

Original Research Article

EFFECTS OF VARYING PROTEIN LEVELS ON GROWTH, PROTEIN UTILIZATION AND YIELD OF THE AFRICAN CATFISH *Clarias gariepinus* (BURCHELL, 1822) ~~GROWTH, PROTEIN UTILIZATION AND YIELD~~ IN HAPA SYSTEM

ABSTRACT

The study evaluated effects of varying dietary protein levels on growth, protein utilization, survival and yield of the African catfish *Clarias gariepinus* using floating hapa (1m x 1m x 1m) system. Fish fingerlings (4.50± 0.01g) were randomly stocked at 20 fish/m³ hapa. Five diets with protein levels 40.0, 42.5, 45.0, 47.5 and 50.0% were fed to triplicate groups for 24 weeks. Growth responses and economic performances of fish harvested under various treatments were evaluated. Results showed that no significant differences ($p > 0.05$) were observed in metabolic growth rate, percentage survival, total feed intake, cost of feeding and total cost of production in all the treatments. However, significant differences ($p < 0.05$) existed in specific growth rates, gross profit, profit index and economic conversion ratio. The preferential diet being 42.5% protein, produced the highest best growth {mean final weight (946.89g), specific growth rate (3.21%/day), ~~the best protein utilization~~ {food conversion ratio (0.27), protein productive value (59.55%), protein index (5.29g/day), the highest yield {net fish production (17,850kg/hapa), gross profit (~~4~~4,774/hapa) and the best economic conversion ratio (58.98). From these results, *Clarias gariepinus* would grow best in floating hapa when fed diets containing 42.5% protein.

Key Words: Catfish, dietary protein, growth, survival, yield, profit index

INTRODUCTION

The African catfish, *Clarias gariepinus* is an omnivorous species that is indigenous to Africa and one of the most cultured species in sub Saharan Africa. It has been shown to have remarkable growth rate as well as high quality meat and excellent taste, hence, of great demand and commands good commercial value in Nigeria market (Adewolu *et al.*, 2009). However, sufficient nutritional research has not been carried out on this economic species, thus, hindering the viability of commercial production in non-conventional culture system. Dietary protein has been appraised as the body block building nutrients and given the most prominent consideration in the formulation of fish feeds. Protein requirement of other catfish groups had been reported. Fagbenro *et al.* (1992) reported 42.5% dietary protein requirement for genetically induced hybrid catfish. Olufeagba and Aluko (1997) recommended 45% for triploid catfish while Jamabo and Alfred-Ockiya (2008) opined that 40% protein produced the best growth in *Heterobranchus bidorsalis*. However, NRC (1993) recommended between 38 and 55% for catfish culture in general. The present study has been designed to determine a proper dose response relationship regarding catfish growth and yield in floating net-hapa system for maximum profitability.

Comment [VOE1]: Mention the total number of fish used and the number of hapa. Also, where was the hapa placed?

Comment [VOE2]: You did not mention this in your topic. What about protein utilization and yeield?

Comment [VOE3]: Protein utilization could be evaluated using protein intake, protein efficiency ratio (PER) etc and not FCR. FCR is a measure of the total feed consumed to biomass. Also, 0.27 obtained for FCR here is too low. Re-calculate your FCR.

Comment [VOE4]: Sub-Saharan

Comment [VOE5]: Several studies have been carried out on the economics of this species such as studies conducted by Ugwumba & Chukwuji (2010). Therefore, provide information on what has been done.

