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Dietary Effects of Coconut Oil and Peanut Oil in Improving Biochemical Characteristics of *Clarias gariepinus* Juvenile

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Abstract

Attempt in reducing the high cost of feeding in aquaculture through the use of energy rich oils was taken as a means of protein sparing action. Juveniles of *Clarias gariepinus* with an average weight of 20.0±1.20 g were allotted at random, 5 fish per tank in a total of ten tanks and were fed five isocalorific and isonitrogenous diets containing 5% and 10% graded levels of coconut oil and peanut oil, respectively over a period of 6 weeks. Results obtained showed that fish fed diets containing graded levels of oil had significantly higher ($P<0.05$) weight gain, feed efficiency ratio and specific growth rate when compared to the control diet that had no oil. Among the oil diets, 5% inclusion level of peanut oil gave the highest feed and protein efficiency ratios (1.75 and 4.37, respectively). No significant difference was observed in weight gain, feed conversion ratio, and specific growth rate between fish fed 10% coconut oil and 10% peanut oil. The cholesterol level is lower in the control diet (198 mg/dl) compared to other diets with values ranging from 220-260 mg/dl. Carcass analysis shows no significant difference between the control diet and others in terms of the crude protein values; but the ether extract result of the carcass is significantly higher in the control compared to other diets (25.62>16.86). The lowest economic conversion ratio of 0.51 was obtained on the 5% peanut feed as compared to 0.73 for the control. Diet 1-4 which had graded level of oil had better ratios of feed conversion and economic conversion than the control without oil inclusion. Inferences from this study conclusively support the inclusion of graded levels of coconut and peanut oil in the diets of *Clarias gariepinus* for better growth and economic value in the sustenance of aquaculture.

Keywords: dietary effect, peanut oil, coconut oil,biochemical characteristic, *Clarias gariepinus*.

Introduction

Dietary lipids play an important role in commercial diets of fish as concentrated source of energy, essential fatty acids for growth and development of fish (Pie *et al.*, 2004). They are also an essential component of steroids and phospholipids used as precursors in the synthesis of certain vitamins and hormones. The use of dietary lipids can spare dietary proteins from use as energy and limit ammonia production through a process called protein sparing action (Gaylord and Gatlin, 2000). Higher energy levels generally come from increased dietary lipid as lipid is an energy dense nutrient and readily metabolised by fish (N.R.C., 1993). However, high dietary lipid content in the diet of fish could result in oxidative stress and invariably pathological conditions (Sakai *et al*., 1998). It could also result in decreased growth as a result of reduction in feed consumption (Daniels and Robinson, 1986), increased lipid deposition and poor nutritional value of fishmeal (Scaife *et al*., 2000).

Marine fish oils are traditionally used as the main dietary lipid source in many commercial fish feeds; but with the rapid development of aquaculture all over the globe, a great task is put on the availability of marine oil. According to Tacon (2003), global fish oil production has reached a plateau and is not expected to rise beyond the current level of production. To sustain this rapid growth in the industry, the reliance on future stock of fish oil must be checked and advanced production technology should be targeted towards possible alternatives.

Potential substitute for marine fish oil in aquafeed could be plant oils. This is probably because of more stable price and increase in production volume of plant oil (Bimbo, 1990). Examples of plant oil include almond oil, canola oil, corn oil, shea butter, cottonseed oil, grape seed oil, palm oil, peanut oil and coconut oil. However, the use of plant vegetable oils as the only lipid source in marine fish feed is limited either by low ability to convert linoleic and linolenic acid (abundant in many vegetable oil), into arachidonic, eicosapentaenoic and docosahexaenoic acids, which are essential for marine fish and are found in high concentration in fish oil (Piedecausa *et al*., 2007). Fatty acid requirement vary between fresh and marine water fish. The use of plant oil is more favoured by those species with an essential dietary requirement for n-6 fatty acids.

Coconut is grown all over the world for decoration as well as for its many culinary and non-culinary uses. Virtually every part of the coconut palm has some human use. Before now, coconut oil had received bad publicity because of its high level of saturated fat, but recent researches have corrected this misconception (Conrado, 2003). It has been found that the lauric acid present in coconut oil has antiviral, antiprotozoal, antibacterial properties and at the same time, increases body metabolism. Other advantages of coconut oil include being the most stable oil and its resistance to oxidative rancidity. Unlike most oils, coconut oil will not be damaged by warmer temperatures (Alice *et al.*, 2006). Coconut oil is very cheap and abundant in Nigeria compared to other oils. For now, it is not directly consumed by man so there is less competition on its usage.

