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Evaluation of Farm-Made Feeds for Feeding Growers of the African Catfish, Clarias Gariepinus (Burchell, 1822)

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Abstract:
The growth and economic performance of Clarias gariepinus growers (average weight 305.28±2.30g) to farm made feed was evaluated and compared to that of a reference feed (GRD, 6mm Coppens feed). Three farm-made diets were prepared using differently processed soybean with broiler starter feed and bovine blood meal. These were: toasted soybean blend (G1); cracked and cooked soybean blend (G2); and autoclaved soybean blend (G3). The diets were formulated at 38% crude protein level and used to feed the fish. Each treatment was replicated thrice and the experiment lasted for 70 days. The results showed that Fish fed GRD had the best growth rate with SGR of 0.498±0.08, FCR of 1.358±0.25 and PER of 2.299±0.57 followed by the fish fed G1, with SGR of 0.301±0.03, FCR of 2.338±0.26 and PER of 1.891±0.20 while fish fed G3 had the least growth rate with SGR of 0.249±0.03, FCR of 2.879±0.32 and PER of 1.537±0.17. However, the result of the economic evaluation showed that fish fed G1 had the best economic performance with PI of 1.58 and IC of 0.51, followed by the fish fed GRD with PI of 1.50 and IC of 0.53, and the least performance was in fish fed G3 with PI of 1.04 and IC of 0.77.
For profit maximization, G1 which had the best economic performance, with growth rate next to GRD, is considered best for feeding Clarias gariepinus growers.

Keywords: *Farm made, growth, economic performance, clarias gariepinus growers*

1. Introduction

The consumption and demand for fish as a cheap and good quality source of protein is on the increase. FAO (2002) reported that 56% of the world's population derives at least 20% of its animal protein intake from fish, and that some small Island States depend almost exclusively on fish. Natural fish stock in the oceans and fresh waters are on the decline therefore there is heavy reliance on aquaculture to bridge the gap between fish demand and supply as it has the capacity to expand.

A major factor needed for increased growth in the aquaculture sector is feeding. Two sources of fish feeds are identified namely, farm-made aquafeeds and commercial pelleted feeds. Some of these commercial pelleted feeds are imported and are sold at exorbitant prices that sometime double that of the same quantity of locally produced, farm-made feeds. Although the quality of many commercial aquafeeds is very good, the cost is not friendly to farmers and this puts them out of reach of most farmers.

This paper evaluates the growth and economic performance of *Clarias gariepinus* growers fed farm made feeds and compares it with that of fish fed with a commercial feed.

2. Materials and Methods

2.1. Diets Preparation

Ingredients used included soybean, broiler starter feed, bovine blood meal, vitamin/mineral mix and starch. Soybean was purchased from the Oba market, Akure, distributed into three treatment batches and processed in Federal University of Technology, Akure (F.U.T.A.) Fish Farm using three heat processing methods which include: toasting, crack-and-cook and autoclaving.

Toasting: This was carried out by putting sand in a heavy metallic frying pan to a depth of 40 cm and allowed to warm up on kerosene stove to 55^{0}C. At 55^{0}C the seeds were added and toasted for 20mins.

Cracking-and-cooking: Soybean was cracked into 2-5 coarse pieces/seed using a milling machine, the shaft was blown off, and the soybean was cooked for 45 minutes, oven-dried for 24 hours at 40^{0}C and kept for further use.

Autoclaving: This was done by steam-cooking the soybean at 15 Per Square Inch (PSI) in an autoclave for 15 minutes. It was oven-dried for 24hours at 40^{0}C and kept until use.

Fresh cattle blood was collected from the abattoir and processed to blood meal while broiler starter, vitamin/mineral mix and starch were purchased from a feedstuff market in Akure.,

Three farm made diets were prepared at 38% crude protein level using differently processed soybean with broiler starter feed and bovine blood meal (Tables 1 & 2). The formulations were designated as growers-feed 1, 2, 3 (G1, G2 and G3, representing toasted soybean blend (TSB), cracked-and-cooked soybean blend (CSB) and autoclaved soybean blend (ASB) respectively). The feeds were pelleted using a Hobart A120 pelleting machine with a die size of 6mm, sundried at 36^{o}C and kept till use. Coppens® aquafeed of 6mm diameter grains size was used as Growers Reference Diet (GRD).

