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Acceptability, Growth Performance and Cost Analysis of Diets Enriched with Lipids from Varied Plants and Animal Sources Fed to Fingerlings of *Clarias gariepinus* (Teleostei, Clariidae) Burchell, 1822

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Abstract
The acceptability of diet, growth performance and cost benefit analysis of *C. gariepinus* fed varied diets enriched with dietary lipids from plant and animal sources was investigated. The acceptability of diets enriched with lipids was investigated using the "time to strike and acceptability index." The growth potentials and survival of *C. gariepinus* fed varied dietary lipid, were investigated using "weight gain, specific growth rate and normalized biomass index." The combined effects of diets fortified with either animal or plant lipids on diet acceptability, growth and survival of *C. gariepinus*, were studied. Furthermore, the cost benefit of feeding *C. gariepinus* fingerlings with diet enriched with varied lipid types was established. Results indicated that enrichment of *C. gariepinus* fingerlings diets with lipids enhances the acceptability of the diet, the best acceptable diet being olive oil enriched diet. The acceptability of diets enriched with olive oil, cow fat and pig fat were statistically not significantly different. Although, olive oil diets were easily accepted, with regards to weight gain, growth induction and survival the pig fat enriched diets performed best when compared with other lipid fortified diets. All lipid enriched diets had significantly different weight gain ($p < 0.05$), specific growth rate ($p < 0.05$) and survival rate ($p < 0.05$) than the control diet. Although lipid enhanced diets were better than those without lipid in *C. gariepinus,* animal lipid enriched diets had better acceptability index, weight gain, specific growth rate and survival than plant lipid fortified diets. The cost benefit analysis revealed that both pig and goat fats had better comparative and effective cost per unit weight gain.

Key Words: Diet, Fingerlings, Clarias *gariepinus*

Introduction

Feeding constitutes one of the most functional aspects of fish growth and development. In tropical finfish culture, fish feed is the most important single contributor to the operation cost, accounting for over 50 % of the annual running cost. Based on this fact, it is advisable to prepare fish feed in such a way as to be most acceptable to fish, thereby increasing feed consumption and thus resulting in reduction in feed wastage (Eyo, 1997).

Feed attractants strongly influence the acceptability of dietary pellets (Eyo, 1997). Feed attractants employed in finfish aquaculture includes *Spirulina* (Henson 1990), glycine (Hughes 1991), ginger (Eyo, 1997) and fresh palm fruit extract (Mgbenka and Orji, 1997) among others. The acceptability of diet pellets enriched with fresh palm fruit extract indicated the possibility of lipids acting as feed attractants.

Furthermore, dietary lipids play an important role in finfish nutrition through the provision of metabolizable energy and supply of essential fatty acids, thus beneficial to fish growth. Lipids currently utilized in fish diet includes cod-liver oil in rainbow trout (Philips et al, 1963), beef tallow, menhaden oil and vegetable oil in *Ictalurus punctatus* (Stickney and Andrews, 1972), fresh palm fruit extract in *Clarias gariepinus* (Mgbenka and Orji, 1997), among others. These studies reported differential response of fish species to varied dietary lipids. Thus one may infer that growth potentials among fish species fed diets fortified with varied lipids are selective and species specific. This work will assess the performance of lipids either from plant or animal source acting as feed attractant in C. *gariepinus*. Furthermore, the study will also investigate the growth performance of the enriched diets in promoting growth in C. *gariepinus*. The combined effect of lipid, either of plant or animal origin on diet palatability and growth potentials will also be investigated. A cost benefit analysis using adjusted feeding levels due to differential changes in mean weight gain will be established as a mean of ascertaining which of the lipid fortified diets gave the best growth performance at a relatively lower cost.

Materials and Methods

Experimental Catfish

One hundred and fifty (150) hatchery raised C. *gariepinus* fingerlings bought from Aquafish Nigeria Limited, No 158 Enugu Road, Awka, Anambra State, Nigeria were transported in FAO fish transit tank to the Fisheries and Hydrobiology Research Unit Wet Laboratory located within the Zoological garden, University of Nigeria, Nsukka. The catfishes were acclimatized in 24 plastic basins (25 cm^3) containing 15 litres of water for 14 days. One part per million of Potassium tetraoxomanganate VII ($KMnO_4$) was given as flush prophylactic treatment. The water in the plastic basins was changed twice weekly. The catfishes fingerlings were individually weighed using Mettler electronic balance (PC 2000) to the nearest 0.01 gram. The fingerlings were fed 5 % of their body weight twice daily with 37.25 % crude protein pelletized fish diet in divided rations. The control diet was compounded following the methods of Eyo (2001) as presented in Table 1.