Peanut oil on the other hand is organic oil derived from peanuts. 40-50% of the weight of the nut is oil and the major fatty acids in the oil are palmitic, oleic and linoleic acids. The oil also contains some 6-8% (total) of arachidonic acid, behenic acid, and other fatty acids. 51% of the oil in peanut oil is monosaturated oil, 30% polyunsaturated and 19% saturated oil (The American heritages, 2007). It is also very abundant because of the availability of groundnut for livestock feed.

Clarias gariepinus, also known as African mud catfish, is the most popularly cultured fish in Nigeria (Sogbesan and Ugwumba, 2006). It has the ability to feed on variety of food items ranging from Zooplankton to fish (Olaosebikan and Raji, 1998). Fish with omnivorous feeding habits may be able to use dietary vegetable oils in more efficient manner than the counterpart carnivorous species (Sala and Balesteros, 1997). Catfish has been credited for been hardy, resistance to handling stress; it has better growth and feed conversion abilities. The high quality and better taste of its flesh makes it a highly demanded fish, hence there is a need to increase the local production of this specie at cheaper production cost (Sogbesan and Ugwumba, 2008).

Considering the lower cost price and high availability of vegetable oils in the tropics, their potential as alternative dietary lipids source for fish needs to be investigated.

Materials and Methods

Culture System

The growth trial was carried out in 15 plastic tank aquaria (30 cm depth, 36 cm width and 52 cm length) containing 40 L of dechlorinated water and operated on a flow-through system. During the experiment, water temperature was recorded daily and ranged from 27°C to 31°C, ammonia monitored once a week and it was less than 0.4 mg/L, dissolved oxygen average was 5 mg/L and pH was around 6.8. The photoperiod was 12L/12D with light period between $07.^{00}$ to $19.^{00}$ hrs.

Experimental Diets

Five isonitrogenous and isoenergenic diets were formulated (average crude protein 40.2% and energy 2,839 kCal). The control diet had no oil while diets 1 and 2 had 5% and 10% inclusion level of coconut oil, respectively. Diets 3 and 4 had same inclusion of oil as in 1 and 2, but the oil type was peanut oil. The diet formulation is shown in Table 1. All ingredients were bought at the same time to avoid variations associated with batch differences and were thoroughly mixed and made into pellets (2 mm dimension) with a laboratory pellet pressers. All diets were later air-dried and stored for subsequent use.

Experimental Fish

From about 90 pieces of African mud catfish (*Clarias gariepinus*) juveniles, average weight 20.00±1.20 g were obtained from a local fish farm in Lagos, Nigeria and held in a 1000 L plastic tank upon arrival at our laboratory. All fish were acclimatized for 2 weeks and fed a commercial catfish pellet (42% crude protein). At the commencement of feeding trial, groups of five catfish juvenile per tank (mean weight,

Table 1. Formulation and estimated chemical composition of experimental diets fed to *Clarias gariepinus*

Ingredients %	Control	5% Coconut oil	10% Coconut oil	5% Peanut oil	10% Peanut oil
Fishmeal (72%)	20	20	20	20	20
Soybean meal	30	30	30	30	30
Groundnut cake	30	30	28	30	28
Maize	18	15	10	15	10
D-calcium phosphate	1.5	1.5	1.5	1.5	1.5
Fish premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Coconut oil	-	5.00	10.00	-	-
Peanut oil	-	-	-	5.00	10.00
Estimated crude protein	41.5	41.0	39.5	40.2	39.5
Estimated ether extract	4.47	9.35	14.0	9.35	14.0
Estimated energy (Kcal)	2800.5	2860.45	2825.3	2873.95	2834.5

*Vitamin A, 10,000,000 I.U.D.; D3, 2,000,000 I.U.D.; E, 23,000 mg; K3, 2,000 mg; B1, 3000 mg; B2, 6,000 mg; niacin, 50,000 mg; calcium pathonate,10,000 mg; B6, 5000 mg; B12, 25.0 mg; folic acid, 1,000 mg; biotin, 50.0 mg; choline chloride, 400,000 mg; manganese,120,000 mg; iron, 100,000 mg; copper, 8,500 mg; iodine, 1,500 mg; cobalt, 300 mg; selenium, 120 mg; antioxidant, 120,000 mg.

