestibilidad de materia seca, de la proteína bruta (GPD) y de la energía bruta (GED), tasa de eficiencia proteica (PER), valor productivo de la proteína (PPV) y el costo de alimentación fueron evaluados. No hubo diferencias en los valores de peso final, FW, WI, RWI, GR e IGR entre T1 y T2; solo la dieta en T3 y T4 mostró resultados peores que la dieta T1. El FCR fue mayor en la dieta control (T1) y en T4 que en T2 y T3. A medida que el porcentaje de racuyá aumentaba, el costo de la dieta disminuía. GP y GE no mostraron diferencias en T1, T2 y T3, sólo el ensayo T4 tuvo valores de digestibilidad más bajos. El PER del ensayo de control tenía un coeficiente mejor que T2, T3 y T4. Se encontraron diferencias significativas en el PVP entre el ensayo de control, T2 y T4. Sin embargo, los valores más bajos se obtuvieron con este último ensayo. La adición de hasta 3-6% de maracuyá no afectó el rendimiento, y el costo de la dieta se redujo significativamente.

Palabras clave: *Andinoacara rivulatus*; digestibilidad aparente; fase de engorde;dietas experimentales; *Passiflora edulis*

Recibido: 01/07/2020 Aceptado: 26/08/2020

INTRODUCTION

Currently in Ecuador, there is no constant and adequate supply of plant resources for high protein certified organic preparation of diets for fish farming, highlighting the need to explore alternative plant resources (PR) to replace conventional protein sources, such as passion fruit cake (PFC) [18, 22, 31].

Organic aquaculture differs from conventional aquaculture in that it is focused on production in harmony with the environment, employing practices that seek to duplicate the natural conditions of organisms [8], striving always be committed to social, economic and sustainability factors, including the rational use of resources for feed [31].

The high cost of traditional energy products used in animal feed has sparked the search for new products and an evaluation of their nutritional potential. One of these crops is PFC, which is not well known, though it has great potential in feeding animals due to its very low cost.

PF is a source of protein, minerals, carbohydrates and fats. PF has an energy value of 78 calories, 2.4 grams (g) of carbohydrates, 5 g of calcium, 17 miligram (mg) of phosphorus, 0.3 mg of iron, 684 mg of activated vitamin A, 0.1 mg of vitamin B2 (riboflavin), 2.24 mg of niacin and 20 mg of vitamin C. In Ecuador there are around 28 thousand hectares (hes) planted PF with an average yield of about 14 tons (T) per hes. The main variety is *Passiflora edulis flavicarpa* (yellow fruit), as its production per hes is higher and it is ideal for processing. It is estimated that a well-managed plantation can yield 8-10 T per hes in the first year (yr), 15-20 T in the second yr and 12-14 T in the third yr [2].

Duchi and Pazmiño [10] have showed that the industrialization of PF produces by-products such as PF peel. Originally, these industrial by-products were solid waste that contaminated the environment (soil, air and water); however, advances in alternative animal production methods in the tropics have permitted fresh and dry peel to be used as a supplement in dairy (Bos-taurus) and beef cattle diets *Bos indicus.*

Mazón [21] has reported that PFC has a high content of dry matter (DM), a general average of 92.85% and an average value of 67.32% organic matter (OM). The gross protein (GP) and ether extract (EE) showed high values of 23.95 and 11.81%, respectively. Gross fiber (GF) and nitrogen-free extract (NFE) had an average value of 46.27 and 20.98%. The average values of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were therefore high, at 72.47 and 69.29%. The average ash content was 2.07%, and the general average for calcium and phosphorus was 2.85 and 0.32%. The average value of gross energy (GE) was 5.19 mega calories per kilogram of dry material (Mcal·kg $^{-1}$ DM).

The development of high nutritional quality, low environmental impact and economically profitable diets for fish farmers is a pressing need in the fish feed industry, especially for intensive production systems. Rations having these characteristics are possible when formulated with ingredients of high nutritional value, based on the ingredient digestibility data of each particular species [17].

