Journal homepage: https://www.multiscipub.com/index.php/AgricultureReports

AG RE | Agriculture Reports

Volume 3 Issue 2 (2024) Pages 26-37

Effect of fungal compost hoof and feather meal on growth, feeding performance and cost benefitted analysis of the catfish (*Clarias gariepinus*)

Ekinadose Orose[1], Okechukwu Kenneth Wokeh[1], Noordiyana Mat Noordin[2], Roslizawati Ab Lah[2] and Nur Asniza Aziz[3*]

[1] Animal and Environmental Biology, Hydrobiology and fisheries unit, University of Port Harcourt, Nigeria

[2]Institute of Climate Adaptation and Marine Biotechnology (ICAMB), Universiti Malaysia Terengganu (UMT), Kuala Nerus 21030, Terengganu, Malaysia

[3]Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu (UMT), Kuala Nerus 21030, Terengganu, Malaysia

*Correspondence: asniza.aziz@umt.edu.my at Institute of Climate Adaptation and Marine Biotechnology, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Malaysia

Citation: Ekinadose Orose, Okechukwu Kenneth Wokeh, Noordiyana Mat Noordin, Roslizawati Ab Lah and Nur Asniza Aziz (2024). Agriculture Reports, 3(2): 26-37.

Received: 17 August 2024
Accepted: 20 November 2024
Published: 30 December 2024
eISSN Number: 2948-4138

Abstract: The use of fish as a protein source in the production of fish feed has contributed to the increasing cost of fish. Animal waste sources can serve as alternatives but very little is known about the effects. This study assessed the effects of fungal compost cow hoof and feather meal growth of the catfish (*Clarias gariepinus*). Bio-composting was used to degrade cow hoof and poultry feathers for 42 days for the feeding trials which lasted for 12 weeks. Juveniles with a mean weight 17±0.58g were stocked 7 per aquarium in 12 aquaria (60×60×40cm). The diets contained 45% crude protein and were offered twice daily at 5% body weight. The control contained fishmeal, while diets 1 to 3 were substituted with compost feather (CFW), cow hoof (CH), and an equal ratio of CFW and CH, respectively. Growth performance and cost-benefit analysis of the fish were evaluated. The results showed that the control feed recorded a higher weight gain and total feed intake but a lower feed conversion ratio and survival rate than the fish-fed cow hoof and feather meal. The gross profit of the cow hoof (₦150) had a similar comparable value with the fishmeal (₦163). Based on the above findings it is concluded that compost feather and hoof meal are suitable alternatives in the culture of catfish.

Keywords: Biological approach, composting, renewable resources

INTRODUCTION

There is a critical need to develop bioproducts using renewable and sustainable resources (Tesfaye *et al*., 2017). Many similar attempts have already been made and implemented in both developing and developed countries in order to meet future generations' food, clothing, pharmaceutical, automobile, cosmetic, and plastic demands. Due to the scarcity of fossil fuels, agricultural by-products and co-products are both economical (non-conventional feedstuffs) and environmentally friendly. Through the application of new and innovative ideas and technologies for the reuse of these resources for energy, organic fertilizers, and animal feed, selected non-conventional feeds that are sometimes viewed as a trash can either be decreased or turned into biologically beneficial products (Abdel-Shafy and Mansour 2018). This will eventually result in a new approach to improving people's quality of life.

Fish has been a significant source of food for generations, accounting for around half of many Africans' total animal protein diets (FAO, 2003). Globally, aquaculture output accounted for 42.2% of total fish production of about 158 million tonnes in 2012 from aquaculture and capture fisheries (FAO, 2014). Aquaculture is extremely vital in providing a living for millions of people all over the world (Ababouch and Fipi, 2015).

The aquaculture sub-sector in Nigeria has considerable potential for growth (Kaleem and Sabi, 2021), particularly because demand for fish is growing as a consequence of population increase and low production from capture fisheries, both at the domestic and global levels. Many individuals are employed in a variety of aquaculture-related occupations, including input and output processing (Adeyemi, 2020). The increasing population, globally and locally, has created concerns about infrastructure, housing, security, and employment. Consequently, food security is going to be the most serious situation (FAO, 2019).

Obiero *et al*. (2019) emphasized that fish production continues to be the most efficient method of correcting of Africa's animal protein shortage because they grow fast and convert feed to meat, which allows them to increase animal protein supply for human consumption at a reduced cost.

Fishmeal protein can be substituted with chicken feather silage meal up to 100 percent in the feed formula of the Pomfret (*Colossoma macropomum*) to determine the effect and optimal utilization of the chicken feather silage meal as a substitute for fish meal protein source (Ekawati *et al*., 2016). The therapy had no influence on the survival rate, specific growth rate, feed conversion ratio, or protein efficiency ratio, according to the findings. Suloma *et al*. (2014) utilized silage chicken feathers as a partial replacement for fish meals and found no detrimental effects on the fish's development.

