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# Growth Performance and Nutrient Utilisation of (*Clarias garienpinus*) Fed with Formulated Diet Produced from a Modified Extruder and Durante Commercial Feed

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author OOK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors OJO and OTA managed the analyses of the study and the literature searches. All the authors read and approved the final manuscript.*

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## ABSTRACT

A fabricated modified single screw fish feed extruder was used to extrude formulated floatable fish feeds from obtainable available feed ingredients. They were fed to 225 *Clarias garienpinus* (mean weight of 56 ± 4.22 g) for 120 days in order to compare their nutritional values with that of a commercial feed. The fishes were first acclimatized for a period of 48 hours under laboratory condition. The weight of the fishes were taken every two weeks and recorded in comparison with

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the commercial feed (Durante) which served as the control. At the end of the feeding trials, the fishes were weighed, sacrificed and analysed for whole body composition, haematological status and proximate analysis. At the end of the feeding trial, Treatment 1 had the highest mean values of growth and nutrient utilization indices on *Clarias garienpinus* at standard deviations of 260.77 g (45.59%), 2.01%, 1.92 and 52.10% for the percentage of weight gained, specific growth rate, feed conversion ratio and feed conversion efficiency of the experimented fishes respectively when compared with the commercial feeds (Control) that had mean values of 416 g (71.36%), 2.18%, 1.20 and 83.33%. Treatment 4 had the lowest weight gained with mean values of 99.67 g (17.77%) 1.67%, 5.02 and 20.00% respectively. The white blood cell of the fishes in Treatment 1 had a high value of 6600 when compared to that of the Control which had a value of 7500. Treatment 1 ($T_1R_1$) experimented on *Clarias garienpinus*, gave the highest values of growth performance and nutrient utilization compared with other treatments in terms of its whole body composition, proximate analysis and haematolgical status. This implies that treatment 1 experimented on *Clarias garienpinus*, was the best and can be used for feeding fishes since their values are closer to that of the control. There was significant differences in the final weight of fish fed with treatment 1, 3 and 4 ($p > 0.05$). However, there was no significant difference in treatments 1 and 2.

*Keywords: Clarias garienpinus; fish feed; extruder; whole body composition; diet; nutrient utilisation.*

## 1. INTRODUCTION

There is a corresponding demand for fish consumption since the population of Nigeria is on the increase. Thus, there is the need for a suitable method of fish feed production to meet the increasing demand for fish. This has also led to increase in market demand for fish leading to the overexploitation of capture fisheries due to overcapacity and over fishing. Hence, there is need for increased aquaculture production to supplement the capture fisheries and solve the market demand of fish and fish products [1]. Depletion of wild fisheries, combined with rising demands for seafood products for human foods, has led to increased aquaculture production during the last several decades. Depending upon the species and maturity, fish have high dietary protein demands of up to 55% [2]. In general, fish possess better efficiency to convert feed into body weight when compared to chickens, pigs, beef cattle, or sheep. In addition, fish are often fed higher percentages of protein in their diets in comparison with other land animals [3].

Fish is one of the cheapest sources of animal protein in Nigeria and constitute about 40% animal protein intakes by the average Nigerian [4]. Consumption of fish provides an important nutrient to a large number of people worldwide and thus makes a very significant contribution to nutrition. Unlike protein supplies from terrestrial sources which are derived mainly from livestock farming, fish supplies are heavily reliant on natural sources [5]. The most reliable source of protein compared with beef is fish, yet millions of people who depend on fish are faced daily with the fear of food shortage [6].

Fish production cost in Nigeria is majorly experienced in two dimensions namely: fish feeding and pond management. The feeding of fish constitutes about 40-60% of the recurrent cost of most intensive fish farming ventures and can sometimes negate the economic viability of a farm if suitable feeds are not used [7]. Feeding of catfish and tilapia fish are seemingly the most challenged species of fish due to the fact that they need adequate feeding for good quality production and feed accuracy. Pond management on the other hand, would have been easier, if the compounded feeds can afloat or even last long in water used for stocking fish rather than disintegrate and hence pollute the water. This makes fish farmers to seek for floating and water stable feeds of high quality and nutritive value to aid adequate production. The feeds satisfying this requirements however, are commercial due to the extrusion technology adopted in producing them. This technology is not readily available and accessible [8].