The rapid expansion of fish farming in recent yr, like other forms of intensive animal production, requires improved nutrition as well as complete rations [13]. Feed is the most significant production cost; the increased complexity of the feed required in aquaculture means that this item normally exceeds 70% of the total cost, and therefore justifies the efforts to understand the principles of fish nutrition and feeding [1, 9].

Green terror (*Andinoacara rivulatus*), the target species of this work, is native to Peru and Ecuador. Males can reach 30 centimeter (cm), while females do not exceed 20 cm. They prefer rather high temperatures, not below 25 °C. They are very adaptable to pH and water hardness conditions, but they do not tolerate the presence of nitrogenated compounds in the water (such as ammonium); it is thus essential to change the water continuously and have a good filtration system when they are grown in captivity. It is an omnivorous fish, so it accepts any type of food. However, due to their voracity, they should not be overfed, as they will always seem dissatisfied. They are territorial and aggressive, so they should be housed in large ponds and never share the same place with smaller fish [22].

Passion fruit cake (PFC) has been used for fish, poultry and ruminants feeding programs as a source of protein and energy in monogastric and ruminant diets. In the case of monogastrics, it is used to replace fishmeal as the source of animal protein and corn (*Zea mays*) as the energy source, as both products are more expensive. There are reports of research into the use of PFC in the diets of native fish such as *Andinoacara rivulatus* to replace industrial fishmeal as the source of protein, and yellow corn as the source of energy.

Therefore, with the aim of expanding the knowledge of PFC and its uses in animal feed, this study evaluated the effect of diets based on PFC on the yield of the native “green terror” in the fattening stage during the dry season.

MATERIAL AND METHODS

Fish housing, feeding and sampling

Four hundred fish with an initial weight of 44.2 ± 1.5 g were used, and the stocking density was 25 fish per cage (1.11kg/meter (m^3)). There were 16 experimental cages 1 m long x 1 m wide x 1 m high, covered with 6 x 8 cm extruded plastic mesh, and the tank was 30 x 20 m and 0.8 m deep. An electric balance of 5 kg capacity and a minimum weight of 1 g was used for the biometric data of the fish. A 30 x 1.5 m platform was used to deliver the experimental diets. The pond did not have aeration equipment because it was supplied with a constant 15 liter (L)/ minutes (min) flow of highly oxygenated, double filtered water from a 0.25 hes reservoir. The water temperature was 20 ± 0.5 °C. The dissolved oxygen content of the water in the tanks was maintained at 11 ± 1 mg/L and the pH was 7.5 ± 0.5. Nitrogenated wastes (unconsumed food and excreted organic matter) were removed daily using a Monge drainage system.

The fish had seven days (d) o adapt to the experimental cages before the start of the experiment and were fed high-protein extruded feed to accustom them to consuming concentrated feed. Four experimental diets were prepared with different percentages of PFC (0, 3, 6 and 9%) formulated by the trial and error method to represent isoproteic (35% total protein) and isocaloric (3000, 3006, 3006 and 3013 kilocalories (Kcal)/kg) diets, using the inputs and quantities shown in TABLE I. The experimental diet was offered *ad libitum* four times a d (0800, 1100, 1300 and 1500 hours (h) for 30 d. As a prophylactic measure, the fish were treated with a solution of methylene blue (5g/10 L every 30 d) to prevent *Ichthyopthirius* fungus and pathogenic bacteria. After each sampling, a solution of methylene blue diluted in water was used to prevent contamination by fungi and bacteria.

Dietary Treatments (DT)

The experimental DT were: T1 (0%), T2 (3%), T3 (6%) and T4 (9%), depending on the percentage of PFC in the diet. Experimental diets underwent a pelleting process involving agglomeration through the addition of binders such as bentonite and molasses, and water. Then they were passed through a fine diameter matrix to form spherical particles (pellets), which were hardened by steam cooking in a rotary kiln. A completely randomized design with four DT were used (4 diets with different percentages of PFC, four repetitions (4 cages) per DT, and the data were collected for 30 d. The manual on Nile Tilapia (Oreochromis niloticus) nutritional needs by Torres-Novoa [30], University of The Llanos, Colombia, was used as a reference, based on the inputs and the amounts indicated in TABLE I.