Table 1: Composition of Basic (Control) Diet Fed to Clarias gariepinus

Diet Constituents	Percentage Ingredients in diet	g/kg	Crude protein (CP) in ingredient (proximate analysis)	Estimated Crude protein (CP) % per kilogram diet
Fishmeal (FM)	20.00	200.00	60.00	12.00
Blood meal (BM)	3.00	30.00	70.00	2.10
Soya bean meal (SBM)	45.70	457.00	44.60	20.38
Corn meal (CM)	28.30	283.00	9.80	2.77
Vitamin premix (VP)[1]	0.65	6.50	-	-
Mineral premix (MP)[2]	0.65	0.60	-	-
Hemicellulose binder (HB)	1.70	17.00	-	-
Total	100.00	1000.00	183.80	37.25

Vitamin premix provided the following ingredient per gram of diet. Vitamin a, 4 IU: Vitamin D3, 2 IU; Niacin, 0.088 mg; d-panthotenic acid, 0.035 mg; Vitamin B12, 0.0009 mg; vitamin E, 0.055 IU; Riboflavin, 0.013mg; Choline chloride, 0.55 mg; Manadione sodium bisulfate complex, 0.01mg; Pyridoxine hydrochloride, 0.01mg; Thiamine mononitrate, 0.01 mg; Folic acid, 2.03 mg; Antioxidant, 0.138 mg; Ascorbic acid 0.176 mg.

Mineral premix provided the following trace elements per gram of diet: Mn 0.087 mg; I 0.001 mg; Cu 0.004 mg; Zn 0666 mg; Fe 0.033 mg; Co 30.00007 mg.

Experimental Diet

One kilogram each of the experimental diets were measured out using Mettler electronic balance (PC 2000) into eight plastic basins. The ingredients were homogeneously mixed with 250 ml of water per kilogram of diet to produce dough. The difference between the control diet (Table 1) and other experimental diets was the non-introduction of lipid from the specified animal and / or plant source (Table 2). In all other diets, 4 % of each lipid type (goat fat, pig fat, cow fat, cod-liver oil - animal lipid sources; palm oil, groundnut oil and olive oil - plant lipid sources) were individually added to each diet batch. Thus diet B contained 4 % goat fat, diet C – 4 % pig fat, diet D – 4 % cow fat, diet E – 4 % cod liver oil, diet F – 4 % palm oil, diet G – 4 % groundnut oil and diet H – 4 % olive oil. The resulting diet doughs were individually packaged in heat resistant polythene, sealed and autoclaved at 140°C for 40 minutes. Apart from destroying the anti-nutritive factor in soya bean, the heat treatment aids binding through gelatinization of starch (Eyo 1997), and lipid mobilization. The different diet doughs were individually ran through a meat mincer (Natural, Japan) fitted with 3 mm dye and the resulting strands were cut into pellets and oven dried separately at 50°C for three hours.

Experiment I: Acceptability of Lipid Enriched Diets to C. *gariepinus*

The acceptability of lipid enriched diets to C. *gariepinus* fingerlings was assessed using the "time to strike index" (Eyo, 1997). Six catfish starved over night (to increase their desire for food) were left in a glass aquarium (darkened on three sides) containing 10 litres of water. One pellet of each dietary type was dropped into the aquarium. The mean time that elapsed from the moment the pellet penetrates through the water surface to the moment the first and / or last fish struck the pellet with its mouth were recorded in seconds. This experiment was replicated thrice for each dietary type respectively.

Experiment II

(a) Growth Performance of C. *gariepinus* Fed Lipid Enriched Diets

Six catfish fingerlings were randomly assigned to each triplicates plastic culture basins (20 cm^3) respectively for each of the eight treatments. The treatments were labeled A, B, C to H and replicates 1,2,and 3. Treatment A catfishes were fed the control diet having no exogenous lipid. Treatment B were fed diet supplemented with 4 % goat fat and treatment C catfishes were fed with 4 % pig fat enriched diet. In treatment, D, E, F, G and H catfishes were fed diets fortified with 4 % cow fat, 4 % cod liver oil, 4 % palm oil, 4 % groundnut oil and 4 % olive oil respectively. In all treatments catfishes were fed 5 % of their body weight for ten weeks. Individual weights were measured weekly and used in adjustments of feeding rates, estimation of weight gain and in calculation of other growth parameters such as:

(i) SGR (% Body Weight / Day) = $\{\frac{\text{In weight}_t - \text{In weight}_o \times 1000}{T}\}$

(Weatherly and Rogers 1978), where weight_t = weight of catfish at time t, weight_o = weight of catfish at time 0, and T = culture period in days; and

(ii) NBI (Normalized Biomass Index) = $[(W_f \times N_f) - (W_i \times N_i)] \times 1/100$ (Beck 1979), where W_f = final weight of catfish in milligram N_f = final number of catfish, W_i = initial weight in milligram and N_i = initial number of fish.