In addition, utilizing organic waste to replace fish meals which is often costly and contributes to high fish production costs provides an alternate approach and has been gaining pace (Nugroho and Nur, 2018). Furthermore, most farmers cannot afford to purchase feed and fertilizer throughout the year. Inadequate fish feed and fertilizer management have led to the development of a gap between targeted fish output and demand throughout the years (Akankali and Nwafili, 2015). The National Organics Standards Board (NOSB) in the United States has suggested phasing out fish meal in legally recognized aquaculture products over a 12-year period (Forbes and Ramkrishnan 2019). Both economic and ethical concerns are driving these advances.

This research is geared towards unraveling the biodegradation potentials of animal waste protein sources in African catfish production. It also assesses the effects of using microbial compost feedstuffs on the growth and cost-benefit in catfish culture.

MATERIALS AND METHODS

Experimental Design

The feeding trial was conducted using Complete Randomized Design (CRD). Fungal: *Fusarium spp* was used for composting as described by Orose *et al*., (2022). The fungi were obtained from Spendid Stand Microbiology Laboratory in Benin City, Edo State, Nigeria. A total of 100 African catfish (*Clarias gariepinus*) juveniles were procured from Uyi fish farm, Benin City, Edo State.

Substrate Preparation for Bio-composting

The cow hoof and poultry feathers were gathered, cleaned, oven-dried, and ground into smaller particles. They were then placed in a biocomposter after being weighed and autoclaved, to unlock the nutrients hidden inside each protein source. Composting was done using plastic bio-composters with a one-liter capacity. Throughout the composting process, substrates and microbial inocula were piled in layers and evenly mixed with respect to time. The procedure was left to run at room temperature for 42 days. After composting, the feather meal and cow hoof were used for the formulation of the various experimental feeds for the feeding trials.

Feeding Trial

The feeding trial was conducted in twelve 60-liter plastic containers. The juveniles were divided into three replicates of each of the four treatments in a completely randomized design; seven (7) juveniles were randomly assigned to the four food regimens. An electronic weighing scale (Model M P 2001) was used to weigh them, and a metre rule was used to measure their length. The fish were allowed to acclimatize for 14 days. After the acclimation period ended, the fish were not fed for 24 hours to empty their guts before the experiment began.

Feed Formulation

The experimental diets were created using bio-compost from non-traditional waste protein sources on account of their higher crude protein level, poultry feather meal (FeM) and cow hooves (CH), as alternative dietary protein sources to the conventionally used fish meal (FM) in fish diets. The working composition of African Regional Aquaculture Center (ARAC), Port Harcourt, Rivers State, acquired from the feed mill was used. The feeds were isonitrogenous containing 45% crude protein using the Pearson square methods to formulate the feed. Feed was also composed of wheat bran, soybean, groundnut cake (GNC), wheat bran, cassava, wheat flour, premix (vitamin) and palm oil in various percentages (Table 1). Five kilograms of feed each was formulated for the control and the animal waste feed and their replicates.

1.1 Table 1. Nutritional Composition of Experiment Diets (%)

Feed ingredients	Experimental diets			
	FM	CFM	CCH	M
Maize	0.71	1.30	1.68	1.49
Wheat bran	0.71	1.30	1.68	1.49
Rice bran	0.71	1.30	1.68	1.49
BDG	0.71	1.30	1.68	1.49
FM	28.62	-	-	-
CFM	-	27.83	-	13.79
CH	-	-	27.32	13.79
Soybean	28.62	27.83	27.32	27.57
GNC	28.62	27.83	27.32	27.57
Cassava flour	3	3	3	3
Wheat flour	2	2	2	2
Palm oil	4	4	4	4
Premix	0.40	0.40	0.40	0.40
Methionine	0.15	0.15	0.15	0.15
Vitamin C	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15
Bone meal	0.40	0.40	0.40	0.40
Limestone	0.40	0.40	0.40	0.40
Salt	0.40	0.40	0.40	0.40
DCP	0.20	0.20	0.20	0.20
Total	100	100	100	100

BDG (Brewers dried grain), GNC (Groundnut cake), FM (Fish meal), CCH (Cow hoof), CFM (Compost feather meal), M (Equal amount of CFM and CCH)

Feeding of the Fish

Fish were fed twice daily using 5% body weight and reduced to 3% after the fifth week, weekly weights were taken, and the water in the tanks was replaced every day with borehole water containing 50 litres. During the feeding trial, the fish were monitored daily. Growth response and nutrient utilization parameters, which include: final weight gained, total feed intake, feed conversion ratio, survival rate, specific growth rate, and protein efficiency ratio, and were determined at the end of the feeding trial. The cost-benefit analysis was done at the end of the feeding trial.

Measurement of Growth performance

The following methods, described by Rashid, (2010) and Orose *et al*., (2018) were used to calculate growth performance.

Mean Weight Gain (MWG)

Weight gain: Three fish were caught from the four treatments and their replicates and placed separately in a bowl containing water. Then water was poured into the beaker and placed on an electric weighing balance and weighed. The mean weight was recorded weekly using the formula below.

MWG = MFW- MIW

Where: MIW = Mean initial weight of fish at stocking (T1) and MFW = Mean final weight of fish at the end of the experiment (T2)

Total Feed Intake (TFI)

The total feed intake was estimated by adding the weekly feed intake of fish in each group during the duration of the experiment.

