

## Protein Sparing Effects of Lipids in The Practical Diets of *Oreochromis niloticus* (Nile tilapia)

\*A.M. Orire and S.O.E. Sadiku

Department of Water Resources, Aquaculture and Fisheries Technology  
 Federal University of Technology, P.M.B 65, Minna, Niger State-Nigeria.  
 [Corresponding Author: E-mail: [Orire9@yahoo.com](mailto:Orire9@yahoo.com); Tel.: +234-70325595]

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**ABSTRACT:** A feeding trial was conducted to establish the protein sparing effects of various lipid sources in *Oreochromis niloticus* fingerlings (mean weight 8.05 ±0.05g) for 8 weeks. Nine experimental diets and one commercial reference diet was used for the trial. The experimental diets comprised of three levels of lipid (L) and protein (P) designated as 15P : 25L, 10P : 30L and 5P : 35L ratios. Three lipid sources used were groundnut oil, palm oil and fish oil. The result obtained showed significant differences (P<0.05) among the lipid sources. Fish oil showed significant differences in the mean weight gain (MWG), specific growth rate (SGR), feed conversion rate (FCR), and apparent net protein utilization (ANPU) for all the treatments. The carcass compositions was also significant (P<0.05) in moisture, lipid and ash which resulted in protein sparing at 10% inclusion level thereby bringing down crude protein inclusion level to 30%. Groundnut oil did not show significant difference (P>0.05) in the MWG, and SGR for all the treatments, but showed significant difference (P<0.05) for the FCRs, PERs and ANPUs. The palm oil based diets also gave significant difference (P<0.05) in the MWG, SGR, PER and ANPU. There was significant difference (P<0.05) in the carcass compositions. Groundnut oil was observed to spare protein at 10% inclusion level while palm oil spared same at 15% inclusion level. These findings will ensure reduction in the crude protein inclusion level in the diets of *O. niloticus* using these lipid sources.

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### INTRODUCTION

The imperative need to reduce feed cost in aquaculture has been reported (Jauncey, 1998; Peres and Oliva-Teles, 2002; Jamu and Ayinla, 2003; Martino *et al.* 2002). The protein component of feed is responsible for its high cost (Shiau and Lin, 1993) and most especially fishmeal (NRC, 1993). Thus, efficient transformation of protein into tissue protein for growth is of immense significance (Weatherly and Gill, 1987). Furthermore, metabolization of protein by fish should be directed towards body protein synthesis rather than energy supply (Shiau, 1997; Borba *et al.* 2006). Growth rates of fish may be highly variable and, in many cases, appear to be limited by food availability, quality and quantity of dietary non-protein to protein nutrients. In hybrid tilapia (*Oreochromis niloticus* x *O. aureus*), optimum dietary lipid for maximum growth has been reported to be about 12% (Chou and Shiau, 1999). However, Tilapia has been reported to utilize vegetable oil that is high in omega 6 (n-6) fatty acids better than fish oil that is rich in omega 3 (n-3) fatty acids for maximum growth (NRC, 1993). Although the available

dietary energy plays an important role in determining body lipid deposition, the dietary lipid content is regarded as the most important factor influencing carcass lipid in fish (Sargent *et al.*, 1989; Hanley, 1991). An increase in dietary lipid level elevates the body lipid level in *O. niloticus*. The increase in carcass lipids with increasing dietary lipids and the consequent reduction in carcass proteins have been reported for most species investigated (Refstie and Austreng, 1981; De-Silva *et al.*, 1991). The authors suggested that Tilapia do not utilize the additional energy provided by the supplementary dietary lipid (over 5%) for growth. The objective of the present study was to examine the protein sparing effects of lipids in *O. niloticus*.

