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Effects of fish oil replacement with palm kernel oil as lipid source on the growth performance of *Clarias gariepinus* fingerlings

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Research Paper

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Fish is one of the cheapest and direct sources of protein and micro nutrient for millions of people in Africa. This study investigated the effects of dietary palm kernel oil on growth performance of *Clarias gariepinus* fingerlings with the goal of replacing dietary fish oil with palm kernel oil . A 56 day feeding trial experiment was conducted using 20 *C. gariepinus* fingerlings in each of the five different net happas representing four treatments and the control experiment. The fish were fed at 5% body weight twice a day while monitoring the water quality parameters to determine the various growth parameters. The treatment with 40% and 60% replacement has the highest mean weight gain of 5.50g±0.01 and 5.30g±0.01 respectively while the treatment with 100% replacement has the least mean weight gain of 4.89g±0.07. Dietary palm kernel oil had significant effect on growth rate or feed conversion ratio. Thus, it is better to culture *C. gariepinus* with diets compounded with palm oil.

Key words: Palm kernel oil, replacement, treatment, growth, *C. gariepinus*, fingerlings.

INTRODUCTION

Aquaculture production in the developing world is greatly constrained by undersupply, scarcity and high cost of conventional fish feed (Fagbenro and Arowosegbe, 1991). The high cost of fish meal has been a major factor affecting the growth of fish culture in Nigeria. To reduce the use of fish meal without adversely displeasing the quality of fish feed, some plants and animal sources of protein have been investigated (Eyo and Olatunde, 1996; Fagbenro and Fasakin, 1996; Absalom et al., 1999, Fasakin et al., 2000). Feed is often considered as the single largest cost item and can represent over 50% of the operating cost in intensive aquaculture (El- Sayed, 1999). Moreover, fish feed alone account for between 60 and 75% of the total cost of fish production (Babalola, 2010). A general approach that have been adopted to reduce diet cost has been to develop low-cost diets by replacing the costly fish meal components with cheaper plant protein sources (Jackson et al*.,* 1982; Hossain and Jauncey, 1989; Webster et al*.,* 1992). Presently fish feed alone account for between 60 and 75% of the total cost of fish production (Babalola, 2010).

Fish raw materials (fish oil and fish meal) are the most expensive ingredients used in aqua feed production. 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. Their global production is around 100 times higher than that of fish oils (Bimbo, 1990). Vegetable oils are more abundant and often cheaper than marine fish oils and offer an added advantage of containing fewer organic contaminants (Jacobs et al*.,* 2004; Guruge et al*.,* 2005; Berntssen et al*.,* 2005; Higgs et al*.,* 2006). Therefore, replacement of fish oil with vegetable oil alternatives is necessary and is being practiced. The use of available lipids such as vegetable oils in the tropics may reduce costs, while producing a comparable or better-quality product compared to non-sustainable marine fish oils.

The available vegetable oil sources sunflower oil and sesame oil among others. Of these, palm oil is presently the most abundant vegetable oil produced in the world (Turchini et al., 2009), its products such as crude palm oil, refined palm olein or palm fatty acid distillate in the diets of tilapia has been shown to elicited growth and feed utilization efficiency comparable with fish fed equivalent levels of dietary marine fish oils (Ng et al., 2006). Crude palm oil has a deep orange-red colour due to the high content of carotenoids. It is the richest natural sources of β-carotene, tocopherols and tocotrienols which function as natural antioxidants (Nesaretnam and Muhammad, 1993). While most vegetable oils contain almost exclusively tocopherols, palm oil is unique because tocotrienols represent about 70% - 80% of the vitamin E content. These confer beneficial effects to growth and flesh quality when fish are fed high levels of palm oil in their diets (Lim et al., 2001, Ng et al., 2004). This would translate to longer shelf life for fish products.

However, there is need to explore some non-conventional feed ingredients which are under less competition for other uses by my man or otherwise and that will not have negative effects on the fish stocks in the wild.

Lipid sources in fish feed in addition to providing the cultured fish with fatty acids, play sparing role of supplying energy to the fish when the need arises. Lipids are known to supply about twice the amount of energy as proteins and carbohydrates (Sotolu 2010). Lipids typically comprise about 15% of fish diet. Supplying essential fatty acids (EFA) and serve as transporters for fat-soluble vitamins (Pertra et al., 2006).