Feed Conversion Ratio (FCR)

The feed conversion ratio (FCR) is the quantity of food needed to produce one unit of fish. This was determined by dividing the amount of feed (feed intake) by the weight of the animal.

$$FCR = \frac{total\ feeds\ consumed}{net\ weight\ of\ fish}$$

Feed conversion efficiency

This is the efficiency with which diets are converted into biomass by the fish. The greater the FCE value, the greater the fish's ability to utilise the feed.

$$FCE = \frac{weight\ gain}{dry\ weight\ of\ feed\ fed} \times 100$$

Protein intake

Protein intake was calculated by multiplying the daily feed ration by the protein content of the diet. That is, feed intake multiplied by the crude protein percentage in the diet.

$$: PI = feed\ intake\ \times\ \%\ CP\ in\ diet$$

Protein Efficiency ratio (PER)

The protein efficiency ratio is calculated as the weight per gram of crude protein given (protein intake). It gives an indication of protein utilization. PER was calculated as;

$$PER = \frac{mean\ weight\ gain}{mean\ crude\ protein\ fed}$$

Where: mean CP fed = feed intake × % CP in diet

Specific Growth Rate (%SGR)

This SGR percentage was calculated by the following equation:

$$SGR\ (\%/day) = \frac{loglog\ e\ W2-W1}{T} \times 100$$

Where: T = trial duration (day) and W_2 and W_1 = mean final and initial weights (g), r espectively

Estimation of Survival Rate (%)

At the end of the feeding experiments, all survivors in each treatment group and replicate were recorded.

The survival percentage was calculated using the formula:

$$\% \quad SUR = \frac{no\ of\ live\ fish}{total\ no\ of\ fish\ stocked} \times 100 \quad \text{(Rashid, 2010)}$$

Cost Benefit Analysis of the Conventional and Non-conventional Feed.

The costs were calculated using current feed component prices in the experimental location (Nigeria) at the time of the study. The following methods were used to compute the economic evaluations of the diets: (Lawal *et al*., 2013).

Profitability Index (PI): this was calculated by dividing the cost of feed by the value of fish.

$$PI = \frac{Value\ of\ the\ fish}{Cost\ of\ feeding}$$

Net profit value (NPV) was calculated by multiplying the total number of fish, the cost of fish per kg, and the mean weight gain.

NPV = Mean weight gain ×Total number of fish (n) × Cost/kg of fish

Investment cost analysis (ICA) was calculated by adding feed cost and cost of juvenile stocked.

ICA = Feeding Cost + Cost of Juvenile Stocked

Gross Profit (GP) was calculated by subtracting investment cost analysis from the net profit.

GP = NPV – ICA

Data analysis

The differences among the various groups were determined using the general linear procedure of Statistical analysis Software (SAS) version 2012 while the Duncan multiple range test (DMRT) was used to determine differences between group means (SE) at a 5% level of probability using same software.

RESULTS

Growth performance parameters

The results of the growth performance parameter of the African catfish (*Clarias gariepinus*) fed with experimental diets are shown in Tables 2

Growth performance parameters

The initial mean weights and mean lengths of all experimental diets were not significantly different ($p>0.05$) from each other with values of 17g and 15.33cm, respectively, as shown in Table4.5. The final mean weights for all groups with were significantly different ($p<0.05$). The control (fish meal) had the highest mean final weight of 204±0.58[a], followed by diet 2 (compost cow hoof) (107±0.58), and diet 1 (compost feather meal). Diets value of 86 ± 0.58 and diet 3 (compost chicken feather and cow hoof) with a value of 85±0.58 were not significantly different ($p>0.05$). There were significant differences ($p<0.05$) in average weight gain, the control had the highest value of 187±0.58g followed by the compost cow hoof basial diet (90± 0.58g), diets 1 (compost feather meal) and 3(mixture of feather and cow hoof compost) recorded the lowest values (69±0.00g and 68±0.58g respectively) and were not significantly different from each other. Total feed intake in the control (fish meal) recorded the highest significant value (253.35± 2.52g) followed by diet 2 (compost cow hoof meal) with a value 154.09 ±2.42g, diet 3 with a value of 1423.97± 16.08g and diet 1 with the value of 127.61±3.65g which was not significant ($p>0.05$). The feed conversion ratio was significant ($p<0.05$) in all experimental diets, with the control (fish meal) having the lowest value (1.35±0.01) but not significantly different from diet 3 (1.71±0.03). Diets 1 (1.85±0.06), 2(1.71±0.03) and 3(2.10±0.24) had the highest values and were not significantly different ($p<0.05$).

The results on feed conversion efficiency showed significant differences among experimental diets. The control diet fortified with the fish meal had the highest value (73.82±0.63%). On the other hand, diets 1 (57.42±1.78%) and 2 (58.43±0.92%) were not significant but significantly different from diet 3, although diet 1 was not different from diet 1. The protein intake values recorded revealed significant differences among experimental diets, the control (fish meal) recorded the highest significant value (114.01±1.13), followed by diet 2 (69.34±1.09), diet 1(65.66± 1.64) and diet 3 (64.34±7.34). The protein efficiency ratio (PER) value for the control was significantly better than diets 2(1.30±0.02), 1 (1.20±0.04) and 3(1.08±0.11). Specific growth rate values were significantly greater in the control (fish meal) than the other diets tested, with values of 5.35±0.01, 5.04± 0.01 and 5.01±0.02 for diets 2 (compost cow hoof), 1 (compost feather meal) and 3(mixture of compost feather meal and cow hoof) respectively. The survival rate of the control had the lowest value 57% compared to the other non-conventional diets used, with values of 85%, 85% and 76% for diets 2, 3 and 1 respectively. Figure 1 shows the weekly weight gain of treatment fish.

