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Growth Performance and Carcass Composition of *Clarias gariepinus* Fingerlings Fed Dietary Plant and Animal Lipids

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Authors' contributions

This work was carried out in collaboration between all authors. Author BSA designed the study and wrote the first draft of the manuscript. Author ACE performed the statistical analysis and wrote the protocol. Author SGA performed the laboratory study. All authors read and approved the final manuscript.

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ABSTRACT

An experiment to study the growth of *Clarias gariepinus* fingerlings fed different practically sourced dietary lipids was conducted with the aim of establishing a preference for either animal or plant lipid for 70 days. Fingerlings with mean weight of 28.66 ± 0.5 g were stocked at random to seven diets in triplicate groups with eachdiet having five fingerlings and were fed with isocaloric and isonitrogenous diets containing 40% crude protein (CP) with varied lipid sources of 8%. Diet 1 (Palm oil), Diet 2 (soya bean oil), Diet 3 (groundnut oil), Diet 4 (Beef tallow), Diet 5 (Pork lard), Diet 6 (Cod liver oil) and Diet 7 as Control (zero oil supplement).

Result showed that there were significant differences (P > 0.05) in feed conversion ratio (FCR) and specific growth rate (SGR) among the Diets. FCR was more efficient in diets containing beef tallow, Ground-nut oil and control (zero oil supplements). Mean weight gain was not significantly different from diets fed with palm oil, soya bean oil, beef tallow, and control (no oil supplement) based diet. Diets fed with groundnut oil and pork lard were significantly (P < 0.05) different from diets fed with

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cod liver oil. Mean weight gain was higher in fish fed with pork lard and beef tallow (9.85% and 9.01%) respectively and lowest in fish fed with cod liver oil (7.39%). Relative weight gain (RWG) showed no significant difference (P > 0.05) between fish fed with palm oil and soya bean oil based diets. However, fish fed with cod liver oil, beef tallow and control (zero oil supplements) based diet were significantly different (P < 0.05) from fish fed with pork lard based diet.

Keywords: Clarias gariepinus; fingerlings growth; plant lipid; animal lipid; fish diets.

1. INTRODUCTION

Feeds play very vital role in fish production, inadequate food prolific breeding are known to cause growth in natural waters [1]. In Nigeria, the high cost of conventional feedstuff underscores the need to develop adequate but relatively inexpensive feed formulations from readily available materials [2]. Several practical diets have been formulated for African catfish using a wide range of non-conventional feedstuffs. This includes pigeon peas, cotton seed, housefly, maggots and poultry hatchery wastes [3].

Clarias gariepinus (African Catfish) is one of the most important tropical freshwater fish species for aquaculture because of its high fecundity rate, acceptance of a wide range of natural and artificial foods, fast growth, tolerance to high stocking density and environmental extremes [4].

For successful expansion of the industry, plant oil sources stand out as the most likely candidates to substitute for fish oil in fish feed, because of their relative stability in price and ready availability [5]. Fish oil is a primary lipid used in fish feed. It is high in fatty acids that are not common in some plant and animal based oils. Fatty acids in fish oil include polyunsaturated fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). They are commonly considered to be highly desirable for use in aquaculture and in human nutrition. However, current studies indicate that vegetable oils are good alternative lipid source for fish which are readily available, cost effective and sustainable in utilization. Examples of such vegetable oil includes palm oil (PO), soybean oil (SO) and sunflower oil (SFO) [6].

2. MATERIALS AND METHODS

Seven isoenergenic diets were formulated (average crude protein 40%). Diet 1, 2 and 3 contained cod liver oil, palm oil, soy bean oil respectively, while diet 4, 5 and 6 contained ground nut oil, beef tallow and pork lard at 8% inclusion level respectively while the control dietcontained no oil supplement. The rendered animal fats (beef tallow and pork lard) were extracted by washing the fat and heating in a pan until fat melts to extract the oil. The composition of the experimental diet is shown in Table 3, all the ingredients were bought at the same time to avoid variations associated with batch differences, and were thoroughly milled, mixed and made into pellets (2 mm in dimension) with a pelleting machine. All diets were later dried and stored for subsequent use. The composition of the experimental diets are shown in Table 1.

Clarias gariepinus fingerlings (initial mean body weight of 28.66 ± 0.5 g) were obtained from outdoor fish tanks of the Department of Fisheries, University of Benin, Benin City.

2.1 Feeding Trials

The experimental design consist of six (6) dietary Diets with three (3) replicates each. Diet 7 with 0% inclusion serves as control. This was conducted in 15 aerated aquaria tank (60 X 45 X 30 cm). Fingerlings from the same broodstocks were stocked randomly at five (5) fingerlings per aquarium in 40 litres of domestic water of university of Benin in the laboratory. The fingerlings were fed crumbled 2.0 mm size pellet of experimental diets twice daily to satiation between 8.00-9.00 hours. and 15.00-16.00 hours. Feeding was monitored for each unit to ensure that fishes were not underfed or overfed. Experimental units were cleaned daily while changing of total water. Weekly weight gain and feed intake were recorded for 10 weeks. A sensitive scale of 400 g capacity was used in weighing the fish andfeed.The data on weight gain; feed conversion ratio and survival rates for the dietary Diets were analyzed by one way ANOVA (Analysis of Variance)using Genstat software version12 (2009). The differences in mean were compared by Duncan multiple range test.