BS:TSB:BBM	G11:1:0.40
BS:CSB:BBM	G2 1:1:0.35
BS:ASB:BBM	G3 1:1:0.40
African catfish requirements*	38% protein, 12%lipid, 19.0 MJ/KG

Table 1: Farm, Made Feeds Design
** Vanweerd (1995)*
Where: G1-G3=Farm-Made Feeds/ Experimental S Diets: G1= Toasted Soybean Meal Blend, G2= Cracked-and-Cooked Soybean Meal Blend and G3=Autoclaved Soybean Meal Blend
TSB = Toasted Soybean Meal, CSB = Crack-And-Cook Soybean Meal
ASB = Autoclaved Soybean Meal, Bs = Broiler Starter, BBM = Bovine Blood Meal

2.2. Growth Experiment

The experiment was carried out using twelve rectangular glass tanks of dimension 75 x 45 x 30 cm each which was supplied with water from a borehole in the Farm. Clarias gariepinus growers (mean weight 305.28±2.30g) were acclimated to experimental conditions for seven days before the commencement of the experiment and randomly stocked in the glass tanks at 10 fish / tank. The treatments were replicated thrice and the experiment lasted for 70 days. The feed was fed to the fish at 5% of their body weight twice daily at 8.00-9.00h and 15.00-16.00h. Uneaten feed and faeces were siphoned out using a siphoning pipe two hour after feeding. Water quality parameters (temperature and dissolved oxygen (DO)) were measured fortnightly using combined digital DO and temperature meter (YSI model 57) while portable pH meter (Knick Portamess pH meter, Model 912) was used to measure pH. The water was changed weekly during the experimental period in order to minimize pollution. Measurement of fish weight was carried out fortnightly and quantity of feed given was adjusted accordingly.

	Reference Diet (GRD)	**Farm – Made Feeds**		
		G1	G2	G3
Toasted soybean meal (TSB)		417	-	-
Cracked-and-cooked soybean meal(CSB)		-	426	-
Autoclaved soybean meal(ASB)		-	-	417
Bovine blood meal(BBM)		166	148	166
Broiler starter(BS)		417	426	417
Total		1000	1000	1000
[1]Vit./Min. premix		50	50	50
Corn Starch		100	100	100

Table 2: Ingredient Composition of Growers Diet (g/kg)

[1]Each kg contains: Vit. A: 4,000,000IU; Vit. B: 800,000IU; Vit. E: 16,000mg; Vit. K_3: 800mg; Vit. B_1: 600mg; Vit. B_2: 2,000mg; Vit. B_6: 1,600mg; Vit. B_{12}: 8mg; Niacin: 16,000mg; Caplan: 4,000mg; Folic Acid: 400mg; Biotin: 40mg; Antioxidant: 40,000mg; Chlorine chloride: 120,000mg; Manganese: 32,000mg; Iron: 16,000mg; Zinc: 24,000mg; Copper: 32,000mg; Iodine: 320mg; Cobalt: 120mg; Selenium: 800mg manufactured by DSM Nutritional products Europe Limited, Basle, Switzerland.

Growth performance was evaluated as described by Steffens (1989) as follows:

- Weight gain = final weight of fish (W_2)-Initial weight (W_1)
- Specific growth rate (SGR) = $\frac{\text{Log}_e \text{ final weight} - \text{Log}_e \text{ initial weight} \times 100}{\text{Rearing period (Days)}}$

- Protein efficiency ratio (PER) = $\frac{\text{fish weight gain (g)}}{\text{Protein consumed (g)}}$
- Feed conversion ratio (FCR) = $\frac{\text{weight of feed (g)}}{\text{Fish weight gain (g)}}$

2.3. Proximate Analyses

The ingredients, feeds and the experimental fish before and after the experiment were analyzed for proximate composition according to AOAC (2000) in Fisheries and Aquaculture Technology (F.A.T.) Department Nutrition Laboratory, F.U.T.A. Gross energy content was determined in F.A.T. Department Nutrition Laboratory, F.U.T.A. using a Ballistic Bomb Calorimeter (Gallenkamp & Co Ltd, Loughborough, England).