The control (fish meal) had the highest weekly gain of the experimental diets fed. Diets 2 and 3 had the highest mean percentage survival rate and weekly survival rate of the experimental diets (Table 2, Figure 2). No mortality was recorded in week one, but in week 2 the control had the highest mortality until week 12. The fish fed the control diet had the highest average weight gain, total feed intake, feed efficiency ratio, protein intake, protein efficiency rate, and specific growth rate, but the lowest feed conversion ratio (1.54± 0.00^{d}) and percent survival. It was discovered that fish fed with diet 2 and 3 were not significantly different (p>0.05) in average weight gain and specific growth rate (69±0.58^{c}; 68±0.58^{c} and 5.04±0.01; 5.0±0.02^{c}) respectively but were significant differences (p<0.05) from (compost chicken feather) the control (90±0.58^{b} and 5.35±0.01^{c}). The protein efficiency ratio was highest in the control (1.44±0.01^{a}) followed by diet 3 (1.16±0.00^{b}) while diet 2 recorded the least PER.

Table 2. Growth performance parameter of African catfish fed with experimental diets

Parameters	Experimental Diets			
	Control(FM)	1(CFM)	2(CCH)	3(M)
IML(cm)	15.35±0.35^{a}	15.33±0.33^{a}	15.67±0.33^{a}	15.33±0.33^{a}
IMW(g)	17±0.58^{a}	17±0.58^{a}	17±0.58^{a}	17±0.58^{a}
FMW(g)	204±0.58^{a}	86±0.58^{c}	107±0.58^{b}	85±0.58^{c}
MWG(g)	187.00±0.58^{a}	90±0.58^{b}	69±0.00^{c}	68±0.58^{c}
TFI(g)	253.35±2.52^{a}	127.61±3.65^{b}	154.09±2.42^{b}	142.97±16.08^{b}
FCR	1.35±0.01^{b}	1.85±0.06^{a}	1.71±0.03^{ab}	2.10±0.24^{a}
FCE (%)	73.82±0.63^{a}	57.42±1.78^{bc}	58.43±0.92^{b}	48.66±4.91^{c}
PI	114.01±1.13^{a}	65.66±1.64^{c}	69.34±1.09^{b}	64.34±7.34^{d}
PER	1.64±0.01^{a}	1.20±0.04^{c}	1.30±0.02^{b}	1.08±0.11^{d}
SGR(%/day)	6.22±0.01^{a}	5.04±0.01^{c}	5.35±0.01^{b}	5.01±0.02^{d}
SR (%)	57.14±8.25^{c}	76.19±12.60^{b}	85.71±8.25^{a}	85.71±8.25^{a}

Mean values (mean ± standard error) in the same row with different superscript are significantly different (p<0.05). IML= Initial mean length, IMW= Initial mean weight, FMW= Final mean weight, MWG= Mean weight gain, TMFI= Total mean feed intake, FCR= Feed conversion ratio, FCE Feed conversion efficiency, PI= Protein intake, PER= Protein efficiency ratio, SGR= Specific growth rate, SR= Survival rate