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) (Pertra et al., 2006), 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 (Stubhang et al., 2007) which are readily available, cost effective and sustainable in utilization. Examples of such vegetable oil include palm oil (PO), soybean oil (SO) and sunflower oil (SFO) (Sotolu, 2010).

Palm kernel oil is currently the largest traded edible plant oil and accounts for about one quarter of the worlds fats and oil supply. Palm kernel oil is gotten from the kernel, the oil is distinct from palm oil in terms of its fatty acid composition, and level of saturation. About 81% of the fats in palm kernel oil are saturated while only 41% in palm oil are saturated (Harold, 2004). Hence, Palm kernel oil, been a cheap source of lipids with the necessary qualities to support optimum growth of fish was adopted for this experiment to be included in the diet of *Clarias gariepinus*.

The African catfish, *C. gariepinus* has shown considerable potential for use in intensive aquaculture and the fingerlings of this fish are widely produced in Nigeria (FAO 2009).

The objective of this work was to investigate the growth response of *C. gariepinus* fed with different levels of palm kernel oil as a dietary lipid source.

MATERIALS AND METHODS

Experimental design

A 56 days experiment was conducted at University of Agriculture fish farm, Makurdi, Benue state, Nigeria. Net happas measuring 1m x 1m x 1m ($1m^3$) were used for the experiment in earthen pond.

Diets and diet preparation

The various ingredients used for feed formulation and production include maize, soybeans and palm kernel oil which were purchased from a food market (Wadata Market) in Makurdi, Benue State, Nigeria where fresh farm produce are sold while fish meal, groundnut cake, salt, vitamin and mineral premix were purchased form a reputable animal feed shop in Makurdi. Table 1 shows the composition of the experimental and control diets.

Table 1. Percentage composition of Formulated Diets fed to *C. gariepinus* fingerlings.

Ingredients	T_0	T_1	T_2	T_3	T_4
Fish meal	25.05	25.05	25.05	25.05	25.05
Soyabean meal	26.35	26.35	26.35	26.35	26.35
Palm kernel oil	0.00	1.00	1.50	2.00	2.50
Fish oil	2.50	1.50	1.00	0.50	0.00
Maize	45.10	45.10	45.10	45.10	45.10
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Experimental fish

One hundred and twenty (120) *C. gariepinus* fingerlings were obtained from Philips fish farm in Wadata, Makurdi, Benue State, Nigeria and used in this study, weighing 5g on the average were procured from Philips fish farm in Wadata, Makurdi, acclimatized for seven (7) days and shared into happas at the rate of twenty (20) fish per happas. During acclimatization, the fish were fed Coppens feed two times a day at the rate of 5% of their Total Body Weight.

Table 2. Growth and nutrient utilisation of *C.gariepinus* fingerlings fed diets containing various levels of palm kernel oil.

Indices	T_0	T_1	T_2	T_3	T_4
Mean Initial weight(g)	1.45±0.00	1.45±0.00	1.45±0.00	1.45±0.00	1.45±0.00
Mean final weight(g)	6.64±0.01^b	6.95±0.01^a	6.75±0.01^b	6.20±0.03^d	6.34±0.07^c
Mean weight gain(g)	5.19±0.01^b	5.50±0.01^a	5.30±0.01^b	4.75±0.03^d	4.89±0.07^c
SGR(%day^{-1})	0.027±0.00^b	0.028±0.00^a	0.027±0.00^b	0.026±0.00^d	0.026±0.00^c
FCR	1.77±0.00^a	1.61±0.00^b	1.63±0.00^b	1.65±0.02^b	1.61±0.02^b
PER	1.44±0.00^c	1.58±0.00^b	1.57±0.00^b	1.57±0.01^b	1.63±0.02^a
ANPU	0.97±0.00^c	0.68±0.00^e	1.10±0.00^b	1.22±0.00^a	0.90±0.00^d
Survival rate (%)	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	90.00±0.00

Means in the same row with different superscripts differ significantly ($p<0.05$).

After acclimatization, the fish were then fed the compounded feed containing different inclusion levels of palm kernel oil, representing different treatments (T_1=1.0%, T_2=1.5%, T_3=2.0% and T_4=2.5%) and the control experiment (T_0=0.0%).

