Journal MVZ Cordoba
2021; January-April. 26(1):e1989.
https://doi.org/10.21897/rmvz.1989

Original

Effect of flour fish hydrolyzate in the growing of rainbow trout (*Oncorhynchus mykiss*)

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Received: April 2020; Accepted: August 2020; Published: November 2020.

ABSTRACT

Objective. To assess the effect of the inclusion of viscera hydrolyzate meal in diets for trout fry, "Kamloop" variety, in terms of weight, length and biomass gains, apparent feed conversion, and survival. **Materials and methods**. This essay was developed at the Guirapungo - Corponariño Environmental and Fish Farming Center, in eight concrete pools, subdivided each pool, into three compartments of equal dimensions. An Unrestricted Random Design (URD) was used, made up of 1680 trout fry, with an average stocking weight of 1.24±0.024 g, distributed in four treatments, six replications per treatment, for a total of 24 units experimental, with 70 fish per experimental unit and 420 fish per treatment. **Results.** Treatment 4, (diet with 20% viscera hydrolyzed) recorded the greatest weight, length and biomass gains, the best feed conversion and average survival. In contrast, the T1 treatment (commercial feed) reported the least adequate productive variables. **Conclusions.** The incorporation of fish viscera hydrolysate, as a protein source in balanced diets of rainbow trout, improve the zootechnical variables of fish production, due to the biological value of the diets that the hydrolyzate contains.

Keywords: Feed conversion; weight gain; diet; protein; production variables (*Sources: MeSH, FAO*).

RESUMEN

Objetivo. Evaluar el efecto de la inclusión de la harina de hidrolizado de vísceras, en dietas para alevines de trucha variedad "Kamloop", en términos de ganancias de peso, talla, biomasa, conversión alimenticia aparente y sobrevivencia. **Materiales y métodos**. El ensayo, se desarrolló en el Centro Ambiental y Piscícola Guirapungo - Corponariño, en ocho piletas de concreto, subdivididas en tres compartimentos de iguales dimensiones. Se utilizó un Diseño Irrestrictamente al Azar (DIA), conformado por 1680 alevines de trucha, con un peso promedio de siembra de 1.24±0.024 g, distribuidos en cuatro tratamientos, seis réplicas por tratamiento, para un total de 24 unidades experimentales, con 70 peces por unidad experimental y 420 peces por tratamiento. **Resultados**. El tratamiento 4, (dieta con 20% de hidrolizado de vísceras) registró con significancia estadística ($p \leq 0.005$) las mejores

How to cite (Vancouver).
López-Macías J, Salas-Benavides J. Effect of flour fish hydrolyzate in the growing of rainbow trout (*Oncorhynchus mykiss*). Rev MVZ Cordoba. 2021; 26(1):e1989. https://doi.org/10.21897/rmvz.1989

ganancias de peso, talla, biomasa, conversión alimenticia aparente y sobrevivencia promedio. En contraste, el tratamiento T1 (dieta comercial) reportó las variables productivas menos adecuadas. **Conclusiones**. La incorporación de hidrolizados de vísceras de peces, como fuente proteica en dietas balanceadas de trucha arcoíris, mejoran las variables zootécnicas de la producción piscícola, debido al valor biológico de las dietas que contiene el hidrolizado.

Palabras clave: Conversión alimenticia; ganancia de peso; dieta; proteína; variables productivas (*Fuentes: DeCS, FAO*).

INTRODUCTION

Aquaculture is of great importance in the food system, due to the production of high quality biological goods, from a nutritional point of view, and its role in underdeveloped areas, where it can create a series of activities that stimulate growth. This last factor is much more evident when considering the many structural limitations faced by the Colombian food system. In 2016, the world fisheries total production was estimated at 171 million tons, 47% of which was owed to aquaculture. Between 1961 and 2016, the average annual increase in world fish consumption, excluding non-food use (3.2%) surpassed population growth (1.6%) and also that of meat from all land animals (2.8%). In per capita terms, consumption of edible fish increased from 9.0 kg in 1961 to 20.2 kg in 2015, at an average rate of approximately 1.5% per year, in addition to a projection relative to the years 2016 and 2017, reaching 20.3 kg and 20.5 kg, respectively (1). Consequently, the importance of aquaculture is increasingly recognized, especially in the supply of fish as food for human consumption, since it represents around 17% of the animal protein consumed by the world population. In addition, fish accounted for almost 20% of the average contribution of animal protein per capita to approximately 3.2 billion people (1).