### MATERIALS AND METHODS

**Experimental System:** The study was conducted in a recycling water system of the Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. Ten-week old (8.05 ± 0.05g) fingerlings of *O. niloticus* were obtained from the

hatchery unit of National Institute of Freshwater Fisheries Research (NIFFR), NewBussa, Niger State. The fishes were randomly assigned into groups of 15 fishes per tank and each group was placed in an individual 50-L cylindrical tank.

### Experimental Diets

Nine experimental diets and one commercial reference diet [(CRD) - Coppens Catfish feed from Netherland)] were used for the feeding trial. The experimental diets were formulated using equational method of two unknowns. The diets were formulated to contain three levels of protein (P) and three levels of lipid (L) ratios (15P : 25L, 10P : 30L and 5P : 35L %), using three lipid sources; Fish oil, Palm oil and Groundnut oil and Fishmeal as protein source. The experimental design 3 x 3 factorial of completely randomized design (CRD). The table of formulation and its proximate analysis is shown in Table 1. The fishes were fed twice daily between the hours 10 .00 and 16.00 to apparent satiation for 8 weeks.

### Experimental Analyses and Growth Parameters:

Proximate analysis for moisture, crude protein, crude lipid and ash of carcass, feed ingredients and experimental diets were determined according to the methods of AOAC (2000). Final values for each group represent the arithmetic mean of the triplicates. Feed intake was monitored to measure average feed intake and their effects on growth. The growth and nutrient utilization parameters measured include weight gain, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), apparent net protein utilization (ANPU). The growth parameters were computed as stated below;

Mean weight gain = Mean final weight ó mean initial weight

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

Where,  $W_2$  and  $W_1$  represent ó final and initial weight,

$T_2$  and  $T_1$  represent ó final and initial time

Feed conversion ratio ó 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.

Apparent net protein utilization (ANPU %) = (P2 - P1) / Total protein consumed (g) X 100

Where, P1 is the protein in fish carcass (g) at the beginning of the study and P2 is the protein in fish carcass (g) at the end of the study.

**Statistical analysis:** The experimental design was factorial and the data was subjected to one way analysis of variance to test their significant levels at 5% probability, the means were separated using Tukey's method and the regression coefficients were analysed using Minitab Release 14 while the graphs were drawn using the Microsoft excel window 2007.

### RESULTS

The diet formulation and proximate analysis are presented in Table 1. The results of growth and feed performance of *O. niloticus* fed different sources of lipids at different levels of crude protein are presented in Tables 2 and 3. The diets were accepted by the fishes throughout the experiment. The growth performances were significantly ( $P < 0.05$ ) affected by the levels of protein and lipids in the diets.

**Groundnut oil (GO) based diets:** There was significant difference ( $P < 0.05$ ) in the utilization of groundnut oil (GO) as dietary lipid source for the growth of *O. niloticus* at different L/P ratios. However, there were no significant differences ( $P > 0.05$ ) in the mean weight gains (MWG) and specific growth rate (SGR) and the feed conversion rate (FCR) for the three L/P ratios fed (Table 2). There were no significant differences ( $P > 0.05$ ) in the PER values for L /P ratios 10:30 (0.87) and 5:35 (0.91) respectively. However, the ANPU values was significant ( $P < 0.05$ ) for L/P ratio 15:25 which gave the highest value (72.67) followed by 5 : 35 (53.32) while the 10 : 30 L/P ratio gave the lowest value (9.09) (Table 2). The body protein value was significantly high for 15 : 25 and 5 : 35 without significant difference ( $P > 0.05$ ) between the treatments. Furthermore, diet containing L/P ratio of 10 : 30 had the highest lipid, ash and moisture contents (Table 3). The survival rate was highest for 5 : 30 (96.67 %) L/ P ratio and lowest for 15 : 25 (70.67 %) (Table 2).