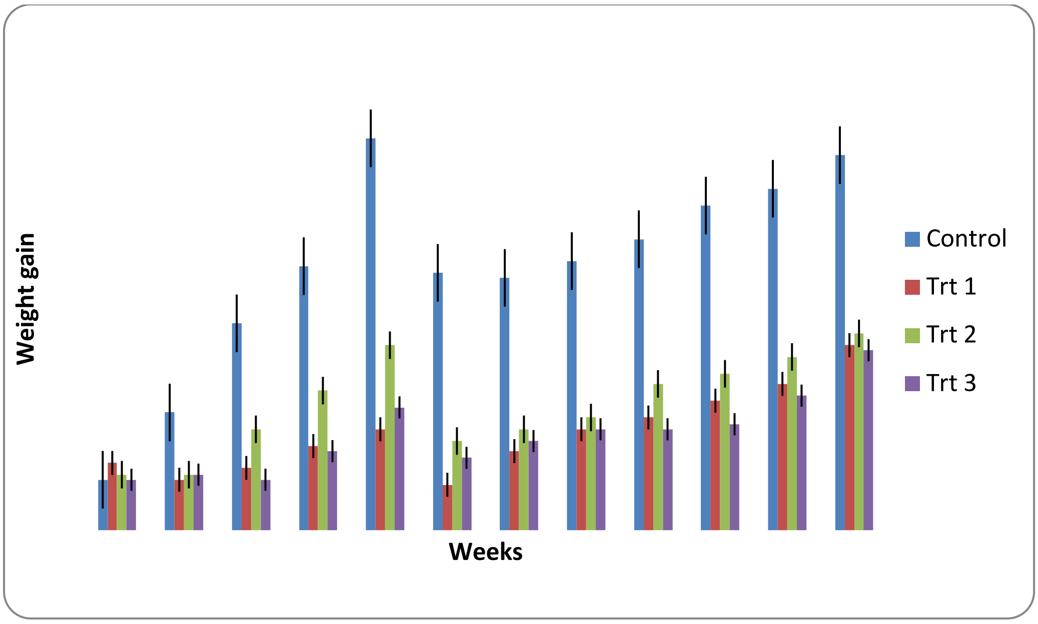

Figure 1. Weekly weight gain during feeding trial of the experimental fish fed the control diet (fishmeal) and the non-conventional feed. Treatment 1 (Trt 1) - compost feather meal, Treatment 2 (Trt 2) - compost cow hoof and Treatment 3 (Trt 3) – equal proportion of compost feather and cow hoof basal diet.

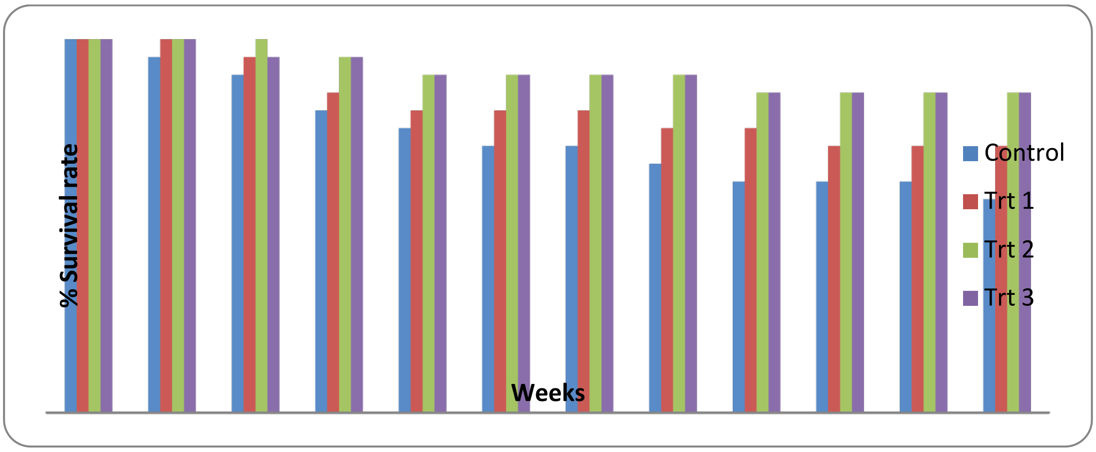

Figure 2. Weekly percentage survivals rate of catfish during the feeding trial fed the control diet (fishmeal) and the non-conventional feed. Treatment 1 (Trt 1) - compost feather meal, Treatment 2 (Trt 2)- compost cow hoof and Treatment 3 (Trt 3) – equal proportion of compost feather and cow hoof basal diet.

Cost-Benefit Analysis of the Conventional and Non-Conventional Feed

The result of the cost-benefit analysis of feed production and growing African catfish given experimental diets is shown in Table 3. The findings demonstrated differences between the dietary groups and the control group. Meanwhile, group 3's net profit index ((₦ 11.62) was higher than group 1 (₦10.98) and the control's (₦3.29), which had the lowest value. However, diet 2 had the highest protein index of ₦13.73. However, the control (fish meal) had the highest cost of feeding ₦148.42, followed by diets 2, 1 and 3 (₦ 20.45, ₦ 25.56 and ₦ 22.85 respectively). The net profit value (₦486.42) of the control was the highest, while diets 2 (compost cow hoof meal), 3 (mixture of compost feather and cow hoof meal), and 1(compost feather meal), had values of ₦ 351, ₦ 265.63, ₦224.47 respectively. The control diet had a higher investment cost (₦323) than the other treatment diets (₦200.56, (₦197.85), and (₦195.45) for diets 2, 1, and 3 respectively). Similarly, the control's gross profit (163.42) was higher than diets 2 ((150.44), 3 (₦67.78), and 1 (₦29.02).

Table 3. Cost Benefit Analysis of the Conventional and Non-Conventional Feed

Parameters (₦)	Groups			
	Control(FM)	1(CFM)	2 (CCH)	3(M)
C/g(Feed)	585.19	160.26	159.37	159.8
C/g (Fish)	0.65	0.65	0.65	0.65
CF	148	20.45	25.56	22.85
PI	3.29	10.98	13.73	11.62
CJS	175	175	175	175
NPV	486.42	224.47	351	265.63
ICA	323	195.45	200.56	197.85
GP	163.42	29.02	150.44	67.78

CF= Cost of feeding, PI= Profit index, CJS= Cost of juveniles stocked, NPV =Net profit value, ICA= Investment cost analysis, GP= Gross Protein and C/g(fish)= cost of fish per g and C/g(feed) = cost of feed per gram

DISCUSSION

Growth Parameters of Fish fed the Experimental Diets

Growth parameters of the dietary treatments showed significant differences. The weekly mean weight gain observed in the control diet was the highest and least in diet 3. The FCR values differed significantly. The control had the least value followed by diet 2, which was slightly different from Bag *et al*. (2012) who investigated the influence of several low-cost unconventional fish feeds. They found no differences (P<0.05) in the feed conversion ratio. This could be a result of the type of diet used in this study. The superior growth in terms of crude protein rather than weight may be due to an increase in lipid deposits in the carcass of fish fed the experimental diet (compost feather meal and cow hoof meal).