Bordering the Andean, Amazonian and Pacific zones of the country, the department of Nariño presents exceptional conditions for the development of aquaculture, due to its variety of soils, topography, thermal cultivation floors, and richness of both water and fish (2). Unfortunately, research on cold water fish species from the southwestern region of Colombia, such as *Eremophilus mutisii*, has shown that this species does not possess ideal characteristics for fish farming, due to its low daily weight gain capacity in captive conditions, territoriality, lack of rusticity and the immaturity of its digestive system in the post larval phase, which creates high production costs due to the need for specific live food (3).

This situation has resulted in the exploitation of the foreign species, rainbow trout (*O. mykiss*) in the cold regions of Nariño, without prior research that allows for the implementation of profitable technological management for feeding, cultivation, and reproduction of the species, that can be transferred and adapted to the existing farms in the high inter-Andean lakes (4).

Research carried out by the Aquaculture Research Group of the University of Nariño (GIAC), has shown that the cultivation of rainbow trout is a viable alternative for socioeconomic development for farmers located in the cold areas of the department of Nariño and specifically in the highland lakes Cumbal and La Cocha and their respective basins (5.6). Consequently, this research set out to evaluate the viscera hydrolyzate meal in the formulation of trout diets and its effect on different productive variables during the fry and juvenile stages.

MATERIALS AND METHODS

Location of the study. The research was carried out at the Guirapungo Environmental and Fish Center, affiliated with Corponariño, located in the township of El Encano, Lake Guamuez at 2840 meters above sea level. Average water temperature is 13°C, and the location measures 4280 hectares. The geographical coordinates are: 01°06´3.80" N and 77°07´2.26" W (7).

Period of study. Once an agreement was made available by the Ethics Committee of the University of Nariño, the investigation began. The field work was carried out between March 2018 and April 2019, during which different activities were realized, such as the acquisition and acclimatization of fry, division of pools, preparation of diets, standardization of feeding techniques, adaptation and food supply. Finally, the effect of the viscera hydrolyzate meal was evaluated for seven months during the cultivation phases. For this, 1680 “Kamloop” trout fry, with an average initial weight of 1.24±0.024 g, and average total length of 4.26±0.824 cm, were randomly sown in the different treatments. The previous values did not register statistical differences in the respective treatments ($p>0.05$).

Installations. The project was developed in eight concrete pools measuring 2.70 m long and 1 m wide, with a 0.65 m water column. . Each pool was subdivided by wooden frames and plastic mesh, in three equal compartments, measuring 0.90 m (Figure 1).

Figure 1. Experimental units.

Cleaning of the pools. Before sowing the specimens, the pools were washed with water and a commercial 2% sodium hypochlorite solution, to avoid the presence of possible pathogens.

Acclimatization of specimens. Once the rainbow trout fry were received, the adaptation process was carried out. The plastic bags that contained the fish were placed on the surface of the water to float for 30 minutes, in order to balance temperatures. The water from the pools was then added to the bags, until the temperatures were homogenized and the sowing was subsequently carried out.

Monitoring of physicochemical parameters. The temperature, oxygen, and pH of the water were recorded every three days, at 3 pm, using a HACH brand water analysis Field Kit, reference FF-1ª (Hach, Loveland, CO).