The experimental DT (diets) and their proximal composition of experimental diets are shown in TABLE II.

Determination of biological parameters

The ingredients, diets and feces were analyzed to determine their proximal composition according to the methodologies of Official Methods of Analysis [25], dry matter (DM) by kiln

TABLE I

COMPOSITION OF EXPERIMENTAL DIETS CONTAINING PASSION FRUIT CAKE USED IN THE FATTENING PHASE OF *Andinoacara rivulatus*

	Experimental diets (%)			
Ingredients (%)[1]	T1	T2	T3	T4
Corn	12.90	5.80	3.40	2.70
Wheat bran	0.00	2.00	3.00	0.00
Rice flour	11.50	16.00	17.30	8.10
Soybean cake	32.00	37.60	38.00	43.50
Fishmeal	36.00	30.00	28.00	27.00
Soybean oil	3.80	1.80	0.50	6.00
Passion fruit cake	0.00	3.00	6.00	9.00
Salt	0.10	0.10	0.10	0.10
Antifungal [2]	0.05	0.05	0.05	0.05
Methionine	0.20	0.20	0.20	0.20
Antioxidant [3]	0.05	0.05	0.05	0.05
Choline Chloride	0.10	0.10	0.10	0.10
Bentonite	3.00	3.00	3.00	3.00
Pre-mix [4]	0.10	0.10	0.10	0.10
Enzyme [5]	0.10	0.10	0.10	0.10

[1]Air dried food; T1: 0% Passion Fruit Cake, T2: 3% Passion Fruit Cake, T3: 6% Passion Fruit Cake, T4: 9% Passion Fruit Cake
[2] Mollejosanitin
3 Endox
[4] Rovimix Pre-mix: Vitamin A, D3, K, E, B1, B2, B6, Nicotinic Acid, Calcium Pantothenate, Biotin, Folic Acid, Choline, Inositol and Vitamin C
[5]Avizyme 1502 (600 U g^{-1} endo-1,4 beta xylanase EC 3,2,1,8; 8000 U g^{-1} subtilisin - protease- EC 3,4,21,62; 800 U g^{-1} alpha amylase EC 3,2,1,1.).

TABLE II

PROXIMAL COMPOSITION OF EXPERIMENTAL DIETS WITH PASSION FRUIT CAKE USED FOR THE JUVENILE PHASE OF *Andinoacara rivulatus*

Proximal composition (%)	T1	T2	T3	T4	Request[1]
Digestible dietary energy (Kcal kg-[1])	3000	3002	3003	3014	3000
Total protein	35.00	35.00	35.00	35.00	35.00
Fiber	3.10	4.20	4.90	6.30	---
Calcium	1.84	1.58	1.49	1.47	1.00
Phosphorus [2]	1.50	1.40	1.40	1.30	0.80
Arginine	1.91	1.96	1.98	2.36	0.94
Lysine	2.09	2.03	1.98	2.36	0.94
Met + Cys	1.11	1.09	1.08	1.12	0.35
Tryptophan	0.36	0.36	0.36	0.39	0.30

[1] **Total phosphorus in the diet**

drying at 105°C/24 h, gross protein (% N x 6.25) by the Kjeldahl method, lipids by solvent extraction with soxlhet apparatus, ash by incineration at 550°C/6 h and gross energy using a Parr Instruments 121AE adiabatic calorimetric pump (USA).

The experiment was carried out in a fattening pond where the 16 experimental cages containing 25 fish each were located, to which the PFC diets were fed to establish the productive yield of the native fish. Once the fattening period was over, the fish were transferred to metabolic tanks and introduced into each of them for processing.