26.80±0.2 g) were stocked over 15 experimental plastic tank aquaria. Three tanks were randomly assigned to each of the 5 experimental diets. Fish were hand-fed close to apparent satiation at 4% body weight twice a day ($09.^{00}$ and $14.^{00}$ hrs). Uneaten food was collected 1hr after feeding and then dried for proper feed intake record. Recovery rate of uneaten food was assumed by placing weighed feed in tanks without fish for 1h. It was then collected, dried and weighed. The recovery rate was calculated as percentage of final dry weight to initial dry weight and used to calibrate the amount of food intake (Pie *et al*., 2004). Fish were batch-weighed weekly and daily feeding was adjusted accordingly. The feeding trial lasted for a period of 6 weeks.

Sampling Procedures and Growth Parameters Evaluation

Fish were weighed at the beginning of the experiment and weekly throughout 6 weeks of the experimental period. Feed intake was monitored for each experimental group in order to measure average feed intake and their effects on growth. These were determined by evaluating a number of growth and nutrient utilization indexes which include weight gain, specific growth rate (SGR), feed conversion ratio (FCR), protein intake and efficiency ratio and condition factor. At the end of the experimental period, 1.5 ml of blood was collected from the caudal peduncle of 2 fish each per experimental diet according to the methods of Joshi *et al*. (2002a). The blood samples were then dispensed into heparinised bottles to prevent coagulation. The capillary tubes were micro-centrifuged and the relative volume of the packed red blood cell was measured to determine the percent heamatocrit value (Joshi, 2002a). Other blood parameters measured included haemoglobin, percent plasma protein and cholesterol. The remaining fish were then used for carcass proximate composition analysis determination (A.O.A.C. 1997).

Data Computation

The weight gain record and feed supplied were computed every week and later used to compute growth, feed utilization and economic parameters.

Mean weight gain = mean final weight – mean initial weight

$$\text{Specific Growth Rate (\%/day)} = \frac{\text{Log}_e W_2 - \text{Log} W_1}{T_2 - T_1} \times 100$$

where, W_2 and W_1 represent – final and initial weight,

T_2 and T_1 represent – final and initial time

Feed conversion ratio (FCR) = Feed fed on dry matter / Fish live weight gain

Protein Efficiency Ratio (PER) = Mean weight gain per protein fed

Protein Intake (g) = Feed intake x crude protein of feed

The cost was based on the current prices of feed ingredients in the experimental locality (Nigeria) as of the time of purchase.

Economic Estimates

Based on the price of each raw material ($) and the amounts that were required to make the different diets, we calculated the cost/kg of each diet. The raw material prices used were average prices during the experimental period, due to the fact that there may be significant changes throughout the year. The economic conversion ratio (ECR) was determined using the following equation, ECR = Cost of diet x Feed conversion ratio (Piedecausa *et al*., 2007).

Statistical Analysis

The experimental design was Randomised Complete Block Design and the data collected was subjected to analysis of variance while the differences among means were separated by Fisher least square difference test. Effect with a probability of $P<0.05$ were considered significant.

Result

Growth Performance and Nutrient Utilization

Growth performance of African mud catfish fed diets with graded levels of oil were significantly higher ($P<0.05$) compared with the fish fed control diet without any oil (Table 2). While 10% level of inclusion of coconut oil resulted in significant weight gain better than 5% level, the contrary was obtained for the peanut treatment No significant difference was noticed in weight gain between the fish fed 10% coconut oil diets, and 5% peanut oil. Feed intake is significantly higher for fish on coconut oil diet compared to other feeds but the control diet is not significantly different from 10% peanut oil diet. Specific Growth Rate (SGR) was significantly different between the control and diets with dietary lipid ($P<0.05$) but between the 10% coconut oil diet and the 5% peanut oil, no significant difference was observed in the SGR. Feed Conversion Ratio (FCR) was significantly different between the control and test diet with the best value obtained for fish on diet 3. Between 10% coconut oil and 10% peanut oil, no significant difference was observed ($P<0.05$). The fish fed with 5% peanut oil seem to perform better than the fish on other experimental diets including the control in all the parameters measured virtually. No mortality was recorded among fish on the different experimental diets through the duration of the experiment.