Sampling. Censuses were carried out at the beginning and at the end of the experiment, along with five additional monthly samples, which consisted of capturing 15% of the total population of each experimental unit. No food was provided on the day of sampling in order to reduce metabolic activity and its negative effect on weighing. The specimens were captured using fishing trays and buckets, maintaining all animal welfare protocols during the sampling process in order to ensure that stress was reduced to the maximum, by permanent aeration and light sedation with a 0.5% clove-based commercial solution. Height and weight were recorded using a wooden ichthyometer and an electronic scale with sensitivity of 0.001 g (OHAUS, Parsippany, NJ). The information was entered in a database, which allowed for the biomass to be calculated along with the amount of food to be supplied in the following week.

Prophylaxis. The specimens were subjected to immersion baths with a commercial solution of NaCl at a dose of 5 g/L. This process was carried out every two weeks in 12 L buckets for a period of 10 minutes, after each sampling, in order to improve the osmotic permeability of the gills and decrease mortality. The walls of the pools were washed and brushed every two weeks in order to fight pathogens that could affect the specimens.

Preparation of the hydrolyzate. The hydrolyzate was made from 50 kg of viscera, from which the fatty tissue, gastrointestinal content, and gallbladder were removed. Once the cleaning process was finished, the viscera was liquefied, until a homogeneous paste was obtained. It was then cooked for 10 minutes in an oven until a temperature of 80ºC was achieved before it was allowed to cool to room temperature. Once at room temperature, 2% of sulfuric acid (98% purity) and 5% of molasses were added. The pH of the hydrolyzate was evaluated at 24, 48 and 72 hours after preparation, until a constant pH of 3.0 ± 0.2 was obtained. This ensured that the ideal conditions for the breakdown of peptide chains was maintained and bacterial growth was controlled. The hydrolyzate was taken to a 25 L capacity electric pressure steam autoclave at 90°C for 10 minutes (All American, Manitowoc, WI) and then stored in 10L plastic containers, which were properly labeled and kept at room temperature, in total darkness, for a period of 20 days. Constant monitoring was carried out during this period- the contents of the container were stirred twice a day and the walls of the container clean were kept clean using a cloth that was slightly moistened with a commercial 2% sodium hypochlorite solution, to avoid bacterial contamination. Subsequently, the hydrolyzate was poured into stainless steel trays to form a 4 mm thick layer, and then dried at a temperature of 60°C in an oven (Memmert, Schwabach, Germany) for 14 hours until a hard paste was obtained. Finally, it was brought to a micro mill (IKA, Staufen, Germany) to create flour.

Screening and bromatological analysis of raw materials. The different raw materials selected in the experimental diets were ground and sieved to a particle size of 450 µ to facilitate homogenization. A proximal and energetic analysis was then performed, following the AOAC methodology (8), adapted by the Laboratory of Bromatology of Specialized Laboratories of the University of Nariño.

Elaboration of the diets. A commercial, pigment-free diet with 48% protein was used as a control treatment, compared to isoproteic (45.17± 0.15) and isoenergetic (4066.90±28.75) diets, made with different percentages of viscera hydrolyzate meal (animal protein source), mixed with other vegetable raw materials commonly used in fish, fish oil (animal lipid source), and a commercial vitamin and mineral premix (Table 1). The diets were supplied during the fry and raise stages, according to the nutritional needs of rainbow trout.

Balancing diets. The balancing of the experimental, isoproteic and isoenergetic diets was carried out using Feedsoft Enterprise (2018) and the Excel Solver tool (2018), quantifying the nutritional contributions on a partially dry basis of each raw material used, according to the certified bromatological tests carried out by the Specialized Laboratories section of the University of Nariño, regarding dry matter, ash, ethereal extract, crude fiber, protein, non-nitrogenized extract and raw energy.

Feeding percentage. The food was supplied "ad libitum," starting at 10% average live weight daily (ADW). One month later it was reduced to 8%, 7% at the third sampling, 6% to the fourth sampling, 5% to the fifth sampling, 4% of the ADW to the sixth sampling, until the end of the trial. This ensured adequate consumption of the experimental diets, which was established by supplying the food in the percentages indicated above and by syphoning out uneaten food. Subsequently, the unconsumed material was dried at room temperature in plastic trays, then weighed by replica and treatment, in order to determine the actual consumption. Food was distributed seven days a week, with the exception of sampling days. It was divided into six meals per day in the first four months and four daily meals in the remaining three months.