The species selected to portray yield potential in Africa for aquaculture production are Nile tilapia (*Oreochromis Niloticus*), Common carp (*Cyprinus Carpio*) and African catfish *(Clarias gariepinus*). African catfish*, Clarias gariepinus* is a fresh water fish, but can thrive in brackish water. It is suited in low technology farming system mainly because of its growth rate, efficient use of aquatic foods, propensity to consume a variety of supplementary feeds, omnivorous food habits and tolerance to a wide range of environmental conditions [9].

## 2. MATERIALS AND METHODS

### 2.1 Feeding of *Clarius gariepinus* with The Extrudates

The formulated feeds was extruded using the fabricated single screw extruder shown in Plate 1 and fed to 225 *Clarius gariepinus* juveniles (mean weight of 56 $\pm$ 4.22 g). The fishes were procured from a reputable farm in Akure and acclimatized for a period of 48 hours. This was done under laboratory condition in the Teaching and Research Fish Farm of the Department of Fisheries and Aquaculture Technnology (FAT) of the Federal University of Technology, Akure (FUTA). They were distributed randomly into fifteen (15) transparent plastic tanks (47 cm × 33 cm × 33 cm) containing clean water with 15 juveniles per tank with three replicates per treatment. Water quality parameters were measured and monitored during the experiment. The fish were fed the feed with mean weight of 2 g/bw and was increased to 5 g/bw twice daily i.e. mornings and evenings for 120 days. The weight of the fishes were taken every two weeks and recorded in comparison with the commercial feed (Durante) which served as the control. The fishes were weighed, sacrificed and analysed for whole body composition, haematological status and proximate analysis.

Data obtained, were subjected to test the difference between treatment means by using, Statistical Package for Social Sciences (SPSS) and Duncan Multiple Round Test (DMRT).

**Plate 1. Pictorial view of the modified single screw extruder**

### 2.2 Determination of Whole Body Composition

The whole body composition was calculated using the following formulas according to Simple and Roopma, [10].

#### 2.2.1 Determination of percentage weight gained

$$\%W_G = \frac{Wf-Wi}{Wi} \times 100 \quad (1)$$

Where,

$W_f$ is the final weight of the fish (g) and
$W_i$ is the initial weight of fish (g).

#### 2.2.2 Determination of specific growth rate

$$SGR = \frac{\text{Log}\,(Wf-Wi)}{N} \times 100 \quad (2)$$

Where,

$W_f$ is the final weight of the fish (g),
$W_i$ is the initial weight of fish (g) and
N is the Number of days of experiment.

#### 2.2.3 Determination of feed conversion ratio

$$FCR = \frac{Ff}{WG} \quad (3)$$

Where,

FCR is the Feed Conversion Ratio,
$F_f$ is the Quantity of Feed fed to fish (g) and
$W_G$ is the Gain in weight of fish (g).

#### 2.2.4 Determination of feed conversion efficiency

$$FCE\ (\%) = \frac{WG}{Ff} \times 100 \quad (4)$$

Where,

FCE is the Feed Conversion Efficiency (%),
$F_f$ is the Feed fed (g) and
$W_G$ is the Gain in weight of fish (g).

#### 2.2.5 Determination of proximate analysis and haematological status of the experimented fishes

The proximate analysis and haematological values were measured following standard methods [11].

## 3. RESULTS AND DISCUSSION

### 3.1 Formulations for Fish Feed

The four different diets were extruded from the designed and modified extruder and were evaluated as shown in Table 1. After evaluation, comparative analyses were carried out with the diets, using the widely accepted imported feed, DURANTE as the control for 120 days.

### 3.1 Effect of the Extruded and Commercial Feed on the Whole Body Composition of the Experimented Fishes

The final weight of *Clarias garienpinus* juveniles fed with the floating feed produced from a fabricated modified single screw extruder on four different treatments ranged between 317.97 ± 37.5 g and 155.77 ± 31.6 g which is in line with Fagbenro and Adebayo [12]. Table 1 shows the different diets made for four treatments that were extruded and fed to fishes. Table 2, shows that $T_1R_1$ had the highest values of 300.9 g (54.71%), 2.07%, 1.66 and 60.18% for the percentage of weight gained, specific growth rate, feed conversion ratio and feed conversion efficiency of the experimented fishes at the end of 120 days respectively when compared with the imported feeds (Control) that had values of 421.7 g (71.48%), 2.19%, 1.19 and 84.24% while $T_4R_2$ had the lowest weight gained with values of 68.5 g (12.30%) 1.53%, 7.30 and 13.70% respectively. This implies that the extruded feed used in $T_1R_1$ can be used for feeding fishes since their values are closer to the one for the control.

