Influence of dietary palm oil on growth and carcass composition of *Heterobranchus longifilis*.

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ABSTRACT

Supplies of marine fish oil (FO) are limited and continued growth in aquaculture production dictates that substitutes must be found that do not compromise fish health and growth. This study investigated the suitability of palm oil (PO) as a replacement for FO (cod liver oil) in diets of H. longifilis. Triplicate groups of H. longifilis fingerlings were fed five practical-type diets in which the added lipid was either 100% FO and 0% PO; 75% FO and 25% PO; 50% FO and 50% PO; 25% FO and 75% PO; or 0% FO and 100% PO for 8 weeks. There were no significant effects of diet on growth rate or feed conversion ratio. Lipid deposition was highest in the liver of fish fed 100% PO. No significant differences were observed between dietary treatments for moisture, protein and ash content in H. longifilis fingerlings. This study suggests that PO can be used successfully as a substitute for cod liver oil in diets for H. longifilis.

Key words: Heterobranchus longifilis, palm oil, cod liver oil, growth, carcass composition.

*Correspondence: tobabalola@yahoo.com. National Institute for Freshwater Fisheries Research, P.M.B. 6006, New-Bussa, Niger State, Nigeria.**Introduction**

Fish oil replacement has been given considerable attention in recent years in the light of perceived situation of world fisheries and aquaculture and potential limitations on fish oil supplies for aquaculture feeds (Caballere *et al.*, 2002; Bell *et al.*, 2003; Glencross *et al.*, 2003; Regost *et al.*, 2003). The steady increase of aquaculture production over the last two decades has resulted in an increased utilization of fish meal and fish oil. Aquafeeds currently use about 70% of the global supply of fish oil and by the year 2010, fish oil used in aquaculture is estimated to reach about 97% of the world supply (Tacon 2003). Fish oil is produced from small marine pelagic fish and represents a finite fishery resource. Over the past decade, global fish oil production has reached a plateau and is not expected to increase beyond current levels. In order to sustain its rapid development, the aquaculture industry cannot continue to rely on finite stocks of marine pelagic fish for fish oil supply. The substitution of fish oil with alternative oil sources is therefore imperative for the successful expansion of the industry.

Palm oil is currently second behind soybean oil in world seed oil production tonnage (O'Mara, 1998). Crude palm oil is the richest natural sources of â-carotene, tocopherols and tocotrienols which function as natural antioxidants. 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). Palm oil has been evaluated in the diets for salmonids (Tortensen *et al.*, 2000; Bell *et al.*, 2002), catfishes (Legendre *et al.*, 1995; Lim *et al.*, 2001; Ng *et al.*, 2000; Ochang *et al.*, 2007) and tilapias (Ng *et al.*, 2001; Ochang *et al.*, 2007). Palm oil can meet the energy requirements of fish by providing easily oxidized fatty acids and at the same time, generate flesh fatty acid composition that are beneficial to the consumer.

The aim of the present study was to evaluate the influence of partial and/or total fish oil replacement with palm oil on growth and carcass composition of *H. longifilis*.

Materials and methods

Three hundred *H. longifilis* fingerlings were obtained from the hatchery of National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa, Nigeria and used in this study. Prior to the commencement of the experiment, fish were acclimatized to the new environmental condition on a commercial catfish feed for two weeks in a mini-flow-through system.

Danish fish meal was used as the primary protein source in the test diets because of its prevalent use in

diets fed to cultured catfish. Danish fishmeal contains approximately 10% fish oil as purchased, which might provide sufficient HUFA to meet the essential fatty acid requirement of *H longifilis* and obviate the effects of the lipid of interest. Therefore, the fishmeal was exhaustively extracted to reduce the endogenous lipid to trace amounts before inclusion in the diets. Five *iso*-nitrogenous, *iso*-lipidic, *iso*-caloric experimental diets were formulated with 6 % lipid originating from 100 % fish oil (FO) and 0 % (PO); 75 % FO and 25 % PO; 50 % FO and 50 % PO; 25 % FO and 75 % PO and 0 % FO and 100 % PO (Table 1). The diets were made into pellet with meat mincer through 2mm die, sundried, packed in polythene bags, sealed and stored at -20°C until used.