Treatments. Four treatments, and six replicates per treatment were evaluated for a total of 24 experimental units, with 70 fish per experimental unit and 420 fish per treatment, for a total of 1680 fish. Average stocking weight was 1.24± 0.024 g, which did not register statistical differences ($p > 0.05$). The treatments were distributed in the following manner:

T1: Commercial balanced without viscera hydrolyzate.
T2: Experimental balancing with 10% viscera hydrolyzate.
T3: Experimental balancing with 15% viscera hydrolyzate.
T4: Experimental balancing with 20% viscera hydrolyzate.

Experimental design. An Unrestricted Random Sampling (URS) was used, consisting of four treatments and six replicates per treatment, for a total of 24 experimental units. The fish were planted in a totally random way.

With the statistical software SPSS IBM 20, an analysis of variance (ANDEVA) was performed to determine the significant statistical differences between the treatments. For the variables that registered statistical differences, Tuckey's multiple comparison test was applied at 95% reliability. This was realized in order to establish the best treatment regarding weight, height, biomass and feed conversion gains.

Variables evaluated

Weight gain (WG). Defined as the increase of weight of the population in a determined period of time.

Length gain (LG). Defined as the increase in length of the population, in a certain period of time.

Biomass Gain (BG). The total weight of fish produced in each treatment.

Apparent feed conversion (A.f.c). The relationship between the food supplied and weight gain obtained during the experimental period.

Survival (S). The percentage of animals that survive until the end of the experimental period.

Table 1. Experimental diets using percentages of substitution with fish viscera.

Raw materials	Amount of Raw Materials/Diet %	Amount of crude protein / R. Materials %	Amount of crude protein / Diet %	CE/ Raw Materials kcal/ kg	CE/ Diet kcal/kg	EE Raw Materials %	EE/ Diet %	Fiber Raw Materials %	Fiber / Diet %	Ash Raw Materials %	Ash / Diet %	NNE/ Raw Materials %
Experimental diet 1: 10% Hydrolyzed trout viscera. Energy-protein ratio 8.94.												
Meat meal	29.5	70.88	20.9	5410	1596	16	4.72	1.18	0.35	3.61	1.06	8.33
Hydrolyzed viscera	10	60.4	6	5520	552	17.3	1.73	0.35	0.04	6.47	0.65	15.48
Soybean cake	25.5	42.5	10.8	2095	534.2	4.8	1.22	5.9	1.5	7.25	1.85	39.55
Corn flour	27.9	7.08	7.08	3790	1057.4	1.85	0.52	9.28	2.59	0.48	0.13	81.31
Fish oil	2	3	0.1	1000	200	100	2	0	0	0	0	0
Molasses	3	9.7	0.3	3390	101.7	0.9	0.03	6.3	0.189	12.5	0.38	70.6
Premixed vitamins and minerals	2	0	0	0	0	0	0	0	0	0	0	0
Ascorbic acid	0.05	0	0	0	0	0	0	0	0	0	0	0
Oxytetracycline	0.05	0	0	0	0	0	0	0	0	0	0	0
Demand	100		45.2		4041.3		10.2		4.67		4.07	
Experimental diet 2: 15% Hydrolyzed trout viscera. Energy-protein ratio 8.96.												
Meat meal	25.4	70.88	18	5410	1374.1	16	4.064	1.18	0.3	3.61	0.92	8.33
Hydrolyzed viscera	15	60.4	9.1	5520	828	17.3	2.6	0.35	0.05	6.47	0.97	15.5
Soybean cake	25.5	42.5	10.8	2095	534.2	4.8	1.22	5.9	1.5	7.25	1.85	39.55
Corn flour	27	7.08	7.08	3790	1023.3	1.85	0.5	9.28	2.51	0.48	0.13	81.31
Fish oil	2	3	0.1	10000	200	100	2	0	0	0	0	0
Molasses	3	9.7	0.3	3390	101.7	0.9	0.03	6.3	0.189	12.5	0.38	70.6
Premixed vitamins and minerals	2	0	0	0	0	0	0	0	0	0	0	0
Ascorbic acid	0.05	0	0	0	0	0	0	0	0	0	0	0
Oxytetracycline	0.05	0	0	0	0	0	0	0	0	0	0	0
Demand	100		45.3		4061.4		10.41		4.55		4.24	
Experimental diet 3: 20% Hydrolyzed trout viscera. Energy-protein ratio- 9.11.												
Meat meal	22.7	70.88	16.1	5410	1228.1	16	3.632	1.18	0.27	3.61	0.82	8.33
Hydrolyzed viscera	20	60.4	12.1	5520	1104	17.3	3.46	0.35	0.07	6.47	1.29	15.48
Soybean cake	22.2	42.5	9.4	2095	465.1	4,8	1.07	5.9	1.31	7.25	1.61	39.55
Corn flour	29	7.08	7.08	3790	1099.1	1.85	0.54	9.28	2.69	0.48	0.14	81.31
Fish oil	1	3	0	10000	100	100	1	0	0	0	0	0
Molasses	3	9.7	0.3	3390	101.7	0.9	0.027	6.3	0.189	12.5	0.38	70.6
Premixed vitamins and minerals	2	0	0	0	0	0	0	0	0	0	0	0
Ascorbic acid	0.05	0	0	0	0	0	0	0	0	0	0	0
Oxytetracycline	0.05	0	0	0	0	0	0	0	0	0	0	0
Demand	100		45		4098		9.72		4.53		4.24	