Comment [VOE6]: Building block of body nutrients

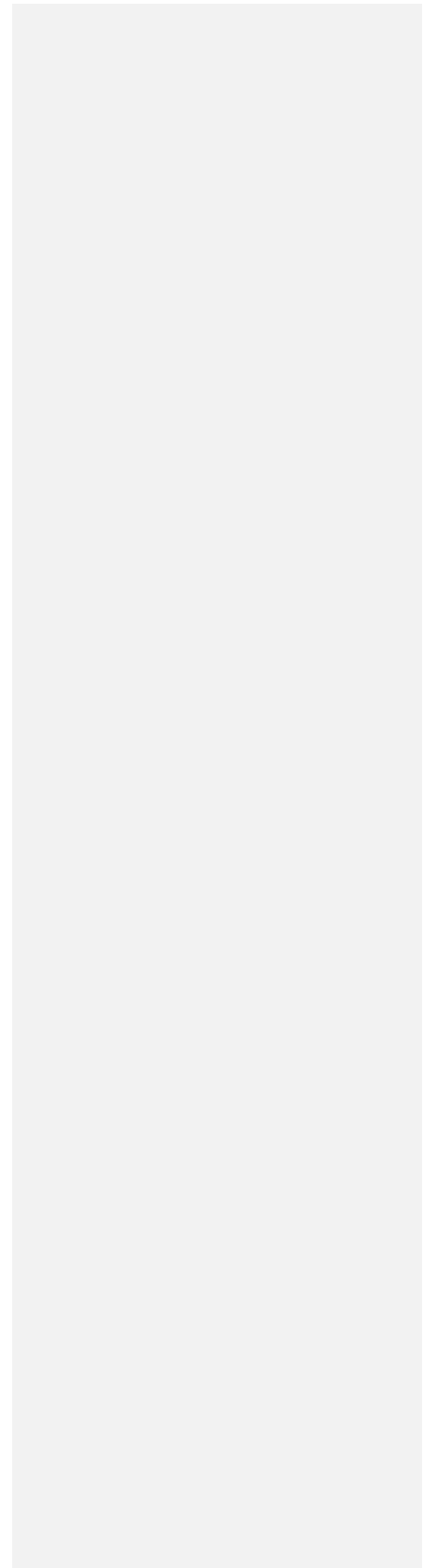
Comment [VOE7]: What about the protein requirement of *Clarias gariepinus*? there are numerous report on this and should be mentioned.

Comment [VOE8]: The objective of this study is to determine the effects of varying crude protein levels on the growth, protein utilization and yield of *C. gariepinus* in floating net-hapa system.

UNDER PEER REVIEW

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44 MATERIALS AND METHODS

45 Experimental design

46 An outdoor concrete tank (8m x 5m x 1.65m) at Vika Farms Limited, Mbak Etoi, Uyo, Akwa Ibom State, located at latitude 5° North and longitude 7° East was used for the study. The experimental design was made up of a module consisting of 8.5m x 6.5m bamboo raft with sixteen 1.5m x 1.5m apartment fittable with 1m x 1m x 1m hapa placed on the concrete tank. Each hapa was rigged and suspended to maintain a depth of 0.75m in water and a free board of 0.25m. The float lines were tied to the four corners of each compartment using kuralon rope (No 52 15) as described by Otubusin (2000).
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54 **Diets preparation:** Diet compositions for the feeding trial are presented in Table 1. All ingredients were carefully weighed out, mixed, made into pellets using 2mm meat mincer, air dried and labelled separately according to diets.

57 Table 1: Ingredients (%/100g) and proximate composition (%) of experimental diets

Ingredients	40.0%	42.5%	45.0%	47.5%	50.0%
Fishmeal	17.21	18.60	20.00	21.53	3.06
Soy meal	17.20	18.60	20.00	21.53	3.06
Corn flour	23.97	18.20	12.43	06.75	01.12
Groundnut cake	34.51	37.50	40.46	43.10	45.66
Fish oil	07.00	07.00	07.00	07.00	07.00
Lysine	0.030	0.030	0.030	0.030	0.030
Methionine	0.030	0.030	0.030	0.030	0.030
Fish premix	0.030	0.030	0.030	0.030	0.030
Analyzed protein level	38.83	40.05	43.43	45.01	48.25
Analyzed lipid level	8.38	8.40	8.64	8.75	8.87
Gross energy (kJ/g)	17.27	17.24	17.38	17.36	17.55

Comment [VOE9]: This is wrong. Write the geographical location correctly.

Comment [VOE10]: Five crude protein levels in triplicate will give fifteen hapa units, then why sixteen? Were all the hapa place in one concrete tank?

Comment [VOE11]: Provide information on the material used in constructing the hapa.

Comment [VOE12]: How many diets were formulated and which method was used in diet formulation? Label the diets for easy identification i.e. Diet A (40.0 % cp), Diet B (42.5 % cp)..... to Diet E (50.0 % cp). You have to mention the method used and mention the ingredients used. Give details of how you prepared the diets, i.e. ingredients processing, weighing, mixing, pelleting, drying etc. How did you obtained values for analyzed protein and lipid level in Table 1? If it was through proximate analysis of the diets, then state where it was carried out and the method used.