Table 3, showing the mean growth of nutrient utilization indices of *Clarias garienpinus* at standard deviations at the end of 120 days with the highest mean weight gained for the catfish fed with the experimental diet to be 260.77 g for Treatment 1 while the lowest mean weight gained was 99.67 g for Treatment 4. For the Control, the highest mean weight gained for the fish was 416g. Treatment 1 had the highest mean values of 260.77 g (45.59%), 2.01%, 1.92 and 52.10% for the percentage of weight gained, specific growth rate, feed conversion ratio and feed conversion efficiency of the experimented fishes at the end of the feeding trials respectively when compared with the commercial feeds (Control) that had mean values of 416 g (71.36%), 2.18%, 1.20 and 83.33% while Treatment 4 had the lowest weight gained with mean values of 99.67 g (17.77%) 1.67%, 5.02 and 20.00% respectively. In the investigation of the growth parameters of the fish samples in this study, it was very apparent in the values recorded that treatment 1 gave the best growth performance and nutrient utilization compared with other treatments.

There was significant difference in the final weight of fish fed with treatments 1, 3 and 4 ($p > 0.05$). However, there was no significant difference in treatments 1 and 2.

### 3.2 Haematological Status of the Experimented Fishes

The Haematological values were measured following standard methods [11]. Fig. 1 shows the haematological status of the experimented fish fed on the four diets For the mean haematological status of the experimented fish, it was observed that the white blood cell of the fishes in Treatment 1 had a high value of 6600 when compared to that of the Control which had a value of 7500 as shown in Table 4. The mean haematology parameters obtained in this report showed that the values of the haematocrit, red blood cells, white blood count and haemoglobin are within the ranges reported by Akinrotimi et al., [13] which can be seen Table 4.

**Table 1. Different formulations for fish feed**

| Feed Ingredients | Diet 1(g) | Diet 2(g) | Diet 3(g) | Diet 4(g) |
|---|---|---|---|---|
| Fish Meal | 20 | 21 | 21 | 23 |
| Soya bean Meal | 16 | 17 | 19 | 19 |
| Groundnut Cake | 19 | 19 | 19 | 18 |
| Yellow Maize | 34 | 32 | 30 | 29 |
| Vegetable Oil | 3.0 | 3.0 | 3.0 | 3.0 |
| Starch | 2.0 | 2.0 | 2.0 | 2.0 |
| Lysine | 0.5 | 0.5 | 0.5 | 0.5 |
| Methionine | 0.5 | 0.5 | 0.5 | 0.5 |
| Bone Meal | 3.0 | 3.0 | 3.0 | 3.0 |
| Vitamin/Mineral Premix | 2.0 | 2.0 | 2.0 | 2.0 |
| **Total** | **100** | **100** | **100** | **100** |