(b) Combined Effects of Lipid Enriched Diets on Growth Performance of C. *gariepinus*

The combined effects of feeding on diets enriched either with animal or plant lipids on diet acceptability, weight gain, specific growth rate and normalized biomass index of catfish were estimated from data arising from experiments I and II a.

Experiment III: Cost Benefit Analysis of Lipid Enriched Diets on Growth Performance of C. *gariepinus*

The cost benefit analysis of feeding 1000 catfishes with diets enriched with lipids from various plant and animal sources was estimated utilizing adjusted feeding levels as influenced by weight gain and specific growth rate. All the costing was done in Naira (Nigerian official currency) using Nsukka Urban market Prices and converted into US dollars based on Nigeria Apex market exchange rate of one US Dollar equivalent to eighty Naira. (1$ = ₦115: 00).

Statistical Analysis

Means and standard deviations from the different treatments were calculated. One way ANOVA and F- LSD were employed to test for significance of treatment means at $P = 0.05$.

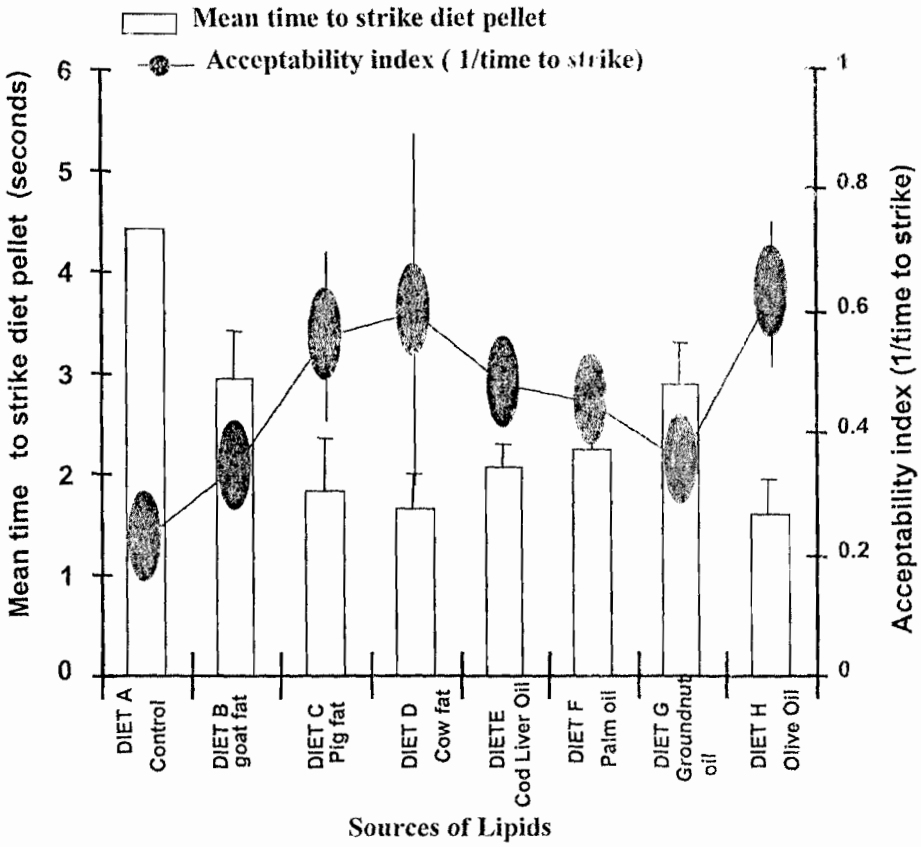

Fig. 1: Acceptability of diets fortified with lipids from varied plant and animal sources by *C. gariepinus*