Table 2. Growth performance and nutrient utilization patterns of fish fed graded levels of coconut oil and peanut oil

Parameters	Control	5% Coconut oil	10% Coconut oil	5% Peanut oil	10% Peanut oil
Mean Initial Weight(g)	26.80±2.31[b]	26.80±2.31[b]	26.90±2.32[a]	27.0±2.32[a]	26.90±2.32[a]
Mean Final Weight(g)	60.8±3.49[e]	70.0±3.74[a]	77.4±3.93[b]	77.6±3.94[a]	76.0±3.90[c]
Mean Weight Gain(g)	34.0±2.61[d]	43.2±2.94[c]	50.5±3.18[a]	50.6±3.18[a]	49.1±3.13[b]
Average Feed Intake(g)	29.63±2.43[b]	30.83±2.48[a]	30.97±2.49[a]	28.80±2.40[c]	29.47±2.44[b]
Feed Conversion Ratio(FCR)	0.87±0.41[a]	0.71±0.38[b]	0.61±0.35[c]	0.57±0.34[d]	0.60±0.35[c]
Feed Efficiency Ratio(FER)	1.15±0.48[e]	1.40±0.53[d]	1.64±0.57[c]	1.75±0.59[a]	1.67±0.58[b]
Protein Intake(g)	11.90±1.54[c]	12.64±1.59[a]	12.23±1.56[b]	11.58±1.52[e]	11.64±1.53[d]
Protein Efficiency Ratio(PER)	2.86±0.76[e]	3.48±0.83[d]	4.13±0.91[c]	4.37±0.93[a]	4.22±0.92[b]
Specific Growth Rate(%/day)	1.95±0.62[be]	2.29±0.68[d]	2.52±0.71[a]	2.50±0.71[b]	2.48±0.70[c]

Means on the same row with different subscript letters are significantly different (P<0.05).

Body Composition and Haematological Parameters

The effect of dietary lipids on whole body composition of African catfish is shown in Table 3. The ether extract and ash were significantly higher for fish on control diet while the % dry matter (DM) was significantly lower (P<0.05) for the control group. At both levels tested in the coconut oil diets (5% and 10%), no significant difference (P<0.05) was noticed in the percentage ether extract.

The addition of oil brought about significant decreases in the haematological parameters. The heamatocrit and the haemoglobin values, except 10% coconut oil diet (Table 4). Cholesterol values were significantly higher between the fish on control and other experimental diets with the highest value recorded for 10% coconut oil diet.

Regarding the economic estimates (Table 5), the control diet was the least expensive but 5% diet feed had the best Economic Conversion Ratio (ECR) when compared to 10% inclusion level of the different test oils. 5% peanut diet had the least FCR value despite having the same feed cost with diet 2. The ECR value of diet 2 comes only next to the 0.51 obtained for diet 3.

Discussion

Recent research has shown that substantial quantities of vegetable oil including coconut oil, palm oil and peanut oil can be used as energy substitutes in fish diets without negative effects on growth performance (Ng *et al*., 2003; Ng, 2004). This experiment yielded quite acceptable growth results and higher SGR when compared to the control diet. The results obtained for this study agreed with the growth improvement reported by Lim *et al.* (2001), Pie *et al.* (2004) and it confirms the suitability of the diets since there was no record of adverse effects on feed intake, growth and survival rate. The fish on the experimental diets showed satisfactory diet acceptance even at high (10% oil) inclusion levels. This indicates that there was neither palatability problem nor feed intake depression. Babalola and Adebayo (2007) fed earlier graded levels of plant oil to *Heterobranchus longfilis* fingerlings and up till 12.5% inclusion level, there was neither retarded growth nor feed intake associated problems. Although Ellis and Reigh (1991) reported that at high dietary lipid level, growth rate may be reduced due to reduced ability to digest and absorb high lipid, reduction in feed intake and or fatty acid imbalance in feed (NRC 1983). The present study showed that increase in dietary lipid level was not associated with decline in feeding rate. It could also be inferred that the level of oil being tested is not enough to cause any of the above side effects.

Improved feed conversion and protein efficiency ratio with increasing high lipid level in both oils tested, is in agreement with other studies (Einen and Roem, 1997; Weatherup *et al*., 1997; Pie *et al*., 2004). The improvement in PER could probably be that increased lipid level spared dietary protein conversion into energy (Chou and Shiau, 1996; Regost *et al*., 2001). On the contrary, Peres and Oliva-Teles (1999) did not observe any protein sparing effect of lipid when they fed European *Zea bass* on graded levels of dietary lipid. The explanation of Lim *et al.* (2001) is that theirs is a definite influence of source of non protein energy (lipid or carbohydrate) on the nitrogen retension and that dietary lipid may also influence the growth performance and protein utilization.