2.4. Economic Performance Evaluation

The economic evaluation of each treatment was carried out using the following information:

- Feed Cost/cost of 1kg feed: Cost of preparation of feed + ingredient based cost
- Feeding Cost: Feeding fish in 12 glass tanks by one man/day at ₦15.00/day
- For 70days = ₦1,050.00
- For each treatment = ₦1,050/4= ₦262.50
- Fish cost: cost of fish growers + transportation
- ₦183.00/fish grower =60 x ₦183.00 = ₦10,980.00
- Transportation cost for 60 growers = ₦500.00
- Fish cost = ₦10,980.00 + ₦500.00 = ₦11,480.00
- For each treatment = ₦11,480.00/4 = ₦2,870.00
- 4. Cost per kg fish = cost of feed consumed x 1000/ weight gain
- Profit index (PI= value of fish/cost of feed) and
- Incidence of cost (IC= Cost of feed/kg of fish produced) models were also used (Vincke, 1969).

2.5. Statistical Analysis

Data obtained were subjected to one way analysis of variance (ANOVA) test ($p<0.05$) to determine the treatment means in the growth data. Duncan's multiple range test was used to characterize and quantify the differences between treatments using SPSS version 20 for Windows.

3. Results

3.1. Proximate Composition of Experimental Diets

Table 3 gives the proximate composition of the diets fed to C. gariepinus growers. The diets were formulated at 38% CP to meet the requirement of C. gariepinus growers (van Weerd, 1995). There were no significant differences ($p>0.05$) in the crude protein, lipid, moisture, energy and NFE contents in the experimental diets but significant differences ($p<0.05$) existed in the ash and crude fibre contents. All the diets were isocaloric (19.03 – 19.10 MJ/kg) and isonitrogenous (37.84 – 38.00 % CP).

Parameters	GRD	G1	G2	G3
Moisture	8.50^a	8.66 ± 0.27^a	8.59 ± 0.62^a	8.96 ± 0.45^a
Ash	9.70^a	9.04 ± 0.56^b	7.97 ± 0.52^c	9.03 ± 0.38^b
Lipid	12.00^a	12.11 ± 0.04^a	12.18 ± 0.31^a	11.84 ± 0.09^a
Crude protein	38.00^a	37.87 ± 0.82^a	37.91 ± 0.79^a	37.84 ± 0.96^a
Crude fibre	4.30^c	5.00 ± 0.41^{ab}	5.49 ± 0.17^a	4.95 ± 0.39^b
NFE	27.50^a	27.32 ± 1.23^a	27.86 ± 0.94^a	27.38 ± 0.77^a
Energy (MJ/kg)	19.10^a	19.03^a	19.05^a	19.04^a

Table 3: Proximate Composition (G/100g Dry Matter) of Diets Fed to C. Gariepinus Growers
Values Are Means of Triplicate Samples Except for GRD and Energy Values
Means along the Same Row Followed by the Same Superscripts Are Not Significantly Different (P>0.05)
Where: GRD = Growers' Reference Diet (6mm Coppens®)
G1-G3= Growers' Experimental Diets 1-3. G1 = Growers' Toasted Soybean Meal Blend
G2= Growers' Cracked-and-Cooked Soybean Meal Blend. G3=Growers' Autoclaved Soybean Meal Blend

3.2. Growth Performance and Nutrients Utilization of C. Gariepinus Growers Fed Farm-Made Feeds

The effect of feeding farm-made feeds using differently processed soybean meal blends on the growth performance and nutrient utilization of C. gariepinus growers is presented in Table 4. There were no significant differences ($p>0.05$) between the initial weights of fish for each experimental diet which means that the weights were similar so there was no bias introduced from the initial weights. There were significant differences ($p<0.05$) in all the parameters determined except initial weight and percentage survival (100%). Fish fed the growers' reference diet (GRD) had the highest value for the final weight (2126.50±110.95), weight gain (626.90±108.16), average daily weight gain (8.956±1.54), specific growth rate (0.498±0.08) and protein efficiency ratio (2.299±0.57), but the lowest value in feed conversion ratio (1.358±0.25). This was followed by G1, then G2 and G3 in that order. In the final weight,

weight gain, average daily weight gain, specific growth rate, protein efficiency ratio and feed conversion ratio, there were significant differences ($p<0.05$) between GRD and all the farm made diets, there were also significant differences between G1 and the remaining diets for values for final weight and weight gain but there were no significant differences ($p>0.05$) between G1, G2 and G3 for the average daily weight gain, specific growth rate, protein efficiency ratio and feed conversion ratio.

