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Original

Effect of Diet Processing on the Productive Performance of *Clarias gariepinus*

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ABSTRACT

Background: Further expansion of aquaculture will depend on balanced and processed feeds that promote optimum productive indicators, particularly in African catfish (*Clarias gariepinus)* cultures, an area with few related studies. **Aim.** To evaluate the effect of diet processing on the productive performance of *Clarias gariepinus*

Methods: Two bioassays were done with the formulation of the balanced feed for fingerling cutlures of African catfish. The first trial was based on a comparison of pelleted balance feeds (pelleted T-1), and extruded (extruded T-II). The second experiment included the commercial pellets (pelleted T-III), which were milled and extruded (pelleted/extruded T-IV). Simple classification models with two treatments and three repetitions were done; the data were compared using simple analysis of variance.

Results: No differences were found ($P<0.05$) in final weight, feed conversion, and protein efficiency between the pelleted and the extruded feeds. However, the extruding process of pellets significantly improved ($p<0.05$) the productive performance of *Clarias gariepinus* fingerlings. Survival was over 90%.

Conclusions: The utilization of extruded feeds from mixed meals had no significant effects on the productive indicators of *Clarias gariepinus.* However, extruding the pelleted feed improved the productive performance of these animals.

Key words: feeding, African catfish, extruded feed, pellet, ration (Source: *MeSH)*

INTRODUCTION

The aquaculture feedstuff industry has made unprecedented advances. The evolution of manufacturing processes, which adapted to the new realities of industry, eventually led to

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improvements in manufacturing methods, as feeding comprises 50-70% of production costs (Perea-Román *et al.*, 2018), especially when culturing requires intensification based on diets and nutritional programs that maximize the productive performance of animals and their cost-effectiveness.

In Cuba, a system of water recirculation (SWR) based on Dutch technology for intensive African catfish (*Clarias gariepinus)* culture, was evaluated. This species demands a nutritional program that includes nutrient levels and digestibilities, biomass supply, feeding frequency, and ration processing type.

Extrusion as a technology to process feeds, gained preponderance within the context of fish feed production. Different from pelletizing, it includes cooking ingredients at high temperatures (130-180 ºC), and mechanical pressure for 10-60 seconds (Cian *et al.*, 2017). Therefore, it has a direct impact on the chemical-physical properties of the product, which might influence on the nutritional quality of ingredients, digestibility, durability, and stability of pellets, and naturally, on water quality (Molina and Espinoza, 2019). Besides, undesirable enzymes are denatured, and some anti-nutritional factors are deactivated, thus promoting bioavailability of feed ingredients (Cian *et al.*, 2018).

The benefits of food processing over the productive performance of African catfish are few, since the commercial value of this species is low. It is cultured in few countries, and its feeding strategy uses non-conventional methods. Hence, the aim of this paper was to evaluate the effect of diet processing on the productive performance of *Clarias gariepinus.*

MATERIALS AND METHODS

Two bioassays were performed at the Nutrition Laboratory, of the Company for Aquaculture Technology Development (EDTA), located in the municipality of Cotorro, Havana. A simple classification model with two treatments and three replicas was used in each experiment.

The containers were 68 L circular cement tanks with a water flow of 0.2 L/min for 24 h. Temperature and dissolved oxygen values were measured every day, using a digital oximeter (*HANNA*, Romania), and the ammonia levels were measured weekly, using an *Aquamerck* water colorimetric kit (http://www.ictsl.net/).

The animals from the fingerling culturing area at EDTA, were adapted for a week in a 4.5 m^2 concrete pool, where balanced feeds for catfish fries were supplied (36% crude protein) in pellets. Then they were selected and distributed in the experimental containers.

In the two bioassays, a formulation of the balanced feed used during the intensive culturing stage of *Clarias gariepinus* fingerlings was supplied. Its percentage and chemical compositions are shown in Table 1.