To determine the digestibility of the diets, the total stool collection method was used in each of the DT and repetitions based on the modified Guelph system [28]. A cylindrical tank with a conical bottom containing 200 L of water was used; oxygen was provided by means of a portable oxygenator located at the top of the tank, and at the bottom, a 20 cm long tube of two inches in diameter length with a ball valve in the middle and a screw cap on the end was inserted, which allowed the feces to be collected every 6 h over a total period of 24 h [16]. The feces obtained in each collection were placed in a 50: cubic centimeter container, the excess moisture was removed and they were stored in a refrigerator (Indurama, Ecuador) at 4 °C until the corresponding bromatological chemical analysis was performed.

The yield of *Andinoacara rivulatus* was evaluated by measuring following zootechnical parameters.

Feed conversion ratio (FCR):

$$\mathrm{FCR} = \frac{\text{Amount of feed distributed (g)}}{\text{Weight gain of the fish (g)}}$$

Weight increase (WI) is the weight increase per unit of time due to food consumption (energy and protein) at a certain temperature.

$$\mathrm{WI} = (\mathrm{Wf} - \mathrm{Wi})$$

Where:
Wf = final weight
Wi = initial weight

The relative weight increase (RWI) is the increase in weight per unit of time at different ages due to food consumption (energy and protein) within a given temperature range.

$$\mathrm{RWI}\ (\%) = 100\ x \frac{(\mathrm{Wf} - \mathrm{Wi})}{(\mathrm{Wi})}$$

Where:
Wf = final weight
Wi = initial weight
The growth rate (GR) is a measure of the average increase or decrease in weight over a period of 30 d due to the amount of feed consumed and the water temperature.

$$\mathrm{GR}\ (\%) = 100\,x\,\frac{(\mathrm{Wf} - \mathrm{Wi})}{t}$$

Where:
Wf = final weight
Wi = initial weight
t = time

The incremental growth rate (IGR) is a measure of the average weight gain over a period of 30 d due to the amount of feed consumed and the water temperature.

$$\mathrm{IGR}\ (\%) = 100\,x\,\frac{(ln\,Wf - ln\,Wi)}{t}$$

Where:
Wf = final weight
Wi = initial weight
t = time

Net feed consumption (NFC) is the amount of complementary feed consumed weekly minus the amount of residual feed of the measure weighed weekly:
NFC = Weight of feed consumed (g) - Weight of waste (g)

The protein efficiency rate (PER) is the weight gained by an animal for each unit of protein in the feed and was calculated for each DT using the following equation [3]:

$$PER = \frac{Weight\ gained}{Protein\ intake\ (g)}$$

The protein production value (PVP) were calculated for each assay using the following equation:

$$PVP = \frac{Protein\ retained\ (g)}{Protein\ intake\ (g)}$$

Apparent digestibility coefficient

The apparent digestibility coefficient (DC) was calculated by collecting all the feces in each of the DT and repetitions using the modified Guelph system [28]. This method employs a cylindrical tank with a conical bottom (metabolic aquarium) where water and oxygen are fed continuously from the top and there is a feces collection tube at the bottom [1, 4, 14, 15]. Subsequently, a bromatological analysis was performed on the feces extracted and samples of the experimental diets used in the studies.

The digestibility of the experimental fish diets was determined by the direct method, also called the total collection method. It consisted of the quantitative collection and analysis of all feces produced. The digestibility coefficient (DC) was calculated as follows:

$$.\% = \frac{Ingested\ nutrients - nutrients\ in\ feces}{Ingested\ nutrients}\,x$$

Statistical analysis

A completely randomized design was used with four DT and four repetitions. All zootechnical and biological parameters were analyzed with an ANOVA analysis of repeated measurements using the General Linear Model (GLM) of the Statistical Analysis System Software statistical package (Workflow Studio 1.3) System for Windows 11, Copyright 2016 by SAS Institute Inc., Cary, NC, USA). The model considered the percentage of PFC (0, 3, 6 and 9%), analyzed as repeated measurements on the same experimental units. When significant differences were detected between the means of factors with more than two levels, they were subjected to a multiple comparison of means using Honestly-significant-difference (HSD) of Tukey values expressed as mean $\pm$ standard error of mean (SEM).