Inclusion of vegetable oils in the diets affects the fish fatty acid profile, but this effect is more obvious in marine species because of their limited ability to convert C18 into polyunsaturated fatty acid. According to the review of Henry *et al.* (1999), dietary lipid source and its degree of saturation can exert a significant effect on the energy flux and protein metabolism of the body. Changes in moisture content of whole fish carcass as a result of plant oil inclusion in the diet of red sea bream was noticed by Huang *et al.* (2007) and a reciprocal change in whole body lipid content compared to the moisture was also suggested by Bendiksen *et al.* (2003).

In this experiment, there was a decrease in body lipid composition, but an increase in crude protein content of the carcass. This could probably be that the quantity of oil used is not in excess of the fish requirement and better utilization of protein for growth as evident in the protein efficiency result obtained in this study. The use of vegetable oils reduces the N-3 series fatty acid and according to Bell

Table 3. Effect of dietary lipid levels on body composition of African mud catfish

Diet	Control	1	2	3	4
Dry matter %	64.06±3.58^d	71.11±3.77^b	69.74± 3.73^b	68.20±3.69^c	74.36±3.86^a
Crude protein %	26.69±2.31^c	28.75±2.40^b	29.50±2.43^a	29.63±2.43^a	29.06±2.41^b
Ether extract %	25.62±2.26^a	19.48±1.97^c	18.72±1.93^c	22.74±2.13^b	16.86±1.84^d
Ash %	0.450±0.30^a	0.210±0.20^c	0.180±0.19^d	0.380±0.26^b	0.360±0.27^b

Means on the same row with different subscript letters are significantly different (P<0.05).

Table 4. Heamatological analysis of *C. gariepinus* fed graded levels of plant oil

Heamatological indices	Control	5% Coconut oil	10% Coconut oil	5% Peanut oil	10% Peanut oil
Heamoglobin, Hb (g/dl)	13.0±1.61^a	12.0±1.55^c	13.4±1.64^a	12.0±1.55^c	12.5±1.58^b
Heamatocrit, PVC (%)	40.0±2.83^b	37.0±2.72^c	42.0±2.90^a	37.0±2.72^c	38.0±2.76^c
Chemistry					
Protein (g/dl)	4.0±0.9^b	3.4±0.82^d	4.2±0.92^a	3.8±0.87^c	3.9±0.88^b
Cholesterol (mg/dl)	198±6.29^d	229±6.77^b	266±7.29^a	220±2.10^c	230±6.78^b

Means on the same row with different subscript letters are significantly different (P<0.05).

Table 5. Economic analysis results for experimental diets

	Control	5% Coconut oil	10% Coconut oil	5% Peanut oil	10% Peanut oil
FCR	0.87	0.71	0.61	0.57	0.60
Feed cost($)	0.84	0.88	0.90	0.90	0.94
ECR	0.73	0.63	0.55	0.51	0.56

et al. (2002) and Piedecausa *et al.* (2007), the fish muscle N3/N6 lipid ratio is strongly influenced by the diets N3/N6 ratio. Feeding on vegetable oils lowered the muscle content of eicosapentaenoic (EPA), decosahexaenoic acid (DHA) and archidioc acid (ARA) and this kind of effect has been noticed earlier in trout (Caballero *et al.*, 2002) and African catfish (Ng *et al.*, 2003). The haematological and blood chemistry result showed positive effect of plant oil inclusion level in the diet of *C. gariepinus* diet.

Blood is a good indicator in determining the health of an organism (Joshi *et al.,* 2002c), it also acts as a pathological indicator of the whole body, and hence haematological parameters are important in diagnosing the functional status of an animal exposed to suspected toxicant (Omitoyin, 2006). Haematological characteristics of most fish have been studied with the aim of establishing normal value range and any deviation from it may indicate a disturbance in the physiological process (Rainza-paiva *et al.*, 2000). The values obtained in this experiment were within the normal ranges recommended for *Clarias gariepinus (*Joshi *et al.*, 2002b). The heamatocrit and blood protein values for both the control and test diets were higher than the result obtained by Omotoyin (2006) for fish fed a control diet and poultry litter diet. The values obtained by Gabriel *et al.* (2004) in their study on the effect of sex, environment, health status and acclimatization on blood parameters were also within the range obtained in this study. Considering the fact that coconut oil had antiprotozoal, antiviral and antibacterial activities (Ogbolu *et al.*, 2007), it could be suggested probably as reason why the haematological properties of fish in this particular group seem higher than the control and the peanut oil diet.

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