RESULTS

Acceptability of Lipid Enriched Diets to C. *gariepinus*

C. *gariepinus* fingerlings took much longer time (seconds) to strike and consume pellets from the control diet (4.43 " 1.10 s), compared with lipid enriched diet pellets (Fig. 1). The least time to strike and consume pellets occurred among catfishes fed either diet H (enriched with olive, 1.60 " and/or diet D (enriched with cow fat, 1.67"0.58 s). The time it took other catfishes to strike pellets were: diet C (enriched with pig fat 1.8"0.35 s), diet E (fortified with cod liver oil diet F (supplemented with palm oil, 2.23 " 0.21 s), diet G (enriched with groundnut

oil 2.87" 0.42 s) and diet B (fortified with goat fat, 2.93 " 1.39 s). Acceptability of all lipids enriched diets were significantly different from the control diet ($P < 0.05$). Diets enriched with olive oil (diets H), cow fat (diet D) and pig fat (Diet C) were not statistically significantly different ($P > 0.05$). Similarly, no significant differences were observed with diets E, F, G and B were statistically identical ($P > 0.05$). The "acceptability index" of treatments B to H, calculated as the reciprocal of "time to strike", were statistically different from those of treatment A ($P < 0.05$).

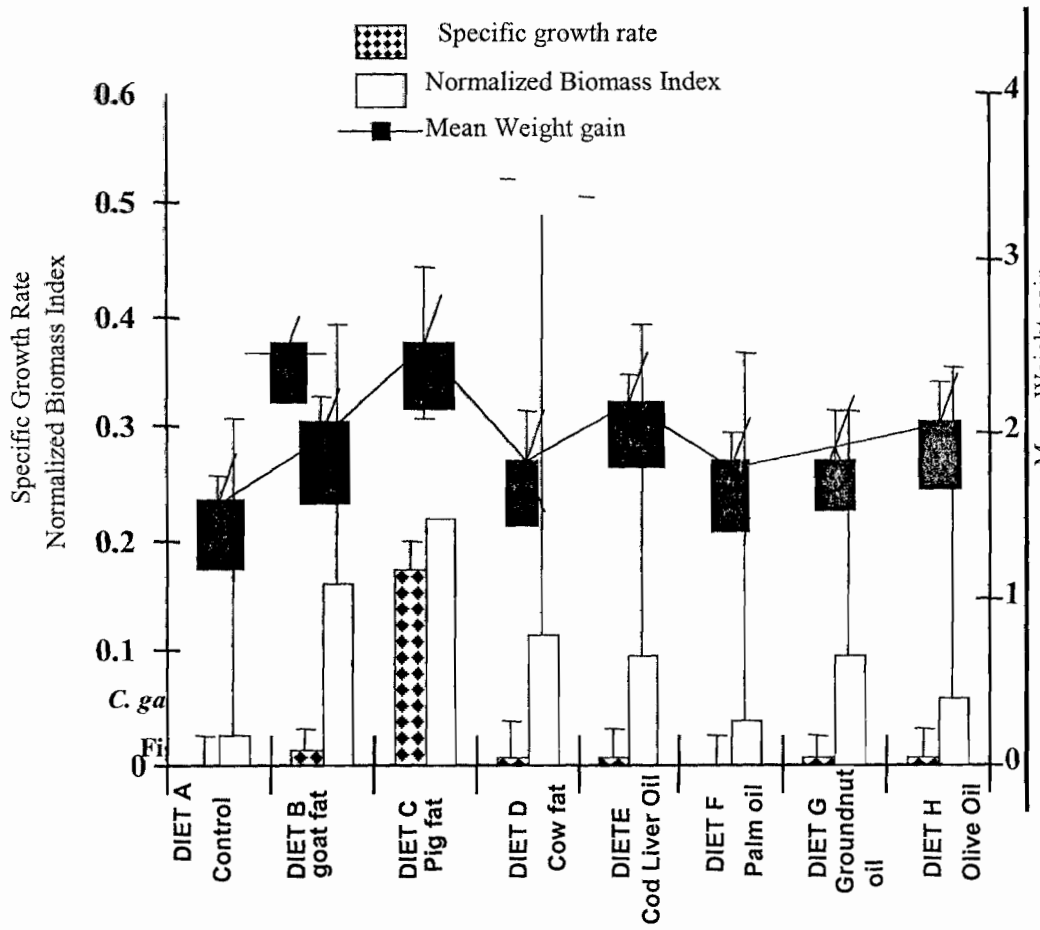

Fig. 2: Effects of varied dietary lipids on weight gain, growth rate and normalized biomass index of C. gariepinus