Comment [VOE13]: Draw the line across the row not underline. It will be very clear if diets are labeled as Diet A (40.0 % cp), Diet B (42.5 % cp) to Diet E (50.0 % cp) etc.

Comment [VOE14]: Which method did you use in these calculation? Re-calculate these values again

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59
60 **Fingerling Rearing:** Each hapa was randomly stocked with *Clarias gariepinus* (4.50±0.01g) at 20 fish/4m³hapa and raised for 24 weeks. The stocked fish were fed at 5% of their body weight three times daily. The stocked fish (20%) were sampled fortnightly. Fish weights were measured using a Furi Digital Balance (Model: FEJ-6000) to the nearest 0.1g.
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65 Growth determination

66 Mean weight gain (MWG) (g) = final weight (g) – initial weight (g)

67 Average daily growth (ADG) = MWG (g)/length of feeding trial (days)

68 Relative growth rate (RGR) = 100[MWG (g)/mean final weight (g)]

69 Metabolic growth rate (MGR) = $(W_1 - W_0) / [\{(W_0/1000)^{0.8} + (W_1/1000)^{0.8}\} / 2]t$

70 Where: W_0 = initial weight (g); W_1 = final weight (g); t= duration of feeding trial (days)

Comment [VOE15]: After stocking, the fish should be acclimated for about fourteen days prior to start of the experiment. Move this section to experimental design section

71 Specific growth rate (SGR, %/day) = $100(\ln W_2 - \ln W_1) / (T_2 - T_1)$ 72 Where: W_2 = Weight at time
73 T_2 ; W_1 = Weight at time T_1

Comment [VOE16]: Give authority for these formulas

74 **Feed and protein utilization determination**

75 Feed conversion ratio (FCR) = Total dry feed fed (g)/MWG (g)

76 Protein efficiency ratio (PER) = MWG (g)/amount of protein fed (g)

Protein productive value (PPV) = 100[(final fish carcass protein- initial carcass protein)/ Crude protein intake]

Protein index (PI) = Survival (W₁-W₀)/t

Nitrogen metabolism (NM) = [0.54(W₁-W₀)/t]/2

Where: 0.54 is experimental constant; W₁= Fish final weight (g); W₀ = Fish initial weight (g); t = duration of feeding trial (days)

Percentage survival rate (%SR) = 100(number at end of feeding trial/number at start of feeding trial).

Comment [VOE17]: Number of what?

Comment [VOE18]: Give Authority for these formulas.

Economic Analysis

Cost of feeding (COF) = Price of feed x total feed intake

Profit index (PI) = Value of fish (₦)/cost of feed (₦)

Economic conversion ratio (ECR) = Cost of diet x FCR

Comment [VOE19]: Give Authority. When was the economic analysis carried out? Which year? Price of ingredients fluctuate especially with the fluctuating Nigerian economy so the year of evaluation is very important and should be mentioned.

Data Analysis

Data analysis was analyses were carried out using Statistical Package for Social Sciences (SPSS 19.0, 2010 version). Effect with a probability of P<0.05 were considered significant.

Comment [VOE20]: No Post Hoc test?

Results

The results of growth performances and survival rates of *Clarias gariepinus* fed diets containing different protein levels for 24 weeks are shown in Table 2. From the results, all the growth indices were highest in diet containing 42.5% protein. There were no significant differences (p > 0.05) in metabolic growth in all the treatments. Fish fed Diet B (42.5% cp) with the 42.5% protein diet had the best growth performance (p < 0.05), with a mean weight gain of 942.38±2.33g, average daily growth of 5.88g/day and relative growth rate of 218.85±0.58. The least weight gain (769.13±2.29g) and poorest specific growth rate (3.15±0.00%/day) was observed in fish fed Diet E (50 % cp) with 50% protein diet. Generally, there was an inverse relationship between protein level and growth performance of fish.

Comment [VOE21]: After first mention, *Clarias gariepinus* should be abbreviated to *C. gariepinus*.

Table 2: Growth performances indices of *Clarias gariepinus* fed diets containing different protein levels for 24 weeks.