Temperature of water ranged from 27-29℃ and PH was between 6.9-7.3

Table 1. Gross composition of the experimental diets (%) (experimental values)

Ingredients	TRT I	TRT II	TRT III	TRT IV	TRT V	TRT VI	TRT VII
	PMO	SBO	GNO	BET	PKL	COD	CONT
Fishmeal (65.5% CP)	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Soy bean (44% CP)	51.00	51.00	51.00	51.00	51.00	51.00	51.00
Maize (9% CP)	7.16	7.16	7.16	7.16	7.16	7.16	7.16
Wheat offal (13% CP)	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Palm oil	8.00	-	-	-	-	-	-
Soy bean oil	-	8.00	-	-	-	-	-
Groundnut oil	-	-	8.0	-	-	-	-
Beef tallow	-	-	-	8.0	-	-	-
Pork lard	-	-	-	-	8.0	-	-
Cod liver oil	-	-	-	-	-	8.0	-
Bone meal	4	4	4	4	4	4	4
Vitamin E	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Vitamin premix	0.1	0.	0.1	0.1	0.1	0.1	0.1
Estimated crude protein	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Estimated digestable energy	2991.6	2991.6	2991.63	2991.6	2991.6	2991.5	2991.5

NB: PMO, SBO, GNO, BET, PKL, COD, CONT stand for palm oil, soy bean, ground nut oil, beef tallow, pork lard, cod liver oil based diet and control (zero oil supplement) respectively.
TRT= Treatment

2.2 Growth and Nutrient Utilization Indices

Weights of fish and feed consumption were obtained at weekly intervals. From the fish weights and feed consumption, the following parameters were determined:

Weight gain = $W_1 - W_0$ (g)

Relative Weight Gain (RWG%)=$(W_1 - W_0) / W_0 \times 100$ (%)

Specific Growth Rate (SGR %)= $\{(\ln W_1 - \ln W_0)/ T\} \times 100$ (%/week)

Where;

W_0: mean initial weight (g)
W_1: mean final weight (g)
T: time in 7 days between weightings

Feed conversion ratio (FCR) = feed intake (g) / wet weight gain (g)

Protein efficiency ratio (PER) = weight gain (g) / protein intake (g)

Net protein utilization (NPU) = $\{(BP_1 - BP_0)/ CP\} \times 100$

Where;

BP_0: Initial body protein content (g). crude protein content was determined according to the procedures of Association of Official Analytical Chemist (A. O. A. C, 2000) using triplicate samples for each determination, crude protein was calculated as Nitrogen Content × 6.25.
BP_1: Final body protein content (g)
CP: Protein intake (g)

2.3 Statistical Analysis

At the end of the experiments, recorded data were subjected to two-way ANOVA test using a Genstat software eight edition, 2005 package for statistical problem. All the means we're compared at 5% level of probability with Duncan multiple range tests. Similarly, responsiveness of fingerlings to treatments was evaluated.

3. RESULTS

The mean weight gain was not significantly different from treatments fed with palm oil, soya bean oil, beef tallow, and control (zero oil supplement) based diet.Treatments fed with ground nut oil and pork lard were significantly different ($P<0.05$) from treatments fed with cod liver oil. Feed intake varied significantly among treatments. However feed treatment was not significantly different from treatments fed with palm oil and soya bean oil based diets. However treatment fed with ground nut oil, beef tallow and control (zero oil supplement) diets were significant different from treatment fed with pork lard. These treatments were significantly different ($P <0.05$) from treatment fed with cod liver oil based diet.

Table 2. Shows mean weight gain (g), relative weight gain (%), feed conversion ratio and survival of fingerlings maintained on various experimental diets for 10 weeks

	Treatments							
Parameter	**COD**	**PMO**	**SBO**	**GNO**	**BET**	**PKL**	**CONT**	**SEM**
Mean weight gain (g)	7.39^{b}	8.91^{ab}	8.88^{ab}	9.01^{ab}	8.85^{ab}	9.85^{a}	8.32^{ab}	0.99
Feed intake (g)	9.98^{b}	10.34^{a}	9.12^{b}	8.33^{c}	8.27^{c}	7.85^{d}	8.64^{c}	0.49
Relative weight gain (%)	11.63^{b}	13.13^{a}	13.30^{a}	12.59^{ab}	11.78^{b}	9.38^{c}	11.54^{b}	1.938
Specific growth rate (%)	1.36	1.44	1.26	1.06	1.10	1.13	1.45^{NS}	0.28
Feed conversion ratio	1.76^{bc}	1.92^{c}	1.34^{ab}	1.19^{a}	1.16^{a}	1.59^{b}	1.26^{ab}	0.28
Protein efficiency ratio	2.18^{a}	1.44^{b}	2.54^{a}	2.66^{a}	2.62^{a}	2.60^{a}	2.34^{a}	0.24
Net protein utilization	56.30^{b}	43.20^{c}	45.90^{b}	63.28^{a}	36.27^{d}	46.84^{c}	38.61^{d}	4.32