Fish were randomly assigned into groups of twenty per tank. Each dietary treatment had three replications and the experiment was conducted for 10 weeks. The fish were individually weighed at the beginning and at the end of the experiment and bulk-weighed by tank fortnightly in-between. Fortnight bulk weights were used to adjust the daily feed ration for the following week. Fish were offered 50 gkg^{-1} of their body weight per day, sub divided into three equal feeds at 09:00, 15:00 and 21:00 h daily.

Faecal matter was collected once a day at about 8:00 am before feeding commenced during the later part of the experiment. Faeces collection was performed by siphoning materials from the bottom of tank. At the termination of the experiment, five fish were taken from each replication for determination of whole body composition, liver and muscle lipid.

The nutrient composition of the experimental diets, muscle and liver samples was determined by proximate analysis. Moisture was determined by thermal drying to constant weight in an oven at 110°C for 24 h. Crude protein was determined using the Kjeldhal method (Association of Official Analytical Chemists, 1990), Total lipid of diets, liver and muscle tissue was extracted according to Folch et al. (1957) and quantified gravimetrically.

The data were subjected to analysis of variance (ANOVA) and if significant ($P<0.05$) differences were found, Duncan's' multiple range test (Duncan, 1955) was used to rank the group using SPSS version 10.0 (SPSS, 1997). The data are presented as mean ± S.E.M. of three replicate groups.

RESULTS

The mean final weights of H. longifilis fingerling fed all levels of palm oil substitution for fish oil were not significantly different. Similar trend were evident for other growth parameters [average feed intake (AVFI), feed conversion ratio (FCR) and specific growth rates (SGR)] (Table 2)

There were no significant differences between AVFI or FCR for all groups. The lowest FCR however (1.90 ±) was observed for 25 % PO treatment, while AVFI ranged from 21.02 ± (25 % PO) to 25.55 ± (0 % PO). Protein efficiency ratio (PER) ranged from 1.01 ± (75 % PO) 1.17 ± (25 % PO) and did not differ significantly between the dietary treatments.

Data on the composition of muscle and liver of the experimental fish are reported in Table 3. There were no significant differences observed between dietary treatments for muscle moisture, protein, total lipid and ash content of *H. longifilis* fed the experimental diets. The lipid content of the liver of fish fed 100 % PO was significantly higher than those fed the other diets.

DISCUSSIONS

The result of the present study suggest that PO can be used to completely replace fish oil with minimal adverse effect on *H. longifilis* fingerlings growth, as reported for other fish species (Martino *et al.*, 2002; Regost *et al.*, 2003; Turchini *et al.*, 2003; Francis *et al.*, 2006; Ochang *et al.*, 2007). This is evident by the weight gain and feed conversion of fish fed 25 %, 50 %, 75 %, and 100 % PO diets which ranged from 5.57 ± to 6.70 ± and 1.90 ± to 2.07 ± respectively, with no significant differences from fish fed the control (FO) diet, and generally comparable to previous results on tropical catfish (Ng *et al.*, 2000; Ochang *et al.*, 2007). The no significant difference between SGR and FCR of the experimental diets indicated that fish were able to digest the diets and convert the diets into body tissue with the same degree of efficiency.

Although muscle lipid levels in this study were not significantly different, higher level of lipid was observed in fish fed 0 % PO (100 % FO) compared with fish fed the other diets. Conversely, the muscle protein content was lower in fish fed 0 % PO, the second highest muscle lipid level, found in fish fed 50 % PO, was correlated with the second lowest protein content. This relationship between muscle protein and lipid content has been observed in studies with salmonids (Reinitz and Hitzel, 1980; Jokumsen and Aisted, 1990; Bell *et al.*, 2002). Lipid deposition in the liver was significantly affected by dietary treatment. The fish group fed 100 % PO had the highest liver lipid content. This observation is similar to that of Caballero *et al.*, (2004), that the reduction of dietary essential fatty acids due to the inclusion of vegetable oils in the diets tends to promote fat accumulation in the liver of seabream.

In conclusion, the replacement of cod liver oil by palm oil as lipid supplement in the diet permitted a clear improvement of growth and FCR of *H. longifilis*. This indicates that PO can effectively replace FO in the diet of *H. longifilis*.