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**Palm oil based diets:** Palm oil based diets also showed significant difference ( $P < 0.05$ ) for all the treatments in the growth performance (Table 2). The L/P ratio of 10: 30 gave the highest MWG, SGR and PER (2.86, 0.51, 4.28 respectively). The ANPU was highest for 15 : 25 (68.94) followed by 10 : 30 (50.30) while 5 : 35 gave the least value of 2.98. The body protein was slightly significantly ( $P < 0.05$ ) lower than the L/P ratio of 15: 35. The L/ P ratio for 15: 35 also gave significantly ( $P < 0.05$ ) high body lipid and ash than other L/P ratios but has lowest moisture percentage (Table 3). The survival percentage was highest for L/P ratio 5: 35 (90.00 %) and lowest with diet containing L/P ratio 10: 30 (56.67 %) (Table 2).

**Fish oil based diets:** Diet containing 10:30 L/P ratio gave the highest MWG, SGR, PER and lowest FCR but significantly low ANPU value (14.44) (Table 4.3.3). However, the ash and moisture contents of 10: 30 were significantly higher ( $P < 0.05$ ) than diets of other L/P ratios. The L/P ratio 5 : 30 diets perform efficiently better than L/P ratio of 15 : 25 diets, however, the ANPU value for diet containing 15 : 25 was significantly higher ( $P < 0.05$ ) than that of 5:35 L/P ratio whose body lipid and ash were equally significantly lower ( $P < 0.05$ ) as shown in Table 3. The survival rate was significantly higher ( $P < 0.05$ ) for diets containing L/P ratios 15 : 25 and 5 : 35 (93.33 % respectively) (Table 2).

**Growth response:** The growth response as shown in Figures 1-3 indicated protein sparing effects of lipids in *O. niloticus*. The groundnut oil based diets exhibited a bundle growth response, a situation where all the treatments exhibited same trend of growth pattern almost throughout the feeding trial. The palm oil and fish oil based diets also showed similar growth pattern to that of groundnut oil but at the 8<sup>th</sup> week palm oil protein sparing appears to arise.

### DISCUSSION

The results showed that Groundnut oil was efficiently utilized for growth at all levels of inclusions as observed in the growth curve (Figure 1), however, the growth performance at 5:30 lipid/protein (L/P) ratio gave a better growth performance than other ratios. The lipid inclusion

level at 10% would have been best if not for the low apparent net protein utilization (ANPU) value recorded. The low ANPU indicated that the high lipid level was not utilized for tissue development as evident in the carcass lipid (Table 3). The L/P ratio at 15 : 25 even though has low MWG and SGR values gave the highest ANPU value.

The Palm oil based diets were also utilized by *O. niloticus*. The mean weight gain was highest at lipid level of 10% and crude protein level of 30% with high SGR, PER but with low ANPU values. However, when the lipid level was lowered to 5% and crude protein level increased to 35%, there was decline in growth. Moreover, increasing the dietary lipid to 15% while reducing crude protein to 25%, there was efficient utilization of the diets and the nutrients which resulted in lowest FCR value and highest ANPU value. The poor growth performance observed at L/P of 5:35 indicated inadequate energy level in the diets for the requirement of tilapia. Thereby resulting in the metabolization of crude protein for energy as was evident in the low ANPU value obtained. The L/P ratio at 15:25 indicated nutrient utilization with concomitant increase in the body lipid. At this level of L/P ratio, *O. niloticus* appeared to be incapable of utilizing the excess lipid for energy which invariably was deposited. This phenomenon has been reported for several species (Refstie and Austeng, 1981; Sargent *et al.* 1989; Hanley, 1991). Similarly, DeSilva *et al.* 1991 also stated that increasing dietary lipid increases body lipid and decreases carcass protein in *O. niloticus* and other species.