Comment [VOE22]: Take this statement to discussion section and give more fact with authorities

Comment [VOE23]: Abbreviate

Comment [VOE24]: Indices

Comment [VOE25]: Label

Variables	40.0%	42.5%	45.0%	47.5%	50.0%
MIW ¹	4.51±0.01	4.51±0.01	4.51±0.01	4.51±0.02	4.50±0.01
MFW ²	884.17±0.82 ^c	946.89±2.33 ^d	843.27±6.61 ^b	790.23±8.04 ^a	773.63±2.29 ^a
MWG ³	879.66±0.82 ^c	942.38±2.33 ^d	838.70±6.61 ^b	785.72±8.05 ^a	769.13±2.29 ^a
ADG ⁴	5.32±0.01 ^a	5.88±0.01 ^c	5.77±0.04 ^b	5.38±0.05 ^a	5.32±0.01 ^a
RGR ⁵	198.74±0.31 ^a	218.85±0.58 ^c	214.79±1.50 ^b	200.54±2.38 ^a	198.33±0.93 ^a
MGR ⁶	2.96±0.00	2.96±0.00	2.96±0.00	2.94±0.02	2.95±0.01
SGR ⁷	3.16±0.00 ^a	3.21±0.00 ^b	3.20±0.00 ^b	3.16±0.01 ^a	3.15±0.00 ^a

Comment [VOE26]: Give their units

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: ¹mean initial weight (g); ²mean final weight (g); ³mean weight gain (g); ⁴average daily growth (g/day); ⁵relative growth rate; ⁶metabolic growth rate (g/kg^{0.8}/day); ⁷specific growth rate (%/day);

The results of protein utilization of *Clarias gariepinus* fed diets containing different protein levels for 24 weeks are shown in Table 3. The ability of fish to convert food given to muscle increased with increasing protein level in diet. The best food conversion (0.27±0.00), protein efficiency (9.41±0.02), protein index (5.29±0.18g/day), nitrogen metabolism (44.76±0.15) and protein productive value (59.55±0.6%) were obtained in group fed with 42.5% protein diet. Inverse relationship also existed between protein content in diet and protein utilization of catfish.

Table 3: **Feed and** Protein utilization and survival rates of *Clarias gariepinus* fed diets containing different protein levels for 24 weeks.

Comment [VOE27]: Too low

Variables	40.0%	42.5%	45.0%	47.5%	50.0%
FCR ⁸	0.28±0.00 ^b	0.27±0.00 ^a	0.27±0.01 ^a	0.28±0.01 ^b	0.29±0.00 ^c
PER ⁹	9.08±0.07 ^d	9.41±0.02 ^e	8.45±0.23 ^c	7.93±0.16 ^b	7.25±0.08 ^a
PPV ¹⁰	49.08±1.75 ^d	59.55±0.56 ^e	41.78±0.55 ^c	36.95±2.12 ^b	31.83±1.10 ^a
PI ¹¹	4.80±0.00 ^b	5.29±0.18 ^d	5.00±0.34 ^c	4.76±0.21 ^b	4.61±0.19 ^a
NM ¹²	40.67±0.00 ^a	44.76±0.15 ^c	44.00±0.26 ^b	41.13±0.40 ^a	40.52±0.15 ^a
SR ¹³	90.00±0.00	90.00±0.00	86.67±6.01	88.33±3.33	86±3.33

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: ⁸food conversion ratio; ⁹protein efficiency ratio; ¹⁰protein productive value (%); ¹¹protein index (g/day); ¹²nitrogen metabolism; ¹³percentage survival rate (%).

In all dietary levels tested, **economic indices including** feed consumption, cost of feed supply and total cost of production were not significantly different ($p > 0.05$). There was an inverse relationship between net fish production, gross profit, and value of fish (Table 4). The best economic conversion ratio (58.98±0.13), profit index (8.50±0.02) and gross profit (₹4,774/hapa) were recorded in fish fed with the **Diet B (42.5% cp) 42.5% protein diet**.

Table 4: **Economic indices** ~~Cost-benefit-evaluation~~ of *Clarias gariepinus* fed diets containing varying levels of protein in floating hapa system for 24 weeks.