Data collection and analysis

The experimental fish were individually weighed on weekly basis to determine the weight gained. Also, the initial and final carcass analyses were carried out on the experimental fish before and after the feeding trial to determine their proximate composition using the method described by AOAC (2000). All test diets were chemically analyzed for crude protein, crude fibre, fat, ash, moisture, nitrogen free-extract and calorific value using standard methods (AOAC, 2000).

Determination of fish growth and performance and water quality data were collected on weekly basis and analysed, from which parameters such as Feed Conversion Ratio (FCR), Protein Efficiency Ratio (PER), Apparent Net Protein Utilisation (ANPU), Specific Growth Rate (SGR) and survival rate were calculated.

Water quality monitoring

Water parameters (temperature, pH and dissolved oxygen concentration) recorded thought the 65-day experimental period (APHA, 1995).The data were subjected to analysis of variance (ANOVA) and if significant ($P<0.05$) differences were found, Duncan's multiple range test was used to rank the group using SPSS version 17.0 (Statistical Graphics Corp, USA).

RESULTS

The result of nutrient utilization and growth performance of *C. gariepinus* fed five different levels of palm kernel oil are as presented in (Table 2). At the end of the 65th day of feeding experimental trials, fish exhibited significant weight gain, specific growth rate (SGR), protein efficiency ratio (PER) and feed conversion ratio (FCR). Fish fed on 1% (T1) had superior weight gains and SGR over other treatments ($p<0.05$). The result showed T1 with highest mean weight gain of 5.50±0.01 while T3 has the least mean weight gain of 4.75±0.03. There was high survival rate observed during the experiment. Feed fed on 1% (T_1) had superior weight gain and Specific Growth Rate (SGR) over other treatments ($P<0.05$).

The result showed T_1 with highest mean weight gain of 5.50±0.01 while T_3 has the least mean weight gain of 4.75±0.03.There was high survival rate observed during the experiment. (Table 3) shows the proximate composition of the diet which the fish were fed during the experiment. The result shows a significant difference between all the nutritional parameters for the treatment diets and the control. The highest values for treatment diets, crude protein (T_1), moisture (T_4), lipids (T_4), fibre (T_4), ash (T_o) and NFE (T_o).

The results presented in (Table 4) shows the mean proximate of *C. gariepinus* fingerlings fed the feed containing varying levels of palm kernel oil as the lipid source. The result shows significant differences in all the proximate composition parameters measured. Table 5 indicated some quality parameters of the bioassay water for the *C. gariepinus* fingerlings fed the feed containing varying levels of palm kernel oil as the lipid source.

DISCUSSION

The results of this trial, where fish oil was substituted with alternative lipid sources, hold promise that complete replacement of marine FO with vegetable oil and animal fats alternatives is a possibility in *C. gariepinus* diet. The result of the present study suggest that palm kernel oil can be used to replace fish oil with minimal adverse effect on *C. gariepinus* fingerlings growth, as reported for other fish species (Martino et al., 2002; Turchini et al.,

Table 3. Proximate composition of the diets containing different levels of palm kernel oil.

Parameters	T_0	T_1	T_2	T_3	T_4
Moisture (%)	10.85±0.02^e	11.73±0.02^d	11.89±0.01^c	12.16±0.01^b	12.96±0.02^a
Crude protein (%)	33.97±0.04^d	34.42±0.01^a	34.39±0.00^a	34.20±0.00^b	34.03±0.04^c
Fats (%)	8.31±0.00^c	10.92±0.01^d	11.81±0.03^c	12.30±0.01^b	12.37±0.03^a
Ash (%)	8.97±0.00^a	7.01±0.01^d	7.15±0.02^c	6.72±0.05^e	7.51±0.01^b
Fibre (%)	4.45±0.01^b	4.42±0.00^c	4.46±0.01^b	4.40±0.02^d	4.57±0.00^a
NFE (%)	33.45±0.04^a	31.52±0.03^b	30.30±0.05^c	30.22±0.03^c	28.56±0.03^d

Mean values on the same row with different superscripts are significantly different ($p<0.05$)
NFE: Nitrogen Free Extract = 100 – (Crude protein % + crude fibre % + crude lipids % + Ash %).

Table 4: Proximate Composition of *C. gariepinus* Fingerlings Carcass before and after Feeding Trials.