Growth Performance of C. *gariepinus* Fed Lipid Enriched Diets

The data on the effects of dietary lipids on mean weight gain of C. *gariepinus* (Fig. 2) indicate that the pig fat treatment (2.5 " 0. 46 g) was significantly different from other treatment means (P > 0.05). Mean weight gain induced by other dietary lipids were: cod – liver oil, 2.167 " 0.17 g; olive oil, 2.040 " 0.27 g; goat fat, 1.943 " 0.25 g; groundnut oil 1.912 " 0.22 g; cow fat 1.796 " 0.34 g; and palm oil 1.77 " 0.22 g. All lipid-enriched diets had apparently higher mean weight gain than the control (1.555 " 0.18 g).

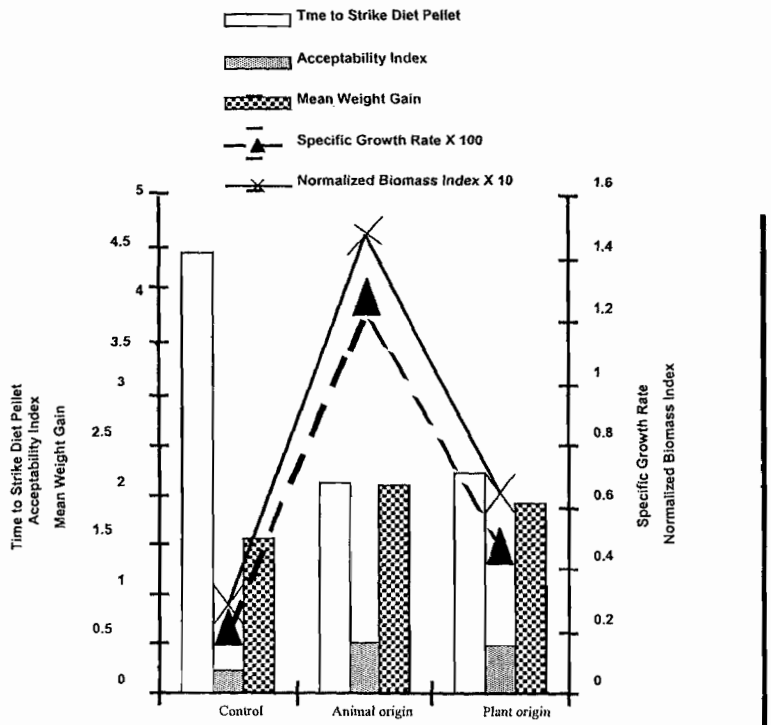

Fig. 3: Combined effect of varied dietary lipids on diet acceptability, weight, growth and normalized biomass index of *C. gariepinus*

The specific growth rate of C. *gariepinus* fed diets enriched with dietary lipids (Fig. 2), showed that catfishes fed pig fat fortified diet (diet C, 0.175 " 0.023) had significantly higher specific growth rate when compared with the control (0.002 1 " 0.023) and other lipids enriched diets (P > 0.05). Specific growth rates of catfish as induced by other lipid fortified diets were: goat fat enriched diet (diet B 0.128 " 0.180), cow fat enriched diet (diet D, 0.0092 " 0. 031), groundnut oil enriched diet (diet G, 0.0081 " 0.017), cod liver oil enriched diet (diet E, 0.0046 " 0.024) and palm oil enriched diet (diet F, 0.0030 " 0.026). All treatments having dietary lipids had significantly

Table 2: Ingredient composition (g/Kg) and cost analysis of enriching C. gariepinus diet with varied dietary lipid of animal and plant origin