CE=Crude energy. EE=Ethereal extract. NNE=Non-nitrogenized extract.

RESULTS

Weight gain: Daily increases in weight, weight at 120 days, and weight at the end of the experiment showed significant differences between treatments ($p \leq 0.01$). Tukey's multiple comparison test showed that, at month 7, T4 registered the highest weight gain (203.17 ± 8.15), while T1 showed the lowest gain (135.63 ± 9.89) (Table 2).

Table 2. Daily increases in weight, weight at 120 days, and final weight, expressed in grams.

Treatment	DWG g	WG g	FWG g
T1	0.6467^{d} ±0.472	17.77^{d} ±1.02	135.63^{d} ±9.89
T2	0.7234^{c} ±0.401	25.37^{c} ±2.74	151.90^{c} ±8.42
T3	0.8411^{b} ±0.250	27.13^{b} ±1.61	176.63^{b} ±5.25
T4	0.9675^{a} ±0.388	34.10^{a} ±1.25	203.17^{a} ±8.15
EEM	0.00825	0.435	--------

DWG: daily weight gain, WG: weight gain at 120 days (month 4). FWG: final weight gain expressed in grams. Mean ± standard deviation. SDE: root-mean-square error. Different letters per column show significant statistical differences ($p<0.05$).

In the experimental period, the average growth was 146.1% in treatment T4. According to the percentage of relation, in the best treatment, the highest growth rate was presented in the first four months of evaluation, equivalent to 2650% (1.24 to 17.77 g). The smallest increase was evident between the fifth to seventh months, equivalent to 496% (203.17 g).

Size gain. The analysis of variance is significant ($p \leq 0.01$) for the monthly growth in size in each treatment. Consequently, there is a significant difference between the days of the experiment, which changes depending on the type of diet, The largest increase in size was in T4 (26.01 ± 0.34 cm), while diet 1 established the lowest mean (21.02 ± 1.35 cm). Tukey's test, by month and treatment, shows the chronological change of the mean in the study indicator (Table 3).

The increase in size, through the different samplings, showed a similar trend between treatments: during months 1 to 4 (120 days of evaluation), the best treatment revealed greater variation (208%) and lower growth rate during the last evaluation quarter (98%).

Table 3. Daily increase in length, length gain at 120 days, and final length gain, expressed in centimeters.