Parameters	Initial value	Final Value				
		T_0	T_1	T_2	T_3	T_4
Moisture (%)	58.51±0.01^e	65.77±0.01^b	65.96±0.01^a	63.79±0.01^c	62.50±0.10^d	63.90±0.01^c
Protein (%)	12.63±0.04^e	15.69±0.00^b	15.96±0.00^a	15.47±0.00^c	15.46±0.15^c	14.83±0.24^d
Fats (%)	5.39±0.05^e	8.28±0.03^g	8.58±0.10^c	8.75±0.07^{bc}	8.78±0.02^b	9.66±0.24^d
Ash (%)	5.20±0.27^c	7.15±0.04^a	6.43±0.00^b	6.41±0.00^b	6.18±0.05^b	7.15±0.09^a
Fibre (%)	3.07±0.07^d	4.62±0.00^c	4.88±0.08^b	4.89±0.08^b	4.89±0.07^b	5.06±0.05^a
NFE (%)	15.2±0.42^a	1.51±0.09^d	1.81±0.06^c	0.69±0.01^e	2.19±0.19^b	0.60±0.19^e

Means in the same row with different superscripts differ significantly ($p<0.05$).

Table 5. Quality Parameters (mean±standard error of mean) of the Bioassay Water.

Parameter	T_0	T_1	T_2	T_3	T_4
Temperature(^{0}C)	25.82±0.45	25.44±0.36	25.98±0.30	25.63±0.26	26.39±0.18
Dissolved Oxoygen (mg/l)	5.44±0.15	5.72±0.13	5.54±0.14	5.58±0.16	5.80±0.24
pH	6.47±0.11	6.50±0.12	6.60±0.10	6.68±0.12	6.51±0.11

No significant difference between means ($p>0.05$).

2003; Francis et al., 2006; Ochang et al., 2007a). The use of palm kernel oil in the diet of fish has significant effect on their growth performance. Lipids provide energy for fish. This is confirmed from the work of Okafor and Odiete (2002) which stated that prior to aestivation, *Protopterus annectens* stored quite a large quantity of fats. The fats were gradually being broken down to provide energy for maintenance of life processes during aestivation as the fish was starving (Okafor and Odiete, 2002; Okafor, 2008).

This study reveals that palm kernel oil could replace fish oil and give an optimum result at 1% inclusion level. The use of alternative vegetable oil sources hold promise that complete replacement of marine fish oil possible giving rise to reduce cost of aqua-feed production and the negative effects of aquaculture on wild fishes in which case the wild fish are used in aquaculture feed production. This is in agreement with the work carried out by Pie et al. (2004) who reported an improvement in carp fed dietary lipid. This finding is consistent with previous studies showing successful partial or total replacement of dietary fish oil with vegetable oil in African catfish as pointed out by Lim et al.,(2001), rainbow trout also (Madrigal et al., 2005), sharpsnout sea bream (Piedecausa et al.,2007), and Atlantic salmon (Rosenlund et al., 2001) without showing any negative effect on their growth and development. Also, FAO (1987) pointed out that palm kernel oil possess the 18-carbon poly unsaturated essential fatty acid needed by freshwater fishes for proper growth and development.

However, low performance was observed in fish fed with higher level of palm kernel oil (2.5%). This could be due to inability of the fish to breakdown excess lipid when compared with that fed 1.0%. In this study, increase in dietary lipid level was associated with decrease in feed intake which may be due to feed intake depression. This can be explained in line with the report of Craig and Helfrich (2009) that stated that freshwater fishes require the 18-carbon essential fatty acid produced by palm kernel oil in a range not beyond 0.5 – 1.5% of dry diet. A previous study by Ng et al. (2001) in which a hybrid tilapia was fed cod liver oil diet showed a depressed growth and feed efficiency which might be attributed to the higher omega-3 poly unsaturated Fatty Acid oncentrations found in cod liver oil which is also present in palm kernel oil (FAO, 1987). Also, growth of *Oreochromis aureus* has been reported to be depressed when fed more than 1% dietary linolenic acid (Stickney and McGeachin, 1983a)of which palm kernel oil also possess trace amount (FAO, 1987).

However, contradictory reports on the dietary requirements of fatty acids by freshwater fishes could be due to various factors such as length of experiment, nutritional history of the experimental fish, size of fish, source of dietary lipids as well as water temperatures.

Conclusion

Thus, it is better to culture *C. gariepinus* fingerlings with diets compounded with palm kernel oil as it could be a better and cheaper lipid source in the diets of *C. gariepinus*.

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