Ingredient	Control	Goat fat	Pig fat	Cow fat	Cod liver oil	Palm oil	Groundnut oil	Olive oil
	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	Diet G	Diet H
Fish meal	200(N35.21)	200(N35.21)	200(N35.21)	200(N35.21)	200(N35.21)	200(N35.21)	200(N35.21)	200(N35.21)
Blood meal	30(N15.00)	30(N15.00)	30(N15.00)	30(N15.00)	30(N15.00)	30(N15.00)	30(N15.00)	30(N15.00)
Soybean Meal	457(N25.97)	457(N25.97)	457(N25.97)	457(N25.97)	457(N25.97)	457(N25.97)	457(N25.97)	457(N25.97)
Corn meal	283(N7.26)	243(N6.23)	243(N6.23)	243(N6.23)	243(N6.23)	243(N6.23)	243(N6.23)	243(N6.23)
Goat fat	-(N0.00)	40(N25.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)
Pig fat	-(N0.00)	-(N0.00)	40(N30.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)
Cow fat	-(N0.00)	-(N0.00)	-(N0.00)	40(N25.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)
Cod liver oil	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	40(N60.00)	-(N0.00)	-(N0.00)	-(N0.00)
Palm oil	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	40(N13.00)	-(N0.00)	-(N0.00)
Groundnut oil	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	40(N25.00)	-(N0.00)
Olive oil	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	-(N0.00)	40(N70.00)
Vitamin premix	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)	6.50(N2.60)
Mineral premix	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)	6.50(N 2.60)
Hemicellulose binder	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)	17.00(N8.50)
Total	**1000.00 (N97.14) [$0.85]**	**1000.00 (N 121.11) [$1.05]**	**1000.00 (N 126.11) [$1.10]**	**1000.00 (N 121.11) [$1.05]**	**1000.00 (N 156.11) [$1.36]**	**1000.00 (N 109.11) [$0.95]**	**1000.00 (N 121.11) [$1.05]**	**1000.00 (N 166.11) [$1.44]**

Table 3: Estimated cost analysis of feeding 1000 Clarias gariepinus fingerlings for 10 weeks with diets enriched with dietary lipids from either animal of plant sources

	Weeks	0	2	4	6	8	10	Total
Diet A (control)	Catfish Weight (g)	1000 x 1.61	1000 x 1.62	1000 x 1.25	1000 x 1.43	1000 x 1.74	1000 x 1.77	1000 x 9.42
	Diet Required	1127.00	1134.00	875.00	1001.00	1218.00	1237.00	6594.00
	Cost of Diet (₦)	N1127.00	N110.16	N85.00	N9.24	N118.32	N120.16	N640.54
	Growth Response (weight gain) (g)	-	10	-370	180	310	30	160
	Diet Cost per Unit Weight Gain (₦)	-	N 11.02	N0.23	N0.54	N0.38	N4.01	N4.00 ($ 0.035)*
Diet B 4 % Goat fat	Catfish Weight (g)	1000 x 1.54	1000 x 1.79	1000 x 1.65	1000 x 2.05	1000 x 2.07	1000 x 2.43	1000 x 11.53
	Diet Required	1078.00	1253.00	1155.00	1435.00	1449.00	1701.00	8071.00
	Cost of Diet (₦)	N130.56	N151.75	N139.88	N73.79	N175.49	N206.01	N977.48
	Growth Response (weight gain) (g)	-	250	-140	400	20	360	890
	Diet Cost per Unit Weight Gain (₦)	-	N0.61	N -0.99	N0.44	N8.78	N0.57	N1.10 ($ 0.01)***
Diet C 4 % pig fat.	Catfish Weight (g)	1000 x 1.93	1000 x 1.94	1000 x 2.24	1000 x 2.78	1000 x 2.86	1000 x 3.15	1000 x 14.90
	Diet Required	1351.00	1358.00	1568.00	19446.00	2002.00	2205.00	10430.00
	Cost of Diet (₦)	170.38	171.26	197.74	245.41	252.47	2705.00	1,315.33
	Growth Response (weight gain) (g)	-	10	300	540	80	290	1220
	Diet Cost per Unit Weight Gain (₦)	-	N17.126	0.66	0.45	3.16	0.96	N 1.08 ($ 0.01)***
Diet D 4% cow fat	Catfish Weight (g)	1000 x 1.74	1000 x 1.63	1000 x 1.49	1000 x 1.90	1000 x 2.00	1000 x 2.37	1000 x 11.13
	Diet Required	1218.00	1141.00	1043.00	1330.00	140.00	1659.00	7791.00
	Cost of Diet (₦)	147.51	138.19	126.32	161.08	169.55	200.92	943.57
	Growth Response (weight gain) (g)	-	-110	-140	410	100	370	630
	Diet Cost per Unit Weight Gain (₦)	-	-1.26	-0.90	0.39	1.70	0.54	N 1.50 ($ 0.013)**