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The unrestricted, randomized experiment consisted of four DT, four repetitions and 25 fish per experimental cage:
The mathematical model is shown below:

$Y_{ij} = \mu + T_i + \varepsilon_{ij}$
Where:
Y_{ij} = Observations for dependent variables.
μ = Average population
T_i = “i-th” effect of the DT
ε_{ij} = Random effect (Experimental error).
The Tukey test was used for the comparison of means, with a probability of 5%.

RESULTS AND DISCUSSION

Digestibility of experimental diets

By feeding experimental diets based on PFC, it was possible to establish the digestibility coefficients of DM, GP and GE for this tropical native species during the fattening period, TABLE III.

When comparing the control diet T1 with diets T2, T3 and T4, significant differences were found in the apparent digestibility coefficients of the dry material ($P \leq 0.05$), but no significant

TABLE III
APPARENT DIGESTIBILITY COEFFICIENTS (DMD, GPD AND GED) FOR
Andinoacara rivulatus **JUVENILES FED DIETS CONTAINING PASSION FRUIT CAKE**

	Dietary Treatments (DT)			
Variable[1]	T1	T2	T3	T4
Dry matter digestibility (%).	58.65 ± 0.35 **a**	58.20 ± 0.35 **b**	57.35 ± 0.35 **c**	50.58 ± 0.35 **d**
Gross protein digestibility (%).	84.48 ± 0.75 **a**	84.53 ± 0.75 **a**	84.42 ± 0.75 **a**	79.58 ± 0.75 **b**
Gross energy digestibility (%).	77.58 ± 0.69 **a**	77.10 ± 0.69 **a**	77.45 ± 0.69 **a**	71.70 ± 0.69 **b**
Protein efficiency rate (%)	0.33 ± 0.02 **a**	0.31 ± 0.02 **b**	0.26 ± 0.02 **c**	0.20 ± 0.02 **d**
Productive value of protein (%).	0.60 ± 0.004 **a**	0.59 ± 0.004 **b**	0.59 ± 0.004 **ab**	0.56 ± 0.004 **c**

[abc] Averages with different letters in the same line differ statistically according to the Tukey test
[1] These are the means (± EEM) of 25 fish housed in a cage (Experimental Unit) with four replicates per trial. T1: 0% Passion Fruit Cake, T2: 3% Passion Fruit Cake, T3: 6% passion fruit cake and T4: 9% passion fruit cake.

differences (*P*≥0.05) were found between DT T1, T2 and T3 and DT T4 in the digestibility of GP and GE. Moreover, this latter DT, which had the highest percentage (9% PFC), had the lowest digestibility coefficient compared to the other DT (*P*≤0.05).

The results obtained in this study agree with Vásquez *et al*. [31] in a study of tilapia (*Oreochromis* spp) and Vasquez *et al*. [32] for cachama (*Piaractus brachypomus*). The apparent digestibility coefficients achieved in this study are generally consistent with those described in other studies involving tilapia (*Oreochromis niloticus*) and cachama with similar DM, GP and GE. There are discrepancies among the results published in the literature, and according to a consensus among researchers, this may be caused by differences in the methodologies used to determine the coefficients or process the diets, differences in the amounts added of the ingredient being studied, the type of control diet used Anderson *et al*. [6], Boscolo *et al*. [8], Furuya *et al*. [13], Guimarães *et al*. [15], Masagounder *et al*. [20] the method of fecal collection Meurer *et al*. [23], the size of the fish, the equation used to calculate the coefficients Foster [12] and the process used to prepare the experimental diets [5]. The selection of the most digestible ingredients makes it possible to improve zootechnical indices and reduce water pollution [26].