Parameters	GRD	G1	G2	G3
Initial wt (g)	1532.60±4.28^a	1530.87±23.51^a	1540.67±9.79^a	1534.43±8.51^a
Final wt (g)	2126.50±110.95^a	1890.10±27.14^b	1840.40±41.73^c	1826.37±22.74^c
Weight gain (g)	626.90±108.16^a	359.23±38.47^b	299.73±50.70^c	291.93±32.28^c
Survival (%)	100.00±00^a	100.00±00^a	100.00±00^a	100.00±00^a
Av. daily wt gain	8.956±1.54^a	5.132±0.55^b	4.282±0.73^b	4.170±0.46^b
SGR	0.498±0.08^a	0.301±0.03^b	0.254±0.05^b	0.249±0.03^b
PER	2.299±0.57^a	1.891±0.20^b	1.577±0.27^b	1.537±0.17^b
FCR	1.358±0.25^b	2.338±0.26^a	2.835±0.49^a	2.879±0.32^a

Table 4: Growth Performance and Nutrient Utilization of C. Gariepinus Growers Fed Farm-Made Feeds
Values Are Means of Triplicate Samples.
Means along the Same Row Followed by the Same Superscripts Are Not Significantly Different (P>0.05)
SGR= Specific Growth Rate; PER=Protein Efficiency Ratio; FCR=Feed Conversion Ratio

3.3. Carcass Analysis for C. Gariepinus Growers Fed Farm-Made Feeds

The whole body composition of C. gariepinus growers fed farm-made feeds is given in Table 5. There were significant differences ($p<0.05$) between the initial and final body compositions of fish during the experiment with respect to crude protein (CP) and lipid. There were no significant variations ($p>0.05$) between the moisture and ash contents in the body of initial and the fish fed the reference diet (GRD), there were also no significant variations ($p>0.05$) in all the parameters tested for fish fed with the farm made diets.

Parameters	Initial	GRD	G1	G2	G3
Moisture	6.71±1.89^a	5.44±0.87^{ab}	3.05±0.39^c	4.07±0.99^{bc}	3.09±0.27^c
Ash	15.63±1.06^a	14.00±1.13^{ab}	11.88±1.17^c	13.20±1.20^{bc}	13.10±0.34^{bc}
Lipid	19.02±0.39^a	16.22±0.80^b	14.12±1.62^c	14.20±0.96^c	13.61±0.64^c
Protein	57.85±1.81^c	64.40±1.04^b	70.75±1.56^a	68.08±1.41^a	70.03±1.46^a

Table 5: Carcass Analysis of C. Gariepinus Growers Fed Farm-Made Feeds
Values Are Means of Triplicate Samples
Means along the Same Row Followed by Same Superscripts Are Not Significantly Different (P>0.05)

3.4. Water Quality Parameters for C. Gariepinus Growers Fed Farm-Made Feeds

Water quality parameters monitored in the experiment are presented in Table 6. Temperature, dissolved oxygen and pH values between 2 weeks interval for GRD ranged from 26.00^{o}C to 26.60^{o}C, 5.80mg/l to 6.20mg/l and 7.28 to 7.90 respectively; those for G1 ranged from 25.90^{o}C to 26.50^{o}C, 5.80mg/l to 6.80mg/l and 7.43 to 7.86 respectively; those for G2 ranged from 26.00^{o}C to 26.50^{o}C, 5.90mg/l to 7.10mg/l and 7.27 to 7.93 respectively; while those for G3 ranged from 26.00^{o}C to 26.50^{o}C, 5.90mg/l to 6.60mg/l and 7.31 to 7.84 respectively. The values were all within the recommended values for fresh water fish (23 -31^{o}C, 4.4 – 8.5mg/l, 6.5 -9 [Boyd, 1979; Landau, 1992]).