The utilization of dietary lipids for energy as non-protein source is subject to fatty acid component and source of lipid (Ng and Cheng, 2006). The results obtained indicated depressed growth in *O. niloticus* fed with fish oil compared with other vegetable oils like groundnut oil and palm oil. Kanazawa *et al.* (1980) established that Tilapia exhibits depressed growth when its diets is supplemented with 18 : 3n-3 or n-3 highly unsaturated fatty acid (HUFA). Ng *et al.* (2001) also reported that hybrid tilapia fed cod liver oil showed significant depressed growth and feed efficiency ratio, which was attributed to high n-3 HUFA in the cod liver oil. However, Chou and Shiau (1996) reported that the optimal dietary

lipid for the maximum growth of hybrid Tilapia (*O. niloticus* x *O. Aureus*) is about 12%.

The low feed and nutrient utilization observed at 5 : 35 L/P ratio for all the lipid sources could be attributed to insufficient dietary energy in the diet to meet the energy requirement of the fish. At this instance, the excess protein would be channeled towards energy production (Smith, 2009; Wilson, 1984). This is uneconomical from the production point of view (Borba *et al.*, 2006; Shiau, 1997; Lovell, 1988). The increment of lipid to the highest level of 15 % gave improved performance for all the lipid sources. However, the palm oil based diets had the highest level of utilization than other lipid sources for growth. The efficient utilization of palm oil by fish more than any other vegetable oils has been reported by several authors (Ng and Chong, 2006; Kaushik, 2004, Ng, 2004 and Hardy *et al.*, 1987). The inclusion of dietary palm oil up to 10% was utilized for energy requirement of the fish, thereby, sparing the available protein for growth.

On the growth response, the groundnut oil based diets exhibited a bundle growth pattern for all the treatments irrespective of levels of lipid-protein inclusion. This trend indicated the ability of *O. niloticus* to utilize vegetable oil of groundnut origin up to 15 % without any negative effects on the growth and health of the fish (Figure 1). This level of lipid actually spared protein for growth thereby allowing for reduction of crude protein level to 25 %. The palm oil based diets spared protein for growth at all levels of input up to the 7<sup>th</sup> week of feeding trial when dietary palm oil level at 10 % began to spare more than other

ratios (Figure 2). The capability of tilapia to utilize palm oil has been reported by Ng *et al.* (2001). The reason is attributed to the omega 6 fatty acid in vegetable oil (Okoye *et al.* 2001). Furthermore, the fish oil based diets optimally spared protein for growth at 10 % inclusion level beyond which there was decline in growth. Huang *et al.* (1989) reported hybrid tilapia *O. niloticus* x *Oreochromis aureus* fingerlings fed 8 % fish oil showed no difference in growth and feed efficiency after 10 weeks on the diets. This observation pointed to the limited ability of tilapia to utilize fish oil over vegetable oil due to the concentration of omega 3 fatty acid in the former (Kanazawa, 1985; Okoye *et al.* 2001). Furthermore, Aderolu and Akinremi (2009) reported satisfactory diets acceptance at 10 % dietary lipid inclusion levels. Babalola and Adebayo (2007) also reported that *Heterobranchus longifilis* fingerlings fed graded levels of plant oil up to 12.5 % inclusion level neither showed retarded growth nor feed intake associated problems.

Therefore, in this study, fish oil spared protein for growth at 10 % inclusion dietary inclusion level thereby lowering crude protein to 30 %. However, other groundnut oil and palm oil spared protein up to at 10% and 15% respectively, thereby lowering the crude protein level to 30% and 25%.

## **CONCLUSION**

Findings from the feeding trial showed protein sparing of lipids in *O. niloticus*. The three lipid types tested spared protein for growth at various inclusion levels.