Treatment	DLI cm	LG cm	FLG cm
T1	0.100^{d} ±0.0065	13.53^{d} ±0.61	21.02^{d} ±1.35
T2	0.109^{c} ±0.0032	12.74^{c} ±1.61	23.00^{c} ±0.66
T3	0.113^{b} ±0.0029	12.93^{b} ±0.46	23.80^{b} ±0.60
T4	0.124^{a} ±0.0017	13.14^{a} ±0.46	26.01^{a} ±0.34
EEM	0.00061	0.065	--------

DLI: daily increase in length, LG: length gain at 120 days (month 4). FLG: final length gain expressed in centimeters. Mean ± standard deviation. SDE: root-mean-square error. Different letters per column show significant statistical differences ($p < 0.05$).

Biomass gain. Table 4 indicates that ANDEVA is significant ($p \leq 0.01$), for the monthly increase in biomass. Consequently, there is a significant difference amongst the different days, depending on the treatment. In month seven, the diet with the highest average corresponded to treatment 4, (13376.49 ± 576.41 g), while T1 registered the lowest mean (7025.24 ± 1541.16 g).

Table 4. Daily increases in biomass, biomass gain at 120 days, and final biomass gain, expressed in grams.

Treatment	DBI g	BG g	FBG g
T1	33.430d ±7.339	1161.65d ±69.90	7025.24d ±1541.16
T2	44.369c ±2.658	1704.39c ±185.55	9317.45c ±558.15
T3	53.970b ±1.818	1836.01b ±108.91	11333.65b ±381.77
T4	63.698a ±2.745	2335.78a ±85.87	13376.49a ±576.41
EEM	0.77612	37.79	--------

DBI: Daily increases in biomass. BG: biomass gain at 120 days (month 4). FBG: final biomass gain, expressed in grams. Mean ± standard deviation. SDE: root-mean-square error. Different letters per column show significant statistical differences ($p < 0.05$).

The total weight of fish produced in treatment 4, according to the ratio percentage, revealed an increase of 473% in the last quarter, in the biomass harvested.

Apparent feed conversion. The analysis of variance of the apparent feed conversion is significant ($p \leq 0.01$) in the evaluation period.

Consequently, there is a significant difference between the experimental months. The least adequate diet was presented in T1 (2.68 ± 1.23), and the best apparent dietary conversion was T4 (1.87 ± 0.65), as shown in Table 5.

Table 5. Daily apparent feed conversion, apparent feed conversion at 120 days and final apparent feed conversion.

Treatment	DFC	FC	FFC
T1	0.0255[d] ±0.118	1.18[d] ±0.27	2.68[d] ±1.23
T2	0.0222[c] ±0.009	0.77[c] ±0.30	2.33[c] ±0.93
T3	0.0240[b] ±0.009	0.70[b] ±0.12	2.52[b] ±0.98
T4	0.0178[a] ±0.006	0.54[a] ±0.04	1.87[a] ±0.65
EEM	0.00062	0,035	--------

DFC: daily feed conversion. FC: apparent feed conversion at 120 days (month 4). FFC: final apparent feed conversion. Mean ± standard deviation. SDE: root-mean-square error. Different letters per column show significant statistical differences (p<0.05).

Survival. Analysis of the survival rate of the rainbow trout in the experimental diets defined significant differences (p = 0.000), with a higher mean in treatment 4 (94%), without differing from treatments 2 and 3, (respectively 88 and 92 %). In contrast, the lowest survival was recorded in T1 (Figure 2).

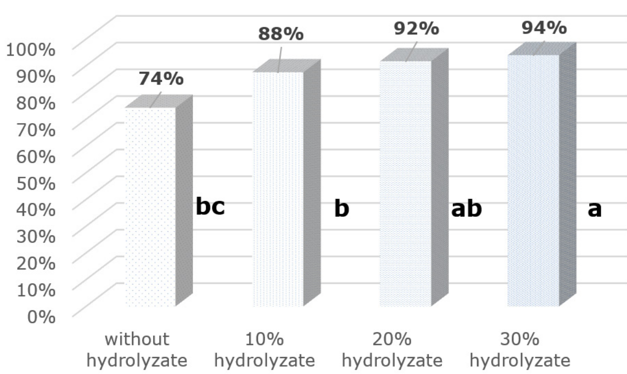

Figure 2. Percentage of final survival rates in the different experimental treatments.