Parameters	GRD	G1	G2	G3	Recommended Range*
Temp (^{o}C)	26.25±0.20^a	26.22±0.25^a	26.23±0.20^a	26.23±0.23^a	23 -31
DO (mg/litre)	5.98±0.15^b	6.27±0.38^{ab}	6.43±0.47^a	6.23±0.30^{ab}	4.4 – 8.5
pH	7.60±0.24^a	7.75±0.16^a	7.60±0.22^a	7.58±0.19^a	6.5 -9

Table 6: Water Quality Parameters for C. Gariepinus Growers Fed Farm-Made Feeds
Values Are Means of Triplicate Samples.
Means along the Same Row Followed by Same Superscripts Are Not Significantly Different (P>0.05)
** Boyd (1979); Landau (1992)*

3.5. Growth Rate of C. Gariepinus Growers Fed Farm-Made Feeds

The growth rate of *C. gariepinus* growers fed farm-made feeds is given in Figure 1. The feed with the highest growth rate was the growers' reference diet (GRD) (2126.50±110.95) followed by G1 (1890.10±27.14), then G2 (1840.40±41.73) and lastly, G3 (1826.37±22.74).

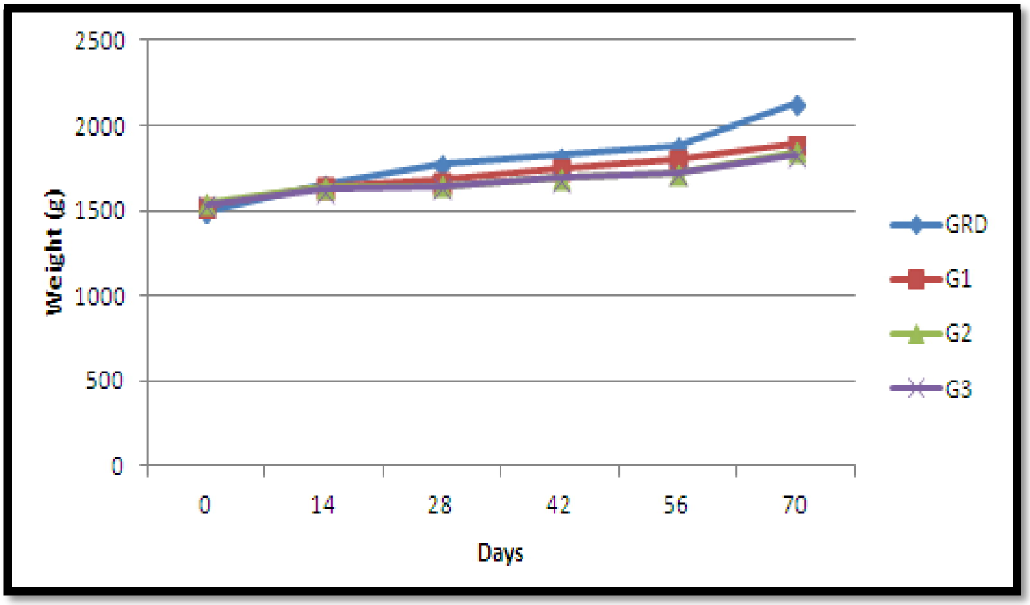

Figure 1: Growth Rate for Growers of C. Gariepinus Fed Farm-Made Feeds

3.6. Economic Analysis of C. Gariepinus Growers Fed Farm-Made Feed

The cost analysis for feeding *C. gariepinus* growers is presented in Table 7. The result showed that the profit index (PI) had the highest value recorded for G1 (1.58) followed by GRD (1.50), G2 (1.29) and G3 (1.04) respectively while the trend of values for incidence of cost (IC) is in the reverse order of PI values.

	GRD (₦)	G1 (₦)	G2 (₦)	G3 (₦)
Toasted Soybean Meal		100.04	-	-
Cracked and cooked Soybean Meal		-	106.12	-
Autoclaved Soybean Meal		-	-	150.04
Bovine Blood Meal		16.60	14.80	16.60
Broiler Starter		41.70	42.60	41.70
Vit./Min. Mix		50.00	50.00	50.00
Starch		10.00	10.00	10.00
1.Cost of 1kg feed	400.00	218.34	223.52	268.34
2. Feeding cost	291.67	291.67	291.67	291.67
3. Fish cost	2,870.00	2,870.00	2,870.00	2,870.00
4.Cost per kg fish	531.71	506.50	621.45	765.99
5.Cost of feed fed	333.33	181.95	186.27	223.62
6.Value of fish	501.52	287.38	239.78	233.54
7.Quantity of fish produced(g)	626.90	359.23	299.73	291.93
8. Profit Index(PI)	1.50	1.58	1.29	1.04
9.Incidence of Cost (IC)	0.53	0.51	0.62	0.77