**Table 2. Whole body composition of (*Clarias garienpinus*) for 120 days**

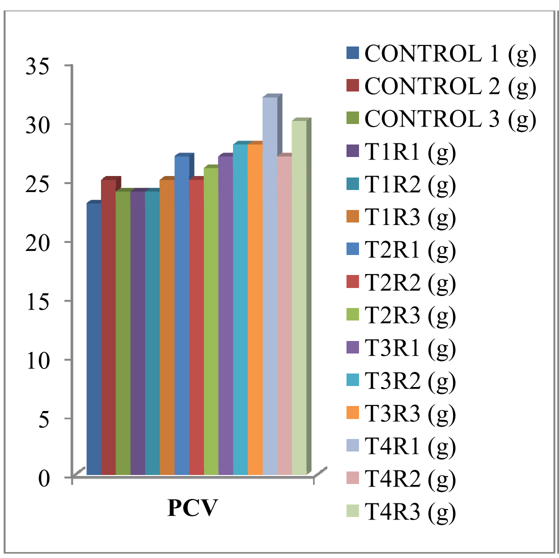
| Treatments | $W_f$ | $W_i$ | $W_f$ - $W_i$ | Log ($W_f$ - $W_i$) | %$W_G$ | % SGR | FCR | % FCE |
|---|---|---|---|---|---|---|---|---|
| CONTROL 1 (g) | 468.0 | 56.5 | 411.5 | 2.61 | 72.83 | 2.16 | 1.22 | 82.30 |
| CONTROL 2 (g) | 480.7 | 59.0 | 421.7 | 2.63 | 71.48 | 2.19 | 1.19 | 84.34 |
| CONTROL 3 (g) | 474.2 | 58.0 | 416.2 | 2.62 | 71.76 | 2.18 | 1.20 | 83.24 |
| $T_1R_1$ (g) | 355.9 | 55.0 | 300.9 | 2.48 | 54.71 | 2.07 | 1.66 | 60.18 |
| $T_1R_2$ (g) | 317.5 | 59.4 | 258.1 | 2.41 | 43.45 | 2.01 | 1.94 | 51.62 |
| $T_1R_3$ (g) | 280.5 | 57.2 | 223.3 | 2.35 | 30.04 | 1.96 | 2.24 | 44.66 |
| $T_2R_1$ (g) | 290.0 | 58.1 | 231.9 | 2.37 | 39.91 | 1.97 | 2.16 | 46.38 |
| $T_2R_2$ (g) | 278.8 | 56.4 | 222.4 | 2.35 | 39.43 | 1.96 | 2.25 | 44.48 |
| $T_2R_3$ (g) | 270.8 | 58.3 | 212.5 | 2.33 | 36.45 | 1.94 | 2.35 | 42.50 |
| $T_3R_1$ (g) | 205.7 | 58.6 | 147.1 | 2.17 | 25.10 | 1.81 | 3.40 | 29.42 |
| $T_3R_2$ (g) | 225.0 | 56.1 | 168.9 | 2.23 | 30.11 | 1.86 | 2.96 | 33.78 |
| $T_3R_3$ (g) | 204.7 | 57.4 | 147.3 | 2.17 | 25.66 | 1.81 | 3.39 | 29.46 |
| $T_4R_1$ (g) | 192.5 | 56.1 | 139.4 | 2.14 | 24.85 | 1.79 | 3.59 | 27.88 |
| $T_4R_2$ (g) | 124.2 | 55.7 | 68.5 | 1.84 | 12.30 | 1.53 | 7.30 | 13.70 |
| $T_4R_3$ (g) | 150.6 | 56.5 | 94.1 | 1.97 | 16.65 | 1.65 | 5.31 | 18.82 |

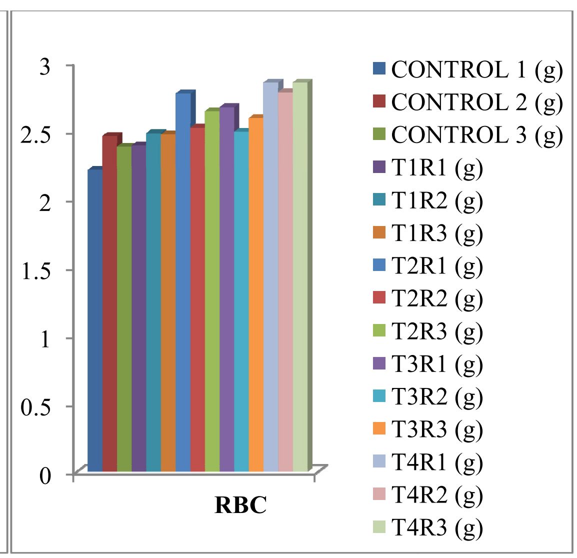
*Legends: $W_G$ is the percentage weight gained, % SGR is the Specific Growth Rate in percentage, FCR is the Feed Conversion Ratio, % FCE is the Feed Conversion Efficiency in percentage, $W_i$ is the initial weight of the fish and $W_f$ is the final weight of the fish*

**Table 3. Mean growth of nutrient utilization indices of *Clarias garienpinus***

| Parameters | Control | Treatments | | | |
|---|---|---|---|---|---|
| | | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
| Mean Initial Weight ($W_i$) (g) | 58.3 ± 1.2 | 57.2 ± 2.2 | 57.6 ± 1.2 | 57.4 ± 1.3 | 56.1 ± 1.1 |
| Mean Final Weight ($W_f$) (g) | 474.3 ± 2.6 | 317.97 ± 37.5 | 279.87 ± 9.1 | 211.33 ± 6.6 | 155.77 ± 31.6 |
| $W_f$ - $W_i$ (g) | 416 | 260.77 | 222.27 | 153.93 | 99.67 |
| % $W_G$ | 71.36 | 45.59 | 38,59 | 26,82 | 17.77 |
| % SGR | 2.18 | 2.01 | 1.96 | 1.82 | 1.67 |
| FCR | 1.20 | 1.92 | 2.25 | 3.25 | 5.02 |
| % FCE | 83.33 | 52.10 | 44.44 | 30.77 | 20.00 |