Similarly, Ogunji *et al.,* (2006) used mag meal as a replacement of fishmeal in tilapia production and revealed no significant difference in growth parameters, protein utilization, or stress indicators among all feeding groups. In the same vein, Aziza and El-Wahab (2019) evaluated the acceptable level of fishmeal (FM) replacement with different protein sources in *O niloticus* diet and found no significant changes in growth performance.

They came to the conclusion that fishmeal can be replaced with alternative protein sources to the tune of 50% without affecting tilapia growth. Goda *et al.* (2007) reported that when FM was totally replaced (100%) by Blood Meal, *Clarias gariepinus* juveniles' growth, survival, and feed conversion were not affected. The FW and BWG of Nile tilapia did not change when FM was partially replaced with RM. Aziza and El-Wahab, (2019) discovered that using 75% RM may substitute FM protein with no noticeable impact on *O. mossambicus* growth.

In addition, the growth performance of diet I (compost feather meal) decreased significantly. This could be as a result of the processing method adopted in this study because the feather was not a completely powdery texture and some of the shafts were still available. However, it was also observed that feed fortified with compost feathers was accepted for the first three weeks but declined thereafter. Furthermore, it was said that the total replacement of fish meal or soya bean meal by hydrolyzed feather meal impaired fish development and feed efficiency due to the high energy requirement to breakdown keratinous materials, as well as increasing the availability of sulphur amino acid for growth and other metabolic activities.

Similarly, silage produced using lamb hair was substituted in the diet of *Labeo rohita,* Calvalho *et al*., (2014) showed comparable results. They discovered that an increase in the diet with lamb hair silage gave a corresponding increase in FCR. Another study found that while chicken feather silage is high in protein, it is poor in histidine, lysine, and methionine (Choung and Chamberlain 1995). Meanwhile, according to Rachmawati and Samidjan (2019), the fragrance of chicken feather silage reduced the fish's appetite. They stated that a diet containing more than 50% protein may cause fish to lose palpability.

Additionally, Dios, (2001) also conducted a feeding experiment to see if steam-commercial processed feather meal (SPFM) and feathers hydrolyzed enzymatically for 60 and 120 minutes could be utilized as a substitute for fishmeal (FM) in white-shrimp juvenile diets. In terms of weight gain, specific growth rate, food conversion ratio (FCR), and protein efficiency ratio (PER) and found no significant differences. Gunben *et al*. (2014) used chicken feathers but discovered that *Ephinephelus fuscoguttatus* can be used up to 50% of the time. Adewolu *et al.* (2010) evaluated an alternative animal protein mixture at the inclusion of 0% (control), 25%, 50%, 75% and 100% of hydrolyzed feather, chicken offal, and maggot meal in a 4:3:2 ratio as a substitute for fishmeal in the diets of catfish for 56 days. There was no significant ($p>0.05$) between the control diet from fish fed 25–50% diets in feed conversion, weight gain, specific growth rate, and protein efficiency ratio. Whereas fish on 75-100% diets grew significantly slower, indicating that the animal protein mixture used can replace fishmeal with 50% in *C. gariepinus* fingerling diets without causing growth rate problems.

Survival rate

In this study diets 1 (compost feather meal), 2(cow hoof) and 3 (compost feather and cow hoof meal) recorded a higher survival rate than the control. This might be due to the increased growth rate in the conventional feed used, which resulted in cannibalism among the experimental fish. Also, the fish meal that has been stored for a long time is prone to microbial degradation. The high survival rate is not in accordance with the findings of Rachmawati and Samidjan, (2019), who observed no significant change in survival rate when they studied the effect of using chicken feathers instead of fish meal in the feed on the growth of saltwater tilapia fingerlings with a concentration of 0, 12.5, 25, 37.5 and 50 % of chicken feather silage.

Chor *et al*. (2013) also reported similar results on the survival rate using chicken silage feathers. Toutou *et al*., (2018) reported a 92% survival rate, indicating that fish had grown under good experimental conditions. Also, Subhadra *et al.,* (2006) indicate no significant difference in survival rates between Hybrid Striped Bass *(Moronechrysops* and *Moronesaxatilis)* fed on 100% fish meal diets and after its feed was replaced by diets including poultry by-product meals at 45, 70, and 100%. Equally, Arisa *et al*., (2018) detected the lowest survival rate from fish fed a diet of 100% feather meal. Olukunle *et al.* (2002) recorded the lowest survival percentage with 15% inclusion of blood meal with fish meal diet in juvenile catfish *Clarias gariepinus*.

Cost-benefit of the Conventional and Non-conventional Feed

The cost-benefit analysis of the production of feed and rearing of fish with an experimental diet showed that the control had a lower profit index than the other groups. This low-profit index was a result of the amount spent on producing the control diet, particularly the fishmeal, which was bought at 1500 naira per kilogram compared to the other groups, which cost little or nothing.