Table 1. Percentage and chemical composition of the balanced feeds supplied to catfish fries

Ingredients	**g/100 g**
Fishmeal	24
Soymeal	38
Flour	33
Soybean oil	4
Vitamin-mineral mix	1
Total	100
Dry matter	90.28
Crude protein	36.05
Ether extract	7.83
Crude fiber	2.36
Ashes	6.54
Digestible energy (MJ/kg)	15 05

Bioassay 1. Pelleted feed vs extruded feed

The raw materials (fish meal, soybean meal, and flour) were milled (approximately 250 µm), and mixed (*Hobart M-600* mixer, Canada); then, the other ingredients of the formulation were added. The final mix was divided in two equal portions, and they were agglomerated in the extruder; one at room temperature (*T-I pelleted feed*), and the other at 140 ºC (*T-II extruded feed*). Then, the diets were dried in a stove (Selecta, Spain), at 60 ºC for 12 h, and were placed in plastic containers covered with a lid.

A total of 120 *Clarias gariepinus* fingerlings (20.3 $\pm$0.06 g average initial weight), were placed in six containers at random (20 fishes in each). The animals were given 4% body weight/day in two daily rations (9:00 and 16:00 h), for 60 days. All the animals were weighed every 15 days to adjust the rations, and evaluate the productive indicators.

Bioassay 2 *Pelleted feed vs pelleted-extruded feeds*

Overall, 20 kg of pelleted balanced feeds made at ALISUR Feedstuffs factory, were used, which were divided in two 10 kg portions. One was directly stored in a plastic container with a lid (*T-III pelleted feed*), and the other was milled (approximately 250 µm), then it was extruded at 140 ºC (DGP 70, China). It was dried in the stove, and stored in another container with a lid on the top (*T-IV pelleted-extruded feed*). Both feedstuffs were stored at room temperature during the experimental period.

A number of 120 *Clarias gariepinus* fingerlings (15.3 $\pm$0.08 g average initial weight) were distributed at random in six tanks containing groups of 20 fishes each. Feeding was at 4.5 % body weight/day in two daily rations (9:00 and 16:00 h), for 60 days. All the animals were weighed every 15 days to adjust the rations.

The bromatological determinations of the ingredients and the balanced feeds were made according to the methods described by Latimer (2016); digestible energy was estimated according to the caloric coefficients reported by Toledo, Llanes, and Romero (2015).

At the end of bioassays, the animals were weighed individually, using a digital scale (*Sartorius*, Germany). The following productive indicators were estimated:

Feed consumption = added feed/Final number of animals

Protein consumption = added protein/Final number of animals

Mean final weight

Feed conversion factor (FCF) = Added feed/Weight gain

Protein efficiency (PE) = Weight gain/Protein supplied

Survival (S) = No. Final animals/No. Initial animals x 100.

Statistical analysis: A simple analysis of variance (ANOVA) was performed to the final weights and the average values of the remaining indicators, using INFOSAT statistic software, version 2012 (Di Rienzo *et al,* 2012).

RESULTS AND DISCUSSION

During the experimental period, the values of temperature and dissolved oxygen in water varied between 25.7 and 26.9 ºC, and 3.1 and 5.0 mg/L, respectively. The ammonia level was 0.01 mg/L, through water circulation. These values are considered safe for adequate productive performance of the species (Toledo, Llanes, and Lazo de la Vega, 2011).

The feed formulation used flour as the main agglutinating element to achieve greater pellet stability in the water, since this starch contained in this grain has a lower gelatinization temperature than corn, rice, and other grains. The gluten contents and particle size (very thin) help during gelatinization and agglutination (Toledo, Llanes, and Romero, 2015).