Table 1: Diets Formulated and their proximate composition

Formulation (%)	GROUNDNUT OIL BASED DIETS				PALM OIL BASED DIETS				FISH OIL BASED DIETS				CRD
	15 : 25	10 : 30	5 : 35	0.00	15 : 25	10 : 30	5 : 35	0.00	15 : 25	10 : 30	5 : 35	0.00	
Groundnut oil	76.14	61.93	49.85	0.00	76.14	61.93	49.85	0.00	76.14	61.93	49.85	0.00	
Palm oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Fish oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.14	61.93	49.85	0.00	
Fishmeal	18.85	33.06	45.14	0.00	18.85	33.06	45.14	0.00	18.85	33.06	45.14	0.00	
Vitamin/Mineral Premix	5.00	5.00	5.00	0.00	5.00	5.00	5.00	0.00	5.00	5.00	5.00	0.00	
<b>Total</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>	<b>99.99</b>
<b>Proximate Analysis (%)</b>													
Crude protein	25.09	30.45	35.37	24.89	30.14	34.55	26.01	29.45	35.27	29.45	35.27	29.45	35.27
Crude lipid	11.12	22.89	16.31	14.51	11.46	5.95	15.04	11.50	5.07	11.50	5.07	20.87	45.78
Crude fibre	10.96	22.99	10.64	23.64	18.92	20.50	19.70	21.41	20.87	21.41	20.87	20.87	15.6
Ash	5.10	21.60	11.32	12.58	12.64	12.20	12.82	11.21	12.44	11.21	12.44	12.44	9.42
NFE	22.49	20.86	21.40	21.96	22.51	20.70	24.13	22.12	22.40	22.12	22.40	22.40	10.00
Moisture	2.10	4.10	5.21	2.42	4.15	6.10	2.30	4.31	3.95	4.31	3.95	3.95	10.2
	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

Table 2: Mean growth parameters/nutrient efficiency of *O. niloticus* fed various Lipid/Protein ratios for 8 weeks

Growth Parameters	GROUNDNUT OIL BASED DIETS			PALM OIL BASED DIETS			FISH OIL BASED DIETS			CRD 45% ±	SD ±
	15 : 25	10 : 30	5 : 35	15 : 25	10 : 30	5 : 35	15 : 25	10 : 30	5 : 35		
Initial Body Wt. (g)	8.65 <sup>a</sup> ±0.11	8.74 <sup>a</sup> ±0.14	8.68 <sup>a</sup> ±0.06	8.58 <sup>a</sup> ±0.13	8.66 <sup>a</sup> ±0.15	8.52 <sup>a</sup> ±0.32	8.73 <sup>a</sup> ±0.04	8.52 <sup>a</sup> ±0.19	8.78 <sup>a</sup> ±0.19	8.64 <sup>a</sup> ±0.13	0.02
Final Body Wt. (g)	8.80 <sup>bc</sup> ±0.52	9.10 <sup>bc</sup> ±0.88	8.88 <sup>bc</sup> ±0.78	10.16 <sup>b</sup> ±2.86	11.52 <sup>a</sup> ±4.35	9.25 <sup>bc</sup> ±0.33	8.74 <sup>bc</sup> ±0.36	8.87 <sup>bc</sup> ±0.38	8.98 <sup>bc</sup> ±0.25	10.04 <sup>b</sup> ±1.66	1.78
Weight gain (g)	0.15 <sup>bc</sup> ±0.46	0.37 <sup>bc</sup> ±0.75	0.20 <sup>bc</sup> ±0.90	1.58 <sup>ac</sup> ±2.80	2.86 <sup>a</sup> ±4.33	0.73 <sup>c</sup> ±0.37	0.01 <sup>b</sup> ±0.45	0.36 <sup>bc</sup> ±0.42	0.19 <sup>bc</sup> ±0.08	1.40 <sup>ac</sup> ±0.99	1.77
SGR (%/Day)	0.03 <sup>b</sup> ±0.06	0.07 <sup>b</sup> ±0.12	0.04 <sup>ab</sup> ±0.16	0.30 <sup>a</sup> ±0.53	0.51 <sup>a</sup> ±0.63	0.15 <sup>ab</sup> ±0.07	0.02 <sup>b</sup> ±0.06	0.07 <sup>b</sup> ±0.38	0.04 <sup>b</sup> ±0.01	0.27 <sup>ab</sup> ±0.17	0.13
FCR	2.66 <sup>cd</sup> ±2.30	1.93 <sup>bd</sup> ±0.00	1.99 <sup>bd</sup> ±0.00	0.22 <sup>b</sup> ±0.17	1.48 <sup>bd</sup> ±1.74	2.50 <sup>cd</sup> ±2.36	3.63 <sup>c</sup> ±0.00	2.28 <sup>d</sup> ±0.00	5.23 <sup>a</sup> ±0.00	2.00 <sup>bd</sup> ±1.04	1.76
PER	0.43 <sup>b</sup> ±0.49	0.87 <sup>bc</sup> ±0.83	0.91 <sup>bc</sup> ±1.20	3.77 <sup>a</sup> ±4.99	4.28 <sup>a</sup> ±6.47	1.68 <sup>b</sup> ±1.17	0.28 <sup>c</sup> ±0.38	0.48 <sup>bc</sup> ±0.57	0.31 <sup>c</sup> ±0.13	1.46 <sup>b</sup> ±1.03	2.88
ANPU (%)	72.81 <sup>a</sup> ±0.01	9.09 <sup>f</sup> ±0.01	53.32 <sup>b</sup> ±0.01	68.94 <sup>b</sup> ±0.00	50.30 <sup>bc</sup> ±0.01	2.98 <sup>g</sup> ±0.01	61.48 <sup>c</sup> ±0.01	14.44 <sup>e</sup> ±0.01	56.79 <sup>bc</sup> ±0.01	15.31 <sup>d</sup> ±0.01	0.01
Survival (%)	76.67 <sup>d</sup> ±15.28	83.33 <sup>c</sup> ±15.28	96.67 <sup>a</sup> ±5.77	60.00 <sup>e</sup> ±36.06	56.67 <sup>de</sup> ±45.09	90.00 <sup>b</sup> ±10.00	93.33 <sup>b</sup> ±5.77	90.00 <sup>b</sup> ±14.14	93.33 <sup>b</sup> ±5.77	86.67 <sup>bc</sup> ±15.28	21.36