Variables	40.0%	42.5%	45.0%	47.5%	50.0%
TFI ¹	254.97±2.75	261.93±1.19	264.37±6.26	253.53±4.51	255.2±2.42
COF ²	1000±10.62	1050±38.17	1047±95.82	1048±54.96	1061±40.77
TCP ³	4100±10.2	4150±38.17	4147±95.82	4148±54.96	4161±40.77
VOF ⁴	8107±7.50 ^c	8925±30.87 ^e	8432±57.37 ^d	8032±35.01 ^b	7781±31.85 ^a
NP ⁵	16215±14.84 ^b	17850±60.82 ^d	16865±15.7 ^c	16064±71.04 ^b	15561±63.66 ^a
GP ⁶	40006±12 ^c	4774±26 ^e	4285±26 ^d	3884±48 ^b	3619±27 ^a
PI ⁷	8.11±0.08 ^b	8.50±0.02 ^c	8.09±0.22 ^b	7.67±0.15 ^{ab}	7.33±0.08 ^a
ECR ⁸	61.84±0.64 ^b	58.98±0.13 ^a	62.17±1.60 ^c	65.62±1.27 ^d	68.61±0.73 ^e

Comment [VOE28]: Indices

Comment [VOE29]: Give units. Total feed consumed by fish in 24 weeks is too small i.e. 254.97 ±2.75g for 40.0 % cp. Calculate TFI again. Compare this value with weight gain of 879.66±0.82g obtained for the same 40.0 % cp treatment. It implies that the fish gains over four time weight after eating 40.0 % cp. This is absolutely impossible. This is also applicable to other treatments.

*Means with different superscript letters within a row are significantly different ($p < 0.05$). Where: ¹total feed intake 137 (g); ²cost of feeding (₦/hapa); ³total cost of production (₦/hapa); ⁴value of fish @ ₦500/kg; ⁵net production 138 (kg/hapa); ⁶gross profit (₦/hapa); ⁷profit index; ⁸economic conversion ratio.

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140 Discussion

141 The culture of *Clarias gariepinus* in net-hapas seems to be feasible if these results are compared with those obtained in conventional culture systems. At the end of the 168-day feeding trial, the percentage survival rate ranged from 88.33 % to 90.00%. These values were comparable with survival of *Heterobranchus longifilis* (90%) cultured in earthen pond by Babalola and Apata (2006). However, in this study survival rates were not affected by dietary protein levels. The growth performances of *Clarias gariepinus* obtained in this study were influenced by dietary protein levels. Similar results were also reported in hybrid catfish fry by Diyaware *et al.* (2009), in *Chrysichthys nigrodigitatus* fingerlings by Adewolu *et al.* (2009) and in *Heterobranchus longifilis* larvae by Babalola and Apata (2006). Diyaware *et al.* (2009) also reported that growth rate and weight gain increased progressively with dietary protein level to a maximum at 50%. Jana *et al.* (2006) observed high growth in terms of live weight gain and specific growth rate in milkfish (*Chanos chanos*) fed at 40% protein level. In addition, Alatisie *et al.* (2005) reported that catfish fingerlings fed with 40% protein gave the best growth (SGR: 1.06%/day and FCR: 0.62). In this study, best growth was observed in fish fed 42.5% protein. The intraspecific differences observed could be explained by the varieties of methodology (feed formulation and feeding rate tests) and culture system used in individual experiment. In this study, low protein content in diet resulted to increased fish growth. This could be seen in fish fed diet containing 42.5 % protein producing better growth when compared with those fed between 45.0 and 50.0 % protein diets. This indicated the capacity of this species to accept and utilize compounded diet with moderate protein contents. The highest feed conversion ratio of 0.28 obtained in this study was better than 1.28 observed in *Clarias gariepinus* fed with 40% protein (Sotolu, 2010). The highest ($p < 0.05$) profit index and economic conversion ratio of fish fed 42.5% protein diet probably pointed to the fact that this dietary protein level may be better in economic terms than all other protein diets in this study. This is also reflected in lack of significant differences ($p > 0.05$) in metabolic growth rate in all treated fish. High growth performance and fish production obtained in this study points to the realization that biological and economic benefits could be achieved in intensive culture of catfish in floating net-hapa system.

No mention of protein utilization in the discussion. Information on water quality measurements which is very important for studies of this nature should be provided.