No statistically significant differences (P>0.05) were found in final weight, feed conversion, and protein efficiency among the animals that consumed the extruded and pelleted feeds (Table 2), which coincides with the results reported by Pokniak *et al.* (1999), in rainbow trouts (*Oncorhynchus mykiss*), and the reports of Aguilar, Afanador and Muñoz (2010), in Nile tilapia (*Oreochromis niloticus* Var. Chitralada). The latter noted that during extrusion, high temperatures and pressure cause gelatinization of starch in the diet, which allows for increases in the availability of feed carbohydrates, though Maillard-like reactions may occur, reducing the availability of some amino acids. Consequently, it does not lead to improvements in the productive performance of animals, compared to pelleted feeds.

Table 2. Results of productive indicators of *Clarias gariepinus* fingerlings with the pelleted and extruded feed

Indicators	T-III pelleted	T-IV extruded	± SE	P
Final weight, g	135.8±3.28	131.7±2.4	-	0.313
FCF	1.09	1.08	0.01	0.836
Protein efficiency	3.07	3.09	0.04	0.862
Survival %	90.0	91.86	3.35	0.813

The extrusion process to the pelleted feed (T-IV) significantly improved ($p<0.05$) growth and feed efficiency of the animals (Table 3), which might indicate that this process helped complete gelatinization of the starch present in the feed, and provided faster starch digestion rates, causing greater energy availability in the metabolism of the fish. Moreover, it is contrary to the report made by Aguilar, Afanador, and Muñoz (2010), regarding the availability of certain amino acids due to Maillard-like reactions.

Table 3. Results of productive indicators in *Clarias gariepinus* fingerlings with the pelleted and pelleted-extruded treatments

Indicators	T-I pelleted	T-II pelleted-extruded	± SE	P
Final weight, g	71.65+1.18	92.4+2.79	-	0.000
FCF	1.24	1.02	0.05	0.001
Protein efficiency	2.29	2.78	0.11	0.001
Survival %	100	97.78	1.11	0.374

It is worth mentioning that in this treatment (IV), the pelleted feed was milled before being extruded, which helped reduce particle size of raw materials, producing greater digestibility and feed conversion (Toledo, Llanes, and Romero, 2015). Accordingly, the effect of ration processing on higher animal productive performance could be more related to the size of raw material particles prior to the manufacture of feeds and starch gelatinization process.

There are few recent studies comparing pelleted and extruded feeds for fish nutrition. Gur (1997) reported no additional benefits in the production of floating pellets by dry extrusion (low humidity levels) in Nile tilapia fingerlings. In turn, Furuya *et al*. (1998), in reverted males from the same species, found no statistically significant differences in final weights, feed conversion, and survival; though protein efficiency was higher with the extruded feed.

In another study, Cruz and Rhida (2001) evaluated the effect of using floating pellets in the diet of Nile tilapia juveniles in SRA, and reported the nest growth and feed conversion with the pelleted feed, though the crude protein level (42%) was higher than the floating (32.8%). The direct link between growth and the protein level in fish is well documented (Mejías, Isea, and Molina, 2016). However, the cost of feeding (feed price x feed conversion factor), and the total cost to produce one kg of biomass improved when the floating feed was used.

The development of intensive aquaculture in Cuba should take into account feed extrusion to improve its physical characteristics, starch gelatinization, floatability rate, pasteurization, water stability, and generally, critical properties that have a nutritional impact on the environment. Furthermore, extrusion allows for more soy contents in the diet, and for a decrease in fish meal contents (Cian *et al.*, 2017), as well as to the formulation of hyperenergetic diets, with high percentages of lipids in its composition (Molina and Espinosa, 2019).

Due to the relevance of feeding over the total costs of fish culturing, and the scarce local information on the current topic, it is important to conduct further evaluations, under other

experimental conditions, of the advantages in ration processing over animal productive performance.

CONCLUSIONS

The utilization of extruded feeds based on mixed meals had a marked effect on the productive indicators of *Clarias gariepinus.*

The extrusion process done to the pelleted feeds enhanced the productive performance of *Clarias gariepinus.*

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CONFLICT OF INTERESTS

The authors declare no conflict of interests.