Means on the same row carrying letter(s) with different superscript(s) are significantly different from each other (P<(05).

**Table 3:** Body composition of *O. niloticus* fed various Lipid/Protein ratios for 8 weeks

Carcass Analysis	Initial	GROUNDNUT OIL BASED			PALM OIL BASED DIETS			FISH OIL BASED DIETS			CRD 45%	SD ±.
		15 : 25	10 : 30	5 : 35	15 : 25	10 : 30	5 : 35	15 : 25	10 : 30	5 : 35		
Moisture	10.12 <sup>d</sup> ±0.01	4.61 <sup>f</sup> ±0.01	10.26 <sup>d</sup> ±0.01	6.78 <sup>e</sup> ±0.01	4.65 <sup>f</sup> ±0.01	4.52 <sup>f</sup> ±0.01	11.26 <sup>c</sup> ±0.01	3.19 <sup>ef</sup> ±0.01	21.14 <sup>b</sup> ±0.01	6.79 <sup>e</sup> ±0.01	28.50 <sup>a</sup> ±0.01	±0.01
Crude protein	41.04 <sup>cd</sup> ±0.01	59.60 <sup>a</sup> ±0.01	43.90 <sup>d</sup> ±0.01	59.90 <sup>a</sup> ±0.01	58.19 <sup>b</sup> ±0.01	56.19 ±0.01	42.09 <sup>cd</sup> ±0.01	57.02 <sup>b</sup> ±0.01	45.02 <sup>b</sup> ±0.01	61.07 <sup>a</sup> ±0.01	48.05 <sup>c</sup> ±0.01	±0.01
Lipid	19.99 <sup>c</sup> ±0.01	23.99 <sup>b</sup> ±0.01	20.99 <sup>c</sup> ±0.01	15.99 <sup>d</sup> ±0.01	12.99 <sup>e</sup> ±0.01	26.99 <sup>a</sup> ±0.01	21.66 <sup>c</sup> ±0.57	16.99 <sup>d</sup> ±0.01	12.99 <sup>e</sup> ±0.01	13.32 <sup>e</sup> ±0.02	12.99 <sup>e</sup> ±0.01	±0.21
Ash	22.99 <sup>a</sup> ±0.01	11.49 <sup>e</sup> ±0.01	20.49 <sup>b</sup> ±0.01	14.79 <sup>bc</sup> ±0.01	14.99 <sup>bc</sup> ±0.01	23.79 <sup>a</sup> ±0.01	13.42 <sup>d</sup> ±0.01	16.51 <sup>c</sup> ±0.01	19.49 <sup>b</sup> ±0.01	13.99 <sup>d</sup> ±0.01	8.99 <sup>f</sup> ±0.01	±0.01