Taking into account all the productive variables, it was established that treatment 4 (diet with 20% viscera hydrolyzate) presented the highest weight gains (203.17 ± 8.15), total length (26.01 ± 0.34 centimeters), biomass (13376.49 ± 576.41 g), feed conversion (1.87 ± 0.65 units), and average survival (94%) when compared to T1 (commercial diet), which reported the least adequate productive variables, with a feed conversion of 2.68 ± 1.23.

Physicochemical parameters of the water. The average temperature in the pools was 15.9ºC, reaching a maximum of 16.2ºC in times of less precipitation, and a minimum of 15.7ºC in the rainy season. The correlation coefficient indicates that the maximum variation of the parameter was estimated at 1.03 (3.18%) degrees Celsius. The average pH in the investigation was 6.9, with a minimum of 6.2 and a maximum of 7.3. The correlation coefficient indicates that the maximum variation of the parameter was estimated at 1.17 (17%) pH units. The average oxygen in the investigation was 7.05, with a minimum of 6.9 and a maximum of 7.23. The correlation coefficient indicates that the maximum variation of the parameter was estimated at 1.02 (2.8%) mg/ L.

DISCUSSION

When raised in closed spaces, such as floating cages or ponds, fish species must consume artificial foods that provide all the necessary nutrients (carbohydrates, fats, proteins, fiber, vitamins, minerals and water), which change according to different physiological stages and handling conditions (9). However, the high stocking densities that are used in trout culture generate a large accumulation of waste metabolites, causing continued stress. This stress depresses the immune system of the fish, making them more prone to attack by viruses, parasites, bacteria and opportunistic fungi, causing high mortalities during the cultivation period. Therefore, one of the mechanisms used to strengthen the immune system is artificial food made with excellent quality protein sources. This provides proteins that ensure the synthesis of antibodies, which constitute the defensive mechanism of fish, reducing rates of mortality, shortening the cultivation time from sowing to harvesting, and therefore increasing the profitability of each production cycle (9). Unfortunately, Colombian trout culture currently faces high costs in the acquisition of traditional protein, raw materials used in the production of balanced fish, due to the scarcity and high cost in the international market of fishmeal as a source of high quality protein, affecting the profitability of the fish farming subsector (10). The need to evaluate low-cost, non-traditional protein sources is therefore created, as is the case with hydrolyzate flours obtained from aquaculture by-products. These products have the physicochemical, bioactive, functional and nutritional properties necessary, with the potential for use with small producers of rainbow trout, while also being ecologically friendly in the pristine environments surrounding the fish-growing lake environment in Nariño.

Based on the above, the incorporation of fish viscera hydrolyzate meal as a protein source in balanced rainbow trout diets, demonstrates the potential for improvement of the zootechnical variables of fish production due to the biological quality of the diets (9,11). This is ultimately reflected in a better use of the nutrients that come from the hydrolyzate, therefore producing higher survival rates, weight gain, and better feed conversions (9). The above coincides with research conducted by Peréa et al (12), who reached higher averages (142.14± 4.74 g), when feeding red tilapia using 20% of trout viscera hydrolyzate.

During the experiment, it was also observed that the fish presented higher consumption with the experimental diets, in relation to the commercial food, demonstrating the greater palatability of the diets with hydrolyzed viscera (13).

In conclusion, the incorporation of 20% of fish viscera hydrolyzate meal as a protein source in balanced rainbow trout diets improves the zootechnical variables of fish production, due to the biological quality of the diets.

Conflict of interest

The authors of this study declare that there is no conflict of interest involved in the publication of this manuscript.

Acknowledgements

Vice-Rector's Office for Research, Postgraduate Studies and International Relations at the University of Nariño, which funded this project by means of an open teaching call for this investigation. Likewise, the authors acknowledge the logistical support provided by the Guirapungo Environmental and Fish Center, affiliated with Corponariño.

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