177 REFERENCES

179 Adewolu, M. A. and. Benfey, T. J. (2009). Growth, nutrient utilization and body composition of juvenile Bagrid Catfish, *Chrysichthys nigrodigitatus* (Actinopterygii: Siluriformes: Claroteidae), fed different dietary crude protein levels. *Acta Ichthyologica Et Piscatoria*, 39 (2): 95–101

Comment [VOE30]: You do not need to number these indices as TFI¹, just leave it as TFI and in the footnote, interpret it as follows: where: TFI = total feed intake (g). This is applicable to other indices.

Comment [VOE31]: Your discussion is too shallow

Comment [VOE32]: abbreviate

Comment [VOE33]: ranged from 88.33% in which treatment? To 90.00% in which treatment?

Comment [VOE34]: Give reasons for the few mortality observed i.e. Eyo *et al.*, (2016) attributed mortality in cultured *C. gariepinus* to its cannibalistic nature. See Awom, I. E., & Eyo, V. O. (2016). Comparative Study of Growth Performance, Food Utilization and Survival of the African Catfish *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Live Maggot (*Musca domestica*) and Coppens Commercial Feed. *International Journal of Scientific Research in Science, Engineering and Technology*, 2(2): 379-386.

Comment [VOE35]: Abbreviate

Comment [VOE36]: This fact disagrees with your findings because in your study growth rate and final weight decreased with increase in CP level with fish fed diet E (50% cp) having the poorest result. Reconcile this in your discussion and give reasons.

Comment [VOE37]: FCR of 0.28 is too low.

Comment [VOE38]: Is this your conclusion? What about your recommendations based on results obtained in your study

- Alatise, S. P., Ogundele, O. and Olaosebikan, B. D. (2005). Growth response of *Heterobranchus longifilis* fingerlings fed with varying levels of dietary freshwater mussel (*Aspatharia sinuata*). In: 19th Annual Conference of the Fisheries Society of Nigeria (FISON), 29 Nov03 Dec 2004, Ilorin, Nigeria, pp. 637-643.
- Babalola, T. O. and Apata, D. F. (2006). Effects of dietary protein and lipid levels on growth performance and body composition of African catfish *Heterobranchus longifilis* (Valenciennes, 1840) fingerlings. *J. Anim. Vet. Adv.* 5: 1073-1079.
- Diyaware, M.Y., Modu, B. M. and Yakub, U. P. (2009). Effect of different dietary protein levels on growth performance and feed utilization of hybrid catfish (*Heterobranchus bidorsalis* x *Clarias anguillaris*) fry in north-east Nigeria. *Afr. J. Biotechnol.* 8 (16): 3954-3957.
- Fagbenro, O. A., Balagon, A. M. and Anyanwu, C. N. (1992). Optimum dietary protein level of *Heterobranchus bidorsalis* fed compounded diet. *Nig. J. Appl. Fish. Hydrobiol.* 1: 41-45.
- Jamabo, N. A and Alfred-Ockiya, J. F. (2008). Effects of dietary protein levels on the growth performance of *Heterobranchus bidorsalis* (Geoffrey- Saint-Hillarie) fingerlings from Niger Delta. *Afr. J. Biotechnol.*, 7 (14): 2483-2485.
- Jana, S.N., Garg, S. K. and Barman, U. K. (2006). Effect of varying dietary protein levels on growth and production of *Chanos chanos* (Fosskal) in inland saline ground water: laboratory and field studies. *Aquact. Int.* 14: 479-498.
- N. R. C. (National Research Council) (1993). Nutrient requirements of warm water fishes and shell fishes. National Academy Press, Washington D.C. 140p.
- Olufeagba, S. O. and Aluko, P. O. (1997). Growth and survival of triploid *Heterobranchus longifilis*. Proceedings of the National Institute for Fresh Water Fisheries Research Annual Report, New Bussa, pp102-109.
- Otubusin, S. O. (2000). The effect of feedstuffs on Tilapia, *Oreochromis niloticus* fry in floating net-hapas. *Nig. J. of Science*, 34 (4): 377-379.
- Sotolu, O. A. (2010). Feed utilization and biochemical characteristics of *Clarias gariepinus* (Burchell, 1822) fingerlings fed diets containing fish oil and vegetable oils as total replacements, *World J. Fish Marine Sci.*, 2 (2): 93-98.

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