Means on the same row carrying letter(s) with different superscript(s) are significantly different from each other (P<0.05).

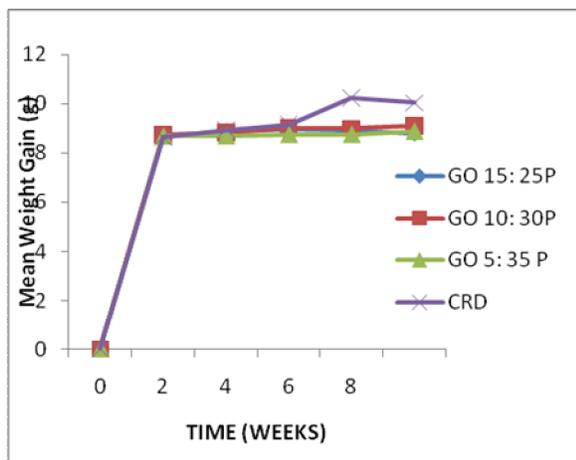


Fig. 1: Growth response of *O. niloticus* fed with Groundnut oil based-diets at different Lipid/Protein ratios for 8 weeks

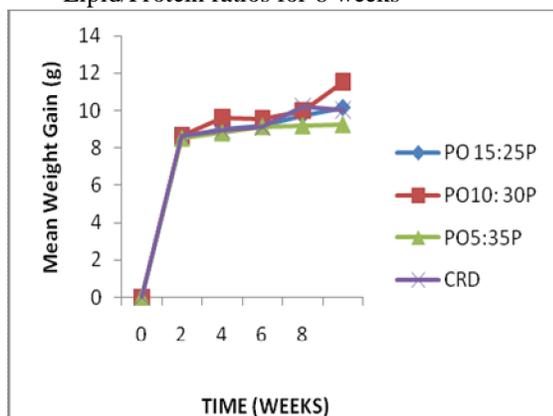


Fig. 2: Growth response of *O. niloticus* fed with Palm oil based-diets at different Lipid/Protein ratios for 8 weeks

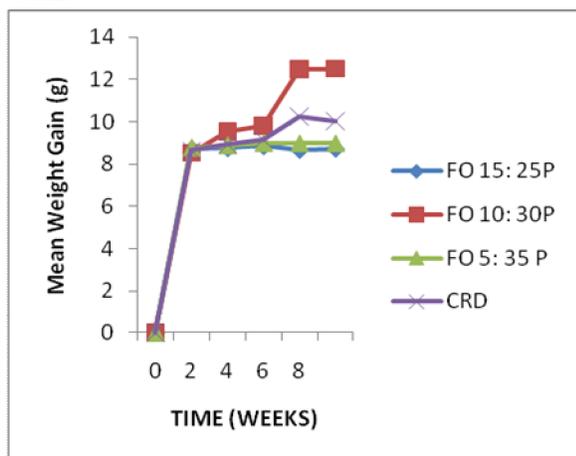


Fig. 3: Growth response of *O. niloticus* fed with Fish oil based-diets at different Lipid/Protein ratios for 8 weeks

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