Mean values with the same superscript on the same row are not significantly different (P>0.05)
NS= No Significant difference. SEM= Standard Error of Mean

Table 3. Carcass composition of initial *Clarias gariepinus* fingerlings and experimental diets after 70 days

Treatments	% Crude protein	% Lipid	% Ash	% Fiber	% MC	% NFE
Fish (initial) carcass	62.25	29.5	2.5	0.10	4.00	1.65
Cod liver oil	60.75	29.8	3.0	0.20	4.22	2.03
Palm oil	59.00	30.0	4.0	0.20	5.00	1.8
Soy bean oil	60.45	27.6	3.0	0.10	5.45	3.4
Groundnut oil	62.37	27.0	3.7	0.30	4.63	2.0
Beef tallow	58.56	32.0	3.2	0.20	5.0	1.04
Pork lard	59.54	31.0	3.0	0.20	5.0	1.26
Control (no oil inclusion)	57.34	10.8	2.5	0.30	4.00	25.06

NB: MC= Moisture content; NFE= Nitrogen free extract

4. DISCUSSION

Treatment fed with palm oil based diet had the highest feed intake of (10.34 g) and the lowest was recorded in treatment fed with pork lard (7.85 g). However, [7] reported increased consumption of diets containing pork lard relative to fish oil-based feeds, although when expressed as percent body weight, the differences in intake were minor (3.1 Vs 3.2% body weight/day for feeds containing 2% supplemental lipids).

Relative weight gain (RWG) showed no significant difference (P>0.05) between treatments fed with palm oil and soya bean oil based diet. However, treatments fed with cod liver oil, beef tallow and control (zero supplement) based diet were significantly different from treatment fed with pork based diet. These treatments were significantly different from treatment fed with ground nut oil. [8], who observed that African catfish, *Clarias gariepinus,* showed better growth when fed semi purified diets containing 10% palm oil as the sole dietary lipid compared with fish fed cod liver oil based diets. In another study, *Heterobranchus longifilis* was reported by [8] to grow better when fed experimental diets containing palm oil compared to fish fed diets with copra, peanut, cottonseed or cod liver oil as the lipid source.

There was no significant difference in the feed conversion ratio (P>0.05) (FCR) and Specific growth rate (SGR) of all the treatments indicating that food was better converted to flesh at different rate. FCR was highest in treatment fed with palm oil based diet (1.91) and lowest in treatment fed with beef tallow based diets (1.16). The result is similar to the result reported by [6] for *Clarias gariepinus* fed fish oil, sesame seed oil, groundnut oil, soybean oil and palm oil based diets, where all diets formulated were adequately consumed and SGR was marginally different among the treatments. [9] and [10] reported that growth and feed utilization efficiency of Atlantic salmon fed crude palm oil were comparable to fish fed equivalent levels of dietary marine fish oils. Similarly, Climbing perch, *Anabas testudineus,* fed 20% dietary palm oil was observed to grow just as well as fish fed a similar level of coconut oil or cod liver oil [11].

However, [12] reported utilization of coconut oil and peanut oil in catfish diet fed for eight weeks to be lower compared to groundnut oil which produced the highest growth. The lack of

statistical difference (P>0.05) across the experimental diet suggest that plant based lipid diets such as groundnut oil, palm oil, and Soyabean oil are well utilized by *Clarias gariepinus*. This is justified by the observation of [5] who observed that *Clarias gariepinus*, being a fresh water species is adapted to utilize more of plant based lipids. According to [13], protein efficiency ratio (PER) showed no significant difference between treatments fed with cod liver oil, soya bean oil, ground nut oil, beef tallow, pork lard and control (no oil supplement). However, these treatments were significantly (P <0.05) different from treatment fed with palm oil.

Studies have revealed that substantial use of vegetable oils as energy sources in fish diets yield positive growth responses in fish [14]. The results obtained in this study have shownthat plant-based oil sources could be used as an excellent nutrient base in catfish feed manufacture. All the experimental diets were adequately consumed by fish and fish showed no sign of stress. This may imply that there were no palatability problem and feed were adequately utilized. This report is similar to the observation of [12] in the utilization of coconut and peanut oil diets and [6] in the utilization of sesame seed and palm oil diets by *Clarias gariepinus.* In this study, there is no clear advantage of lipids from animal source over that of plant sources.

[15] earlier showed that vegetable oils can replace fish oil up to 12.5% inclusion level in catfish diets without feed intake associated problems. The 8% inclusion levels of the various oils used in the present study appeared to be within acceptable limits that ensures balances in lipid components for normal catfish growth [16].

5. CONCLUSION

Lipid is an important source of dietary energy for fish which have limited ability to utilize dietary carbohydrate for energy. When all the required essential nutrients are available in the diet, *Clarias gariepinus* will grow and survive well regardless of the lipid source. However, *Clarias gariepinus* are able to utilize plant based lipids sources better than animal based lipid sources in term of growth and carcass analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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