However, the net profit index, investment cost analysis, and gross profit were highest in the control group. This might be a result of the total weight obtained from the control diet plus the amount sold per kg of feed. Similarly, the investment in the control was the highest compared to the other groups; like group 1, little investment was incurred in producing the experimental diet. Although the gross profit of the control was higher than other diets, group 2 also had a relatively higher gross profit than group 1 and group 3.

CONCLUSION

It is established from the findings that composted cow hooves and feather meal are rich in protein. Feed intake, weight gain, and feed conversion ratio were improved in juvenile *Clarias gariepinus* fed a compost feather meal-based diet and cow hoof-based diet, but were significantly lower than in the control. Juvenile catfish (0-56 weeks) had similar final weights and weight gains, as well as a similar cost-benefit.

Furthermore, the final weight gain, total feed intake, feed efficiency ratio, specific growth rate, and protein efficiency ratio of the conventional feed were all higher than those of the non-conventional feed. However, the feed conversion ratio and the percentage survival rate of the conventional feed were lower compared to the non-conventional feed used for the feeding trial.

The cost of feeding, net profit value, and gross profit was greatest in fish-fed control diets but the lowest profit index. The groups fed on compost cow hoof gave higher values than the other compost feather meals and the mixture in terms of net profit, cost analysis, and gross profit. Both incomes were generated and net profit was reduced with the non-conventional animal protein sources used.

Patents: Not applicable

Author Contribution: Writing- Original draft preparation Reviewing and Editing: Ekinadose Orose, Okechukwu Kenneth Wokeh, Noordiyana Mat Noordin, Roslizawati Ab Lah and Nur Asniza Aziz

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable

Conflicts of Interest: No conflict of interest

References

Ababouch, L., & Fipi, F. (2015). Fisheries and aquaculture in the context of blue economy. *Feeding Africa*, *2*(21–23), 13.

Abdel-Shafy, H. I., & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian journal of petroleum*, *27*(4), 1275-1290

Adewolu, M. A., Ikenweiwe, N. B., & Mulero, S. M. (2010). Evaluation of an animal protein mixture as a replacement for fishmeal in practical diets for fingerlings of *Clarias gariepinus* (Burchell, 1822).*The Israeli Journal of Aquaculture–Bamidgeh*, *62*(4), 237-244.

Adeyemi, J. W. (2020). Dietary replacement of soybean Meal by toasted sunflower seed meal In the diet of *Clarias gariepinus*: Effect on Growth, Body Composition, Digestibility, haematology And Histopathology Of The Liver. *Iraqi Journal of Agricultural Sciences*, *51*(4), 1088-1103.

Akankali, J. A., & Nwafili, S. A. (2015). Management of organic waste impacts on the environment: Utilization as fish feed. *International Journal of Sustainable Development*, *4*(5), 513-528.

Arisa, I. K., Fadli, N., Anwar, A., Nizamuddin, N., & Parmakope, P. (2018). Utilization of organic waste as raw material of fish feed production for African catfish *Clarias gariepinus*. In *IOP Conference Series: Earth and Environmental Science* 216(1): 012035).

Aziza, A., & El-Wahab, A. A. (2019). Impact of partial replacing of dietary fish meal by different protein sources on the growth performance of Nile tilapia (*Oreochromis niloticus*) and whole body composition. *Journal of Applied Sciences*, *19*(5), 384-391.

Bag, M. P., Mahapatra, S. C., Rao, P. S., & Chakrabarty, D. (2012). Evaluation of growth performance of tilapia (*Oreochromis mossambicus*) using low cost fish feed. *International Journal of Biochemistry and Biotechnology*, *1*(4), 150-155.

Calvalho, E. D., Bezzera, D. R., Assis, C. R. D., Bezzera, R. S., Correia, M. T. S., & Coelho, L. C. B. B. (2014). Physiological and Biotechnological Approaches of the Amazonian Tambaqui Fish (*Colossoma macropomum*).

Chor, W. K., Lim, L. S., & Shapawi, R. (2013).Evaluation of feather meal as a dietary protein source for African catfish fry, *Clarias gariepinus*. *Journal of Fisheries and Aquatic Science*, *8*(6), 697.

Choung, J. J., & Chamberlain, D. G. (1995). The effects of intravenous supplements of amino acids on the milk production of dairy cows consuming grass silage and a supplement containing feather meal. *Journal of the Science of Food and Agriculture*, *68*(3), 265-270.

Dios, D. (2001). Fishmeal replacement with feather-enzymatic hydrolyzates co-extruded with soya-bean meal in practical diets for the Pacific white shrimp (*Litopenaeus vannamei*).*Aquaculture Nutrition*, *7*(3), 143-151.

Ekawati, A. W., Yuniarti, A., & Marsoedi, M. (2016). Chicken Feather Silage Meal as a Fish Meal Protein Source Replacement in feed formula Of Pomfret (*Colossoma macropomum*). *Research Journal of Life Science*, *3*(2), 98-108.