*Legends: $W_G$ is the percentage weight gained, % SGR is the Specific Growth Rate in percentage, FCR is the Feed Conversion Ratio, % FCE is the Feed Conversion Efficiency in percentage, $W_i$ is the initial weight of the fish and $W_f$ is the final weight of the fish*



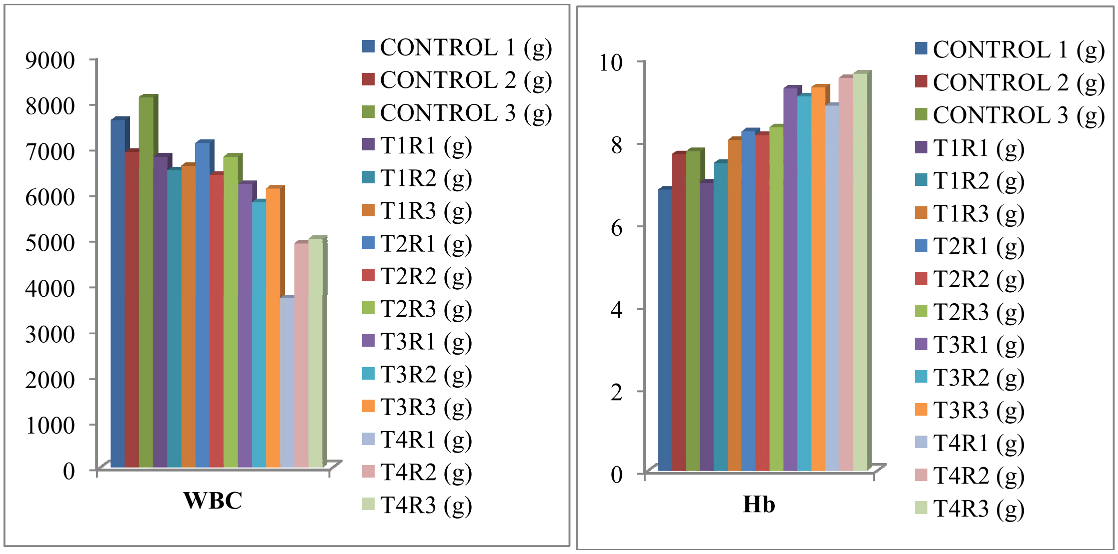



**Fig. 1. Haematological status of the experimented fish**

*Legends: PCV = Packed Cell Volume; RBC = Red Blood Cell; Hb = Haemoglobin; WBC = White Blood Cell*

**Table 4. Mean haematological status of the experimented fish**

| Parameters | Control | Treatments | | | |
|---|---|---|---|---|---|
| | | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
| PCV | 24 ± 1.0 | 24.33 ± 0.7 | 26 ± 1.0 | 27.67 ± 0.3 | 29.67 ± 0.3 |
| RBC | 2.35 ± 0.12 | 2.45 ± 0.04 | 2.64 ± 0.0 | 2.58 ± 0.05 | 2.83 ± 0.03 |
| Hb | 7.42 ± 0.43 | 7.49 ± 0.5 | 8.13 ± 0.1 | 9.22 ± 0.14 | 9.34 ± 0.29 |
| WBC | 7500 | 6600 | 6700 | 6000 | 4500 |

*Legends: PCV = Packed Cell Volume; RBC = Red Blood Cell; Hb = Haemoglobin; WBC = White Blood Cell*