Table 7: Economic Evaluation of C. Gariepinus Growers Fed Farm-Made Feeds
NB: Market Price of 1kg of Fresh Unprocessed Catfish, C. Gariepinus is averagely ₦800.00
Market Price of 1kg Unprocessed Soybean is ₦120.00
Broiler Starter (BS) is ₦100.00/Kg; Bovine Blood Meal (BBM) is ₦100.00/Kg
Vitamin/Mineral Mix is ₦1,000.00/Kg; Starch is ₦100.00/Kg

4. Discussion

The crude protein level in the diets fed to Clarias gariepinus growers are similar, with values ranging between 37.84% and 38% as recommended for Clarias gariepinus juveniles (van Weerd, 1995). Therefore, no bias has been introduced through the feed formulation and any differences in performance evaluation cannot be ascribed to dietary composition.

The best growth and nutrient utilization were obtained in fish fed the commercial (reference) diet (GRD), followed by the fish fed G1. The reference diet is known to be a fish meal based diet therefore its superior performance may be attributed to the high quality of fish meal used in the feed formulation. However, fishmeal is scarce and expensive, also, the use of wild fish from capture fishery to feed farmed fish places direct pressure on fisheries resources.

Apart from the fish fed the reference diet, fish fed on toasted soybean blend (G1) had the best productivity indices among the farm made diets; all the productivity indices (FW, WG, ADWG, SGR, PER) followed the same trend while the trend for FCR was the reverse of the others. This indicates that toasting made the nutrients in the soybean to be biologically available and nutritionally acceptable to fish. Adeparusi and Jimoh (2002) also reported that toasting was the best processing method in eliminating antinutritional factors of lima bean. The next experimental diet in terms of performance was the cracked-and-cooked soybean blend (G2). This is in contrast to the work of Fagbenro et al. (2007) who found cracking and cooking method as the best method in eliminating the toxic thermostable antinutritional factors present in jackbean seeds, with the jackbean being able to provide 20% of the total dietary protein in Oreochromis niloticus diet when cracked and cooked in distilled water and 30% of the total dietary protein when cracked and cooked in trona solution. The autoclaved soybean blend (G3) had the least performance among the experimental diets, this could be an indication that autoclaving only resulted in partial removal of the antinutrients and the residual effect of the antinutrients resulted in poor utilization of the diet, also Fulmer (1989) reported that moist heat treatment caused lysine destruction and protein denaturation at a much faster rate than dry heat treatment, hence the better performance of the toasted soybean blend than the autoclaved blend. It was reported that farm-made feed is of great importance to aquaculture in Asia. Asia accounts for 84% of global production of finfish and 98% of global production of seaweed; and it is estimated that as much as 90% of Asian finfish production from aquaculture is based on farm-made feeds while the remaining 10% is based on commercial feed, also almost 50% of shrimp production from aquaculture in Asia depend on farm-made feeds (New and Csavas, 1993; De-Silva, 1993).

As at 2007, it was estimated based on interviews with aquaculture stakeholders that 50-60% of freshwater fish farmers are still using farm-made feeds in Myanmar, Malaysia (Wing-Keong, 2007), it was also noted by Fagbenro and Adebayo (2005) that only a few commercially available pelleted fish feeds are available in Nigeria, and these only produce on demand and as such, as much as 69.72% fish feeds produced, are farm-made.

The result of the economic evaluation of feeding farm-made feeds to growers of Clarias gariepinus showed that G1, G2 and G3 had better economic values in terms of cost of 1kg feed and cost of feed fed as costs of production were minimized. G1 has slightly higher PI and lower IC than the fish fed GRD which shows that G1 performed better economically than GRD and that cost could be reduced by feeding growers of Clarias gariepinus with farm-made feed made with toasted soybean and this saved cost could mean rewarding returns to investment and a means of making aquaculture operations sustainable. For profit maximization, G1 which has the best economic performance and productivity indices (FW, WG, ADWG, SGR, FCR and PER) next to GRD is recommended for the feeding of Clarias gariepinus growers.

5. Conclusion and Recommendation

The use of farm made feeds using toasted soybean meal brought about better economic profit in this study and should be considered for the feeding of Clarias gariepinus growers.

It is recommended that the use of farm-made feeds should be greatly encouraged as it facilitates the use of locally available agricultural products and wastes of agro-processing industries that would otherwise have limited use within the community thereby bringing about significant environmental advantages and lowered production cost.

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