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Table 1. Composition of the experimental diets (g/kg)

	Diets				
Ingredients	**0 % PO**	**25 % PO**	**50 % PO**	**75 % PO**	**100 % PO**
Fish meal (Danish)	398	398	398	398	398
Soybean meal	313	313	313	313	313
Corn flour (Maize)	177	177	177	177	177
Cassava starch	20	20	20	20	20
Methionine	10	10	10	10	10
*Vit./Min. Premix	20	20	20	20	20
Salt (NaCl)	1.5	1.5	1.5	1.5	1.5
Vitamin C	0.5	0.5	0.5	0.5	0.5
Fish oil	60	45	30	15	0
Palm oil	0	15	30	45	60
Nutrient contents (%)					
Moisture	6.23	6.38	6.56	6.31	6.42
Crude protein	45.08	44.98	45.02	45.06	44.99
Crude lipid	12.52	12.50	12.53	12.56	12.45
Ash	8.75	8.82	8.56	8.32	8.40
Crude fibre	1.45	1.42	1.38	1.41	1.40
Nitrogen free extract	25.97	25.90	25.95	26.34	26.34
Gross energy (MJ/kg)**	19.92	19.88	19.91	20.00	19.87

Vitamin/mineral premix supplied the following (per kg of diet): calcium, 4500mg; phosphorus, 4200mg; potassium, 1700mg; magnesium, 400mg; iron, 30mg; zinc, 30mg; manganese, 20mg; copper, 5mg; iodine, 1mg; selenium, 0.25mg; vitamin A, 5000IU; vitamin D, 2000IU; DL--tocopherol acetate, 100mg; menadione, 15mg; thiamine hydrochloride, 5mg; riboflavin, 10mg; pyridoxine hydrochloride, 10mg. Panthothenic acid, 35mg; nicotinic acid, 50mg; biotin, 0.5mg; folic cid, 2mg; ascorbic acid, 200mg; inositol, 250mg; choline, 400mg; vitamin B_{12}, 0.1mg and ethoxyquin, 60mg.
**Based on 23.4 MJ/kg protein, 39.2 MJ/kg lipid and 17.2 MJ/kg NFE

Table 2. Growth performance of *H. longifilis* fed the experimental diets containing increasing levels of palm oil (PO) for 10 weeks.

Parameters	0 % PO	25 % PO	50 % PO	75 % PO	100 % PO
Initial weight (g)	5.71 ± 0.17	5.48 ± 0.06	5.44 ± 0.17	5.50 ± 0.10	5.53 ± 0.23
Final weight (g)	12.13 ± 1.21	11.05 ± 0.24	11.50 ± 0.97	11.32 ± 0.28	11.39 ± 0.14
Weight gain (g)	6.70 ± 0.19	5.57 ± 0.08	6.06 ± 0.12	5.80 ± 0.10	5.86 ± 0.11
SGR (% day^{-1})	2.07 ± 0.13	1.97 ± 0.02	2.02 ± 0.14	1.89 ± 0.05	2.00 ± 0.07
erage feed intake (g)	25.55 ± 2.77	21.02 ± 0.31	23.27 ± 0.96	23.01 ± 2.08	22.52 ± 0.79
eed conversion ratio	2.07 ± 0.08	1.90 ± 0.03	2.04 ± 0.05	2.03 ± 0.06	1.98 ± 0.01
Protein efficiency ratio	1.07 ± 0.03	1.17 ± 0.01	1.10 ± 0.05	1.10 ± 0.07	1.12 ± 0.05

Table 3. Proximate composition of muscle and liver lipid concentration of *Heterobranchus longifilis* fed diets containing increasing levels of palm oil (PO) for 10 weeks.

Parameters	0 % PO	25 % PO	50 % PO	75 % PO	100 % PO
Parameters	0 % PO	25 % PO	50 % PO	75 % PO	100 % PO
Moisture	72.37 ± 0.18	72.4 ± 0.12	72.37 ± 0.09	72.30 ± 0.17	72.43 ± 0.18
Lipid	4.43 ± 0.15	4.26 ± 0.02	4.37 ± 0.09	4.27 ± 0.09	4.20 ± 0.06
Protein	17.04 ± 0.22	17.18 ± 0.15	17.12 ± 0.28	19.16 ± 0.21	17.24 ± 0.15
Ash	5.67 ± 0.09	5.67 ± 0.09	5.70 ± 0.10	5.77 ± 0.09	5.70 ± 0.06
Liver lipid	3.31 ± 0.01^{a}	3.34 ± 0.01^{a}	3.50 ± 0.01^{b}	3.61 ± 0.01^{c}	3.84 ± 0.03^{d}

Data are mean ± S.E.M. (n=3): means with different superscripts are significantly different ($P<0.05$).