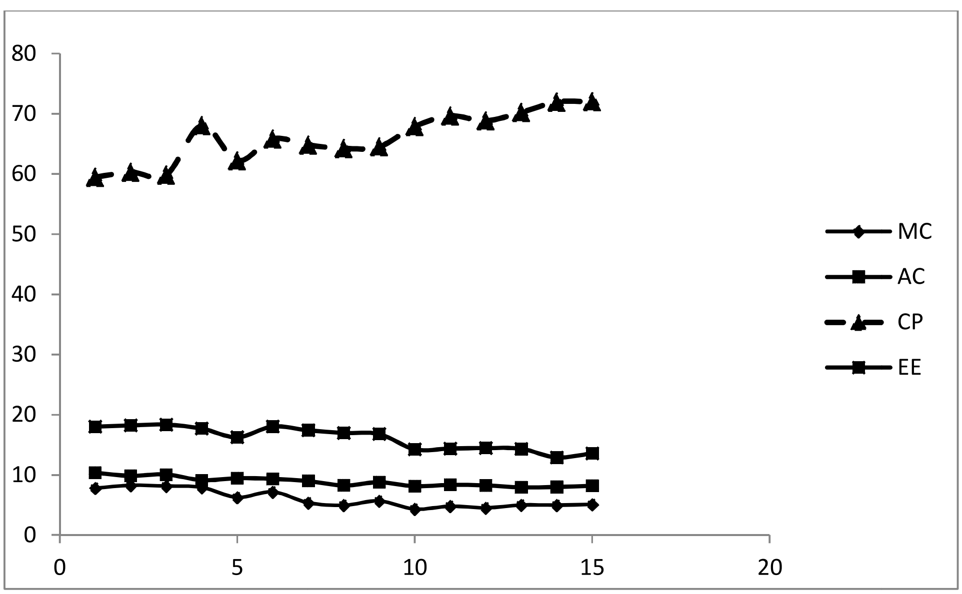



**Fig. 2. Proximate analysis of the experimented fish**

**Table 5. Mean proximate analysis of the experimented fish**

| Parameters | Control | Treatments | | | |
|---|---|---|---|---|---|
| | | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 |
| **Mineral Content** | 8.079 | 7.130 | 5.345 | 4.566 | 5.039 |
| **Ash Content** | 10.085 | 9.295 | 8.658 | 8.237 | 8.035 |
| **Crude Protein** | 59.871 | 65.364 | 64.532 | 68.799 | 71.405 |
| **Ether Extract** | 18.198 | 17.338 | 17.055 | 14.355 | 13.600 |

*Legends: MC = Mineral Content; AC = Ash Content; CP = Crude Protein; EE = Ether Extract*

### 3.3 Proximate Analysis of the Experimented Fish

The profile of the proximate analysis of the experimental fish fed for 120 days showed a significant increase in nutritional value in terms of crude protein of the fish fed with experimental diets above the commercially produced pelletized feeds used in the control diets as shown in Fig. 2. The moisture content was analyzed on dry matter basis and this reflects the available moisture absorbed during the analysis, even though it was stored in desiccators. The analysis of the experimental fish carcass showed that the experimental diets had a direct effect on the flesh yield and significant feed conversion ratio. The procedure described by FAO [14] was followed to ensure good production turn over. The improvement of experimental diets over the commercial could be attributed to freshness of the product and the efforts taken initially to determine the proximate composition of the ingredients before the formulation. This practice ensures that the actual value of the nutrients in each ingredient was determined before compounding the feed. This also ensures accuracy in the formulation. Variations in feed ingredients might occur due to regionalism and seasonality in availability of the ingredients [15].

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Conclusion

A fabricated modified single screw fish feed extruder was used to extrude formulated fish feed from obtainable available materials. The extrudates were fed to *Clarias garienpinus* for 120 days comparing it`s nutritional values with that of a commercial feed (Durante) while whole body compositon, proximate analysis and haematolgical status of the fishes were carried out. In the investigation of the growth parameters of the fish samples in this study, it was very apparent in the values recorded that treatment 1 ($T_1R_1$) experimented on *Clarias garienpinus*, gave the best growth performance and nutrient utilization compared with other treatments in terms of its whole body composition, proximate analysis and haematolgical status. This implies that the extruded feed used in Treatment 1 can be used for feeding fishes since their values are closer to the one for the control. There were significant differences in the final weight of fish fed with treatment 1, 3 and 4 ($p > 0.05$). However, there was no significant difference in treatment 1 and 2.