Diet E	Catfish Weight (g)	1000 x 2.05	1000 x 2.04	1000 x 2.10	1000 x 1.98	1000 x 2.25	1000 x 2.58	1000 x 13.00
4%	**Diet Required**	1435.00	1428.00	1470.00	1386.00	1575.00	1806.00	9100
Cod	Cost of Diet (₦)	224.02	222.93	229.48	216.37	245.87	28193	1420.60
liver oil	Growth Response (weight gain) (g)	-	-10	60	-120	270	330	530
	Diet Cost per Unit Weight Gain (₦)	-	-22.29	3.83	-1.80	0.91	0.85	N 2.68 ($ 0.023)*
Diet F	Catfish Weight (g)	1000 x 1.96	1000 x 1.59	1000 x 1.57	1000 x 1.81	1000 x 2.04	1000 x 2.17	1000 x 11.14
4%	**Diet Required**	1372.00	1113.00	1099.00	1267.00	1428.00	1519.00	7798
Palm oil	Cost of Diet (₦)	143.59	127.55	137.48	140.53	150.46	185.60	885.21
	Growth Response (weight gain) (g)	-	-370	-20	240	230	130	210
	Diet Cost per Unit Weight Gain (₦)	-	-0.35	-6.874	0.59	0.65	1.43	N 4.22($ 0.037)*
Diet G	Catfish Weight (g)	1000 x 1.88	1000 x 1.67	1000 x 80	1000 x 1.84	1000 x 1.97	1000 x 2.43	1000 x11.59
4%	**Diet Required**	1316.00	1169.00	1260.00	1288.00	1379.00	1701.00	8113
Ground	Cost of Diet (₦)	159.38	141.58	152.60	155.99	167.01	206.01	982.57
nut oil	Growth Response (weight gain) (g)	-	-210	130	40	130	460	550
	Diet Cost per Unit Weight Gain (₦)	-	-0.67	1.17	3.90	1.29	0.45	N 1.79 ($ 0.016)*
Diet H	Catfish Weight (g)	1000 x 2.12	1000 x 1.98	1000 x 1.72	1000 x 1.99	1000 x 2.26	1000 x 2.44	1000 x 12.51
4%	**Diet Required**	1484.00	1386.00	1204.00	1393.00	1582.00	1708.00	8757
Olive oil	Cost of Diet (₦)	246.51	230.23	200.00	231.39	262.79	283.72	1,454.63
	Growth Response (weight gain) (g)	-	-140	-260	270	270	180	320
	Diet Cost per Unit Weight Gain (₦)	-	-1.65	-0.77	0.86	0.97	1.58	N 4.55 ($ 0.04)*

₦ Nigerian Official Currency, $ US Dollar, * P=0.1, ** P = 0.05, *** P=0.01.

All treatments having dietary lipids had significantly higher specific growth rates than the control diet ($P < 0.05$). F- LSD separation of means, indicated that the weight gains and specific growth rates of catfishes diets enriched with either cow fat or palm oil were not significantly different ($P > 0.05$).

The data on Normalized Biomass Index (NBI) of C *gariepinus* fed diets enriched with dietary lipids from various plant and animal sources, indicated that the cat fishes fed diet enriched with pig fat (diet C, 0.2172 " 0.2) gave the best result and was significantly different from the control diet and other treatment diets ($P < 0.05$).

The Normalized Biomass Index (NBI) from other treatments were: goat fat enriched diet (diet B 0.1638 " 0.23), cow fat fortified diet (diet D, 0.1134 " 0.38), groundnut oil fortified diet (diet G, 0.099 " 0.22), cod live oil fortified diet (diet E, 0.0576 " 0.30) and palm oil enriched diet (diet F, 0.00378 " 0.33). All treatment diets had higher NBI values than the control diet (0.00288 " 0.28).

Combined Effects of Lipid Enriched Diets on Growth Performance of C. *gariepinus*

The combination of dietary lipids from either plant or animal origin (Fig. 3) on palatability of diet and growth performance of C. *gariepinus* fingerlings indicated that the diets enriched with animal fat were more palatable (2.12 " 0.64 s) thus easily acceptable (0.50 " 0.13 s), when compared to diet enriched with plant oil (2.23 " 0.62 s) and the control diet (4.43 " 1.16 s).

Furthermore, the catfishes fed diets enriched with lipid from animal origin had higher mean weight gain (2.104 " 0.41 g) than those fed diets fortified with plant lipids (1.908 " 0.26 g) and the control diet (1.555 " 0.18 g). Similarly, C. *gariepinus* fed animal fat fortified diet grew faster per day (0.0123 " 0.023 g/d) than plant lipid fortified diet (0.0047 " 0.023 g/d) and the control diet (0.0021 " 0.023 g/d). The catfishes fed diets fortified with animal fat had better survival than those fed diets fortified with plant lipid and the control diet.