Other authors state that the low digestibility of vegetable by-products such as passion fruit cake PFC is normally attributed to high levels of non-starch polysaccharides (NSP) Wing [34] or cell wall composition Dusterhoft and Voragen [11]. Wing [34] states that these antinutritional factors reduce the digestibility and uptake of the nutrients in PFC, either by direct encapsulation of the nutrients or by increasing the viscosity of the intestinal content, thus reducing the rate of hydrolysis and absorption of the nutrients in the feed. This could explain the poorer yields found with the 9% diet compared to the control diets. The addition of proteolytic, fibrolytic or carbohydrate degrading enzymes to PFC diets has great potential for releasing unavailable nutrients and energy.

Significant differences (*P*≤0.05) were found in PER between all DT and significant differences (P≤0.05) were found in PVP between the control DT T1, T2 and T4. However, the lowest values were obtained with this later DT (9% PFC).

Regarding the yield of green terror in the fattening stage, the results obtained for the PER and PVP in this study are relatively low compared to the results obtained by Bermúdez *et al*. [7] with Nile tilapia, Yudy *et al*. [35] with yamú (*Brycon siebenthalae*), Madrid [19] with gulf corvina (*Cynoscion othonopterus*) juveniles, and Madrid [19] with sabaleta (*Briycon henni*).

This could be because this native fish has different feeding habits from those of the fish species compared, and the partial replacement of the fishmeal could have reduced the efficiency rates PVP and PER. Moreover, it should be noted that this native fish has not undergone genetic improvement in any physiological stage, and it has not been exploited using intensive or semi-intensive production systems based on balanced feed, that would have allowed its organism to adapt to consuming balanced feed.

When comparing the mortality between trails, it can be seen that it was very low, and fish deaths occurred due to handling during initial and final weighing, measurement of external anatomical dimensions and fish transfer to the metabolic aquariums of the experiment. Mortality can also be attributed to attacks by *Ichthyopthirius* fungi and external parasites. The mortality was therefore not due to the experimental diets (TABLE IV).

Productive performance

The yield of the native species “green terror” fed different isoproteic and isocaloric diets is shown in TABLE IV. After

TABLE IV

EFFECT OF DIETS CONTAINING DIFFERENT PERCENTAGES OF PASSION FRUIT CAKE ON THE PRODUCTIVE PERFORMANCE INDEX OF *Andinoacara rivulatus* IN THE FATTENING PHASE

	Dietary Treatments (DT)			
Variable[1]	T1	T2	T3	T4
Final weight (g)	49.25± 1.10 **a**	49.00±1.10 **a**	47.25±1.10 **b**	45.00± 1.10 **c**
Weight increase (g)	14.25± 1.10 **a**	14.00± 1.10 **a**	12.25± 1.10 **b**	10.00± 1.10 **c**
Relative weight increase (g).	40.70±3.16 **a**	40.00±3.16 **a**	35.00± 3.16 **b**	28.58± 3.160**c**
Growth rate (%)	47.50± 3.68 **a**	46.68±3.68 **a**	40.82± 3.68 **b**	33.35± 3.68 **c**
Incremental growth rate (%)	1.15± 0.08 **a**	1.12± 0.08 **a**	1.00± 0.08 **b**	0.85± 0.086 **c**
Net feed consumption (g)	80.00± 0.80 **a**	78.00±0.80 **b**	76.00± 0.80 **c**	74.00±0.80 **d**
Feed conversion ratio (g)	1.63± 0.02 **a**	1.59± 0.02 **b**	1.61± 0.02 **b**	1.64± 0.02 **a**
Feed cost ($ Kg. $^{-1}$)	0.72± 0.001 **a**	0.71± 0.001 **b**	0.70± 0.001 **c**	0.69± 0.001 **d**
Mortality (%)	5	4	2	3

[abc] Averages with different letters in the same line differ statistically according to the Tukey test

[1] These are the means (± EEM) of 25 fish housed in a cage (Experimental Unit) with four replicates per trial. T1: 0% Passion Fruit Cake, T2: 3% Passion Fruit Cake, T3: 6% passion fruit cake and T4: 9% passion fruit cake.

supplying the experimental diets during a research period of 30 d during the fattening season, no significant differences were found ($P \leq 0.05$) for Wf, WI, RWI, GR and IGR of "green terror", between DT T1 and T2 when PFC was added; however, these two DT did show differences compared to DT T3 and T4, which showed poorer results than DT T1.