### 4.2 Recommendation

Based on the findings, of the extrudates on *Clarias garienpinus* comparing it with commercial feed, the following recommendation therefore are made:

i. The feed used in treatment 1 ($T_1R_1$) experimented on *Clarias garienpinus*, gave the best growth performance and nutrient utilization compared with other treatments in terms of its whole body composition, proximate analysis and haematolgical status and should be used for the rearing of African catfish, *Clarias garienpinus.*
ii. There is the need for feed manufacturers to provide information on gross composition of fish feeds which should be used by farmers to choose the best feed for their fish production.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Safina MM, Christopher MA, Charles CN, Rodrick K. The effect of three different feed types on growth performance and survival of African catfish fry (*Clarias gariepinus*) reared in a hatchery ISRN zoology. 2013;2012(2012)Article ID 861364:6. Available:http://dx.doi.org/10.5402/2012/861364.
2. Ayadi FY, Fallahi P, Rosentrater KA, Muthukumarappan K. Modeling single

screw extrusion processing parameters and resulting extrudate properties of DDGS-based nile tilapia (*Oreochromis niloticus*). Feeds. Journal of Food Research. 2013;2(2).
ISSN 1927-0887, E-ISSN 1927-0895
Published by Canadian Center of Science and Education11.
Available:www.ccsenet.org/jfr

3. Sankaranandh K, Kasiviswanathan M, Rosentrater KA. Effect of starch sources and protein content on extruded aquaculture feed containing DDGS food bioprocess technology; 2009.
DOI: 10.1007/s11947-008-0177-4
4. Azam K, Ali MY, Asaduzz AM, Basher MZ, Hussain MM. Biochemical assessment of selected fresh fish. J. Bio.Sci. 2004;4:9-10.
5. Nyina-Wamwiza L, Wathelet B, Richir J, RollinX,KestemontP.Partialortotal replacement of fish meal by local agricultural by-products in diets of juvenile African catfish (*Clarias gariepinus*). Growth performance, feed efficiency and digestibility. Aquaculture Nutrition. 2010;16(3):237–247.
6. World Fish Centre (WFC). Fish: an issue for everyone. A Concept Paper for Fish for all Summit. 2003;10.
7. NRC (National Research Council). Nutrient Requirements of Fish. Washington D.C. National Academy Press; 1993.
Available:http://www.nap.edu/openbook.php?record_id=2115andpage=1#
8. Gabriel UU, Akinrotimi OA, Bekibele DO, Onunkwo DN, Anyanwu PE. Locally produced fish feed: Potentials for aquaculture development in sub-Saharan Africa. Department of Fisheries and Aquatic Environment, Rivers State University of Science and Technology, P.M.B 5080, Port Harcourt, Nigeria. African Journal of Agricultural Research. 2007;2(7):287-295.
Available:http://www.academicjournals.org/AJAR. ISSN 1991- 637X © 2007 Academic Journals.
9. Anyanwu DC. Fishing and fish production in the tropics: An overview. Cel-Bez & Co., Owerri, Imo State, Nigeria. 2015;143.
10. Simple S, Roopma G. Growth response and feed conversion efficiency of *Tor putitora* (Ham.) fry at varying dietary protein levels. Department of Zoology, University of Jammu, Jammu (J and K) 180006, India Pakistan Journal of Nutrition 2010;9(1):86-90.
ISSN 1680-5194
11. Joshi PK, Bose M, Harish D. Haematological changes in the blood of Clarias batrachus exposed to mercuric chloride. Eco toxicological Environmental Monitoring. 2002c;12(2):119-122.
12. Fagbenro OA, Adebayo OT. A review of the animal and aquafeed industries in Nigeria. In: A synthesis of the formulated animal and aquafeed industry in sub-Saharan Africa. (John Moel & Matthias Halwart, editors). CIFA Occasional Paper No. 26, FAO, Rome. 2005;61:25-36.
13. Akinrotimi OA, Bekibele DO, Orokotan OO. Select hematological values of the African catfish (*Clarias gariepinus*) raised in a Water Recirculating Aquaculture System African Regional Aquaculture Centre Nigeria Institute for Oceanography and Marine Research P.M.B. 5122, Port Harcourt, Rivers State, Nigeria. Gabrovic Agriculture Nigeria Limited, Fishery Consultancy Services 100 East-West Road, Eliozu Junction, Port Harcourt, Rivers State, Nigeria; 2011.
14. FAO. FAO Global Aquaculture Production Volume and Value Statistics Database. FAO Fisheries and Aquaculture Department. 2014;1-4.
15. Opiyo MA, Ngugi CC, Rasowo J. Combined effects of stocking density and background colour on growth performance and survival of nile tilapia (*Oreochromis niloticus*, L.) Fry reared in aquaria. Kenya Marine and Fisheries Research Institute, National Aquaculture Research Development & Training Centre Sagana, Kenya. Journal of Fisheries Sciences. ISSN 1307. 2014;8(3):228-237.
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