Cost Benefit Analysis of Lipid Enriched Diets on Growth Performance of C. *gariepinus*

The cost analysis of enriching C. *gariepinus* diet with dietary lipids from plant and animal sources indicated cost differential corresponding with dietary lipid types (Table 2).

The highest diet cost occurred in diet enriched with olive oil ($1.44 per kilogram of diet). Other cost differentials per kilogram of diet were; cod liver oil enriched diet ($1.36 / kg), pig fat enriched diet ($1.10 / kg), groundnut oil and cow goat fat enriched diet ($1.05 / kg); and palm oil enriched diet ($ 0.95 / kg). All dietary costs differentials were not significantly different ($P > 0.05$). The comparative cost analysis of feeding 1000 C. *gariepinus* fingerlings at 5 % body weight with diet enriched with dietary lipids from plant and animal sources (Table 3) indicated that diet B (goat fat enriched diet) and C (pig fat enriched diet) produced better cost per unit weight gain ($ 0.01 per gram weight gain) than diets D ($ 0.013 /g), G ($ 0.016 /g), E ($ 0.023 /g), A ($ 0.035 /g), F ($ 0.037 /g) and H ($ 0.04 /g).

Discussion

The palatability of diet enriched with fresh palm fruit extract fed to C. *gariepinus* had been reported (Mgbenka and Orji 1997). This study enhanced diet palatability by incorporating other dietary lipids in the diets fed to C. *gariepinus*, as all treatments were significantly better than the control

Unlike Mgbenka and Orji (1997), the enhanced palatability of the diet (due to lipid enrichment) did not translate systematically into specific weight gain, growth rate and normalized biomass index. Although all lipid-enriched diets had better palatability than the control diet, the olive oil enriched diet was more palatable than others. The high acceptability of olive oil enriched *diet did not result in* comparatively better weight gain and growth among catfish, fingerlings fed the diet. The pig fat fortified diet had better mean weight gain and produced better growth when compared with other dietary types. This could be as a result of the energy content of the pig fat and the effective utilization of w-3 fatty acids by C. gariepinus for higher growth. Furthermore, the presence of linoleuic acid (an essential fatty acid) in pig fat may have enhanced the weight gain as well as the growth rate. Stickney and Andrews (1972) reported rapid growth in Ictalurus punctatus fed diets containing 10 % beef tallow or 10 % fish oil than when compared with diet containing 10 % safflower oil. The above discussion holds same for the observed low palatability and higher weight gain and growth observed among C. gariepinus fingerlings fed diets enriched in goat fat.

A common practice in Anambra River fisheries of baiting hooks with ripe palm fruit for the capture of C. gariepinus may contradict the observed low palatability of palm oil enriched diet compared with other lipid enriched diets of this study. Mgbenka and Orji (1997) indicated that fresh palm fruit extract produced better diet acceptability and growth. It may well be concluded that during the processing of fresh palm fruit extract to palm oil, essential fatty acid required either as attractant in diet or as growth stimulators may be seriously modified.

There exist a positive correlation between weight gain, growth rate and normalized biomass index. The increased weight gain apparently enhanced the growth and survival of C. gariepinus fed lipid-fortified diets. Legendre et al., (1995) observed that fatty acids probably contributed to increased acceptance and thus improved growth and survival of Heterobranchus longifilis fed lipid enriched diets when compared to untreated diets. The high survival rate observed among C. gariepinus fed diets enriched with lipid in this study is in agreement with the results of Viola et al., (1982) for oil coated pellets fed to Cyprinus carpio; Santha and Gatlin (1991) that fed menhaden fish oil enriched diet to Ictarulus punctatus and Mgbenka and Orji (1997) that fed diets enriched with fresh palm fruit extract to Clarias gariepinus.

The combined effect of feeding C. gariepinus with diet enriched with lipids either from plant or animal origin indicated that diet enriched with animal lipid were easily accepted, induced better weight gain and growth and thus may lead to higher survival. The observed better performance of animal lipids fortified diets over plant lipids fortified diet conforms with the report of Legendre et al., (1995) on the effects of dietary lipids on the growth and survival rate and fatty acid composition of Heterobranchus longifilis fingerlings.

Lipid enrichment of C. gariepinus diet resulted in observable lipid specific cost differentials. Both goat and pig fats enriched diets produced the least cost per unit weight gain. Considering the general performance of both lipids, pig fat enriched diets was more palatable, induced higher weight gain, specific growth rate, had the best survival level, and as such is recommended for use by aquaculturist as a better lipid additive for C. gariepinus fingerling diets.

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