FAO (2003). Food energy - methods of analysis and conversion factors.Fao Food Aand Nutrition Paper 77. Report of a Technical Workshop, Rome, 3-6 December 2002.

FAO, 2014.State of World Fisheries and Aquaculture. Rome. pp 223.

FAO. 2019. The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO.

Forbes, S., & Ramkrishnan B. (2019). The USDA National Organic Program and the Effort to Maintain Organic Food Integrity. *Scitech Lawyer*, *15*(2), 10-17.

Goda, A. M., El-Haroun, E. R., & Kabir Chowdhury, M. A. (2007). Effect of totally or partially replacing fish meal by alternative protein sources on growth of African catfish *Clarias gariepinus* (Burchell, 1822) reared in concrete tanks. *Aquaculture Research*, *38*(3), 279-287.

Gunben, E. M., Senoo, S., Yong, A., & Shapawi, R. (2014). High potential of poultry by-product meal as a main protein source in the formulated feeds for a commonly cultured grouper in Malaysia (*Epinephelus fuscoguttatus*). *Sains Malaysiana*, *43*(3), 399-405.

Kaleem, O., & Sabi, A. F. B. S. (2021). Overview of aquaculture systems in Egypt and Nigeria, prospects, potentials, and constraints. *Aquaculture and Fisheries*, *6*(6), 535-547.

Lawal, Muyideen Owonire., Aderolu, Ademola Zaid., Aarode, Oluwaseun Olasunkanmi, Yekinni, Abiodun (2013) Growth and economic performance of *Clarias gariepinus* fed different sources of calcium and phosphorus diets. *Journal of fisheries science.com*, 7(2):187-193

Nugroho, R. A., & Nur, F. M. (2018). Insect-based protein: future promising protein source for fish cultured. *IOP conference series: Earth and Environmental Science,144*, 012002.doi :10.1088/1755-1315/144/1/012002.

Obiero, K., Meulenbroek, P., Drexler, S., Dagne, A., Akoll, P., Of, R., & Waidbacher, H. (2019). The Contribution of Fish to Food and Nutrition Security in Eastern Africa: Emerging Trends and Future Outlooks. *Sustainability*, *11*(6), 1636.

Ogunji JO, Kloas W, Wirth M, Schulz C, Rennert B (2006). Housefly maggot meal: An emerging substitute of fishmeal in Tilapia Diets, Conference on International Agricultural Research for Development. DeuscherTropentag, Stuggart-Hoheheim, Oct 11-13, 2006. pp. 1-7.

Olukunle, O. A., Ogunsanmi, A. O., Taiwo, V. O., & Samuel, A. A. (2002).The nutritional value of cow blood meal and its effects on growth performance, haematology and plasma enzymes of hybrid catfish. *Nigerian Journal of Animal Science*, *5*(1).

Orose, E., Sikoki, F.D. and Vincent_Akpu, I.F (2022). Nutritional quality of Fungi (*Fusarium Spp*) Composted substrates. *IOSR Journal of Agriculyure and Veterinary Science.* 15(10):*0-10*

Orose, Ekinadose; Woke; Godfrey Ngozi and Bekibele, D.O (2018).Growth Response and Survival of Nile Tilapia (*Oreochromis niloticus*) using Steroid Hormone, Animal Testes and Pawpaw Seed based diet. *Nigerian Journal of Fisheries, 15(1): 1336-1341.*

Rachmawati, D., & Samidjan, I. (2019). The effects of chicken feather silage substitution for fish meal in the diet on growth of saline tilapia fingerlings (*Oreochromis niloticus*). In *IOP Conference Series: Earth and Environmental Science*, 246(1), 012015. IOP Publishing.

Rashid, M. H., Hossain, M. T., Mortuza, M. G., & Chowdhury, A. S (2010). Utilization of sunnhemp (*Crotalaria juncea. L*) seed as a protein supplement in fish feed. *Journal Agro for Environment*. 4 (2): 21-24.

Subhadra, B., Lochmann, R., Rawles, S., & Chen, R. (2006). Effect of fish-meal replacement with poultry by-product meal on the growth, tissue composition and hematological parameters of largemouth bass (*Micropterus salmoides*) fed diets containing different lipids. *Aquaculture*, 260(1-4), 221-231.

Suloma, A., El-Husseiny, O. M., Hassane, M. I., Mabroke, R. S., & El-Haroun, E. R. (2014).Complementary responses between hydrolyzed feather meal, fish meal and soybean meal without amino acid supplementation in Nile tilapia (*Oreochromis niloticus*) diets. *Aquaculture international*, 22(4), 1377-1390.

Tesfaye, T., Sithole, B., & Ramjugernath, D. (2017). Valorization of chicken feathers: a review on recycling and recovery route—current status and future prospects. *Clean Technologies and Environmental Policy*, 19(10), 2363-2378.

Toutou, M., Soliman, A. A., E Abd Elnabi, H., E Abouelwafa, A., & M Abdel Rahim, M. (2018). Does feeding African Catfish, *Clarias gariepinus* vinegar-immersed poultry viscera affect its growth performance, hygienic status and pathogenic bacterial load. *Egyptian Journal of Aquatic Biology and Fisheries*, 22(2), 61-76.