Some initial studies suggest that palm kernel cake can be tolerated even up to 30% in rations for catfish (*Clarias gariepinus*) and 20% for tilapia, well above the levels in this work, without any adverse effects on growth or yield [27].

With the same species, Wan [33] and Wing [34] found satisfactory results up to a level of 20%. The yield did not vary when cachama were fed this alternative source of protein Vasquez [31], so these can also serve as a reference for the use of PFC.

The results do not of this work agree with those obtained with palm kernel cake (PKC) for diets of red tilapia fingerlings, which also incorporated PKC up to a level of 8% without affecting the fish yield, which suggests that higher levels could be used. Other authors have also used PKC as an organic ingredient for the partial or total replacement of fishmeal for aquatic species up to 8% without negative effects on the yield [32].

Net feed consumption exhibited significant differences (P≤0.05) between DT T1, T2, T3 and T4. The consumption of feed decreased when the PFC in the diets of the fish was increased.

Significant differences in feed conversion ratio were found ($P \leq 0.05$) between DT T1 and T4, in compared to DT T2 and T3, and the best conversions occurred in these DT compared to the control DT.

As with many ingredients of vegetable-based and oil-seed feeds, there are several factors that can limit the inclusion of PFC in fish diets. These include its relatively low protein content, possible amino acid deficiency, and antinutritional factors [33]. However, in the present study, diets with various percentages o PFC used 59% total protein export quality fishmeal, which provided adequate levels of amino acids. Moreover, it was supplemented with nutritional additives including a pre-mix of vitamins and minerals and synthetic methionine.

Therefore, amino acid deficiency does not seem to be the cause of the poorer yields obtained with the diet containing the highest percentage (9%), despite the high percentage of crude fiber that could possibly have had a lower availability of essential amino acids. This native species has not been exploited in captivity nor fed balanced feed, so its digestive system has not adapted to this type of food and did not produce the necessary enzymes for digesting these nutrients (protein, oil, fiber, etc.).

Regarding feed costs, the price per kg of the diet prepared with the highest fishmeal content (0% PFC) was seen to be higher, as its cost was quite high. When the fishmeal in the diet was partially replaced, the cost per kilogram of feed (3, 6 and 9% PFC) was reduced. It should be noted that the addition of amino acid supplements was not necessary in diets containing PFC, so there was no increase in the added cost, which is why it is considered to be a cheaper alternative to fishmeal.

Ng *et al*. [24] in work carried out with tilapia that were fed PFC pre-treated with enzymes for commercial feed, consistently found greater efficiency in growth and feed utilization compared to fish fed similar levels of raw PKC. They then indicated that up to 30% PKC treated with enzymes could be incorporated into the diet of red tilapia without slowing its growth significantly, which was corroborated by Wing [34]. Therefore, the enzyme addition is key to achieve higher PFC content without negative effects on zootechnnical parameters and performance. That is the reason why an enzymatic complex based on protease, xylanase and amylase was added in our experimental diets.

CONCLUSIONS

Green terror has high capacity to utilize the nutrients in diets prepared with up to 3% PFC, supplemented by an enzymatic complex during fattening, without affecting the yield of fish in terms of final weight, weight increase, relative weight increase, growth rate or incremental growth rate and significantly decreasing the cost of the diet. The diet with 3% PFC obtained the best feed conversion rate. Further, the digestibility coefficients of protein and energy are higher for levels of up to 6% PFC.

However, at increased levels of PFC, the protein efficiency rate and the productive value of protein during the fattening stage are decreased for “green terror”.

The greater availability of PFC throughout the yr at a lower cost compared to other oil products and raw materials such as soybean cake, give it a comparative advantage, since it does not have to compete with the demands of other animal species, which in economic terms would also justify its use.

ACKNOWLEDGEMENTS

This research was supported by the Postgraduate Department of the State Technical University of Quevedo, Ecuador and INIA-FSE.

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