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Effects of Dietary Lipid Sources on Growth and Survival of Mudfish *Heterobranchus longifilis* Fingerlings

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ABSTRACT

Effects of four dietary lipid sources (cod liver oil, palm oil, soybean oil, and pork lard) on growth and survival of *Heterobranchus longifilis* fingerlings were evaluated. Each diet was prepared to contain 40% protein, other nutrients and a lipid source. Diets were tested on triplicate groups of 10 fish per plastic aquarium measuring 45x35x28cm^3 with dechlorinated water. Fish were fed daily with 5% of their body weight for 49 days. Best growth (weight gain, specific growth rate and condition) results were obtained with soybean and palm oil diets, the least being cod liver oil. Pork lard diet produced intermediate performance. The feed conversion ratio was superior for soybean oil diet (0.58) compared to others (0.72-0.90). Protein efficiency ratio was similar in all experimental diets, 4.43± 0.74 (palm oil) – 4.98± 0.53 (soybean oil). Survival rates were high for all treatments (81.43±7.05-89.05±3.90%). Economic evaluation and performance of *H. longifilis* fingerlings suggest soybean oil (34.17/g weight gain) and palm oil (28.75/g. weight gain) diets to be of choice and cheaper to use as potential substitutes for cod liver oil in catfish feeds in this study.

1. INTRODUCTION

Lipids are a group of natural organic compounds comprising fats, oils, phospholipids and sterols [1]. They are non-protein calorie sources which are generally more digestible than some carbohydrates [2]. Lipids of animal origin have shorter chain length and lower degree of unsaturation than those of plant origin [3]. Dietary lipids are utilized in fish as a major energy source to spare proteins, provide essential fatty acids needed for proper functioning of many physiological processes and maintenance of membrane fluidity and permeability [4] as well as for growth and survival. Dietary lipids also influence flavour and texture of prepared feeds and flesh quality.

The requirements of specific fatty acids (FA's) in metabolism have been investigated in warm water fish nutrition [5]. Fish generally require omega – 3 (n-3, linolenic acid) while terrestrial animals prefer omega – 6 (n-6, linoleic acid) FA's which are essential. Essential fatty acid requirements vary considerably from species to species as in tilapias (n-6 FA's), [6], rainbow trout and white fish (n-3 FA's), [7] and both n-3 and n-6 FA's in common carp [8]. Aqua feeds currently use a high proportion of the global supply of fish oil and production of this oil was reported to have reached a plateau [9].In order to sustain the rapid development and expansion of the aquaculture industry, the substitution of fish oil with alternative cheaper and locally available lipid sources (animal fats and vegetable oils) is imperative.

Polyunsaturated vegetable oils are more easily digested by fish and beneficial for efficient production and fish health than saturated fats such as beef tallow of animal origin [10]. These oils are viable alternatives as they are readily available and cost effective than fish oils [11] and can partially or wholly replace fish oil in fish diets without compromising growth performance as long as the essential fatty acid (EFA) requirements are met [12]. Lipid sources used with varying successes was peanut on *Heterobranchus longifilis* [13], palm oil on catfishes [14], pork lard on *Oreochromis niloticus* hybrid fingerlings [3] and menhaden oil on channel catfish [15].

Heterobranchus longifilis has excellent attribute for culture and high market value in Nigeria. However, limited information is available on its feeding nutrition. This study was therefore conducted to evaluate the potentials of some local and readily available lipid sources on growth and survival of mudfish *Heterobranchus longifilis* fingerlings with a view to replace the foreign and more expensive fish or cod liver oils in catfish feeds.

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2. MATERIALS AND METHODS

2.1 Experimental diets

Four experimental diets were formulated and produced using cod liver oil (control), palm oil, soybean oil and pork lard as lipid sources and other ingredients (Table 1). Each diet contained 40% crude protein with Tilapia and shrimp meal as protein source. The ingredients in ground form for each diet were weighed out using a triple beam balance (Model MB-2610) into a clean basin, mixed and made into pellets with a meat mincer through a 2mm die, sun-dried, broken into crumbles and packaged in small polythene bags for later use.

Table 1: Composition (%) of experimental diets.

Ingredient	Experimental diets			
	Cod liver oil	**Palm oil**	**Soybean oil**	**Pork lard**
Fishmeal (Tilapia)	23.50	23.50	23.50	23.50
Shrimp meal	48.25	48.25	48.25	48.25
Corn	10.0	10.0	10.0	10.0
Wheat bran	6.0	6.0	6.0	6.0
Vitamin/Mineral premix	0.5	0.5	0.5	0.5
Bone meal	1.5	1.5	1.5	1.5
Cod liver oil	7.0	-	-	-
Palm oil	-	7.0	-	-
Soybean oil	-	-	7.0	-
Pork lard	-	-	-	7.0
Common salt	0.25	0.25	0.25	0.25
Starch (Binder)	3.00	3.00	3.0	3.0
Total	100.0	100.0	100.0	100.0

2.2 Experimental fish and culture system

One hundred and fifty *Heterobranchus longifilis* fingerlings, weight (0.76±0.10-0.89±0.14g) and total length (0.46±0.04-0.48±0.03cm) were obtained from African Regional Aquaculture Centre, Aluu-Port Harcourt in Nigeria. The fish were acclimatized for 4 days prior to start of experiment and later stocked randomly into 12 plastic aquaria of $45x35x28cm^3$ at a rate of 10 fish per aquarium in triplicate per treatment.

Fish were fed with appropriate diet at 5% body weight, divided into two halves at 0900 and 1600 hours local time. Uneaten feed particles and other waste products were siphoned off daily with a hose. Continuous aeration was provided into the aquaria by Tecas air pumps (AP 1500) fitted with air tubes and air stones. Water in each aquarium was completely removed, facility cleaned and refilled to 40-litre mark every other day. Top of aquaria were covered with 1.0cm mesh net to prevent fish from jumping out and to prevent the entry of foreign object. Fish mortality was monitored daily in aquaria throughout the experimental period. Fish samples in each aquarium were taken weekly for weight and body length measurements to the end of experiment using weighing balance (Model MB-2610) and a metal metre rule. Total fish weight were also taken fortnightly in the aquaria for feed adjustments as test fish increased in weight. The physico-chemical parameters of the culture media were determined with standard procedures [16]. Temperature was measured daily with a laboratory mercury thermometer (0-100^{o}C). A weekly measurement of water pH was with a pH meter (Model Jenway 3150) and dissolved oxygen by Winkler's method. The experiment was conducted at the Department of Fisheries Laboratory, Rivers State University of Science and Technology in Port Harcourt, Nigeria and lasted for 7 weeks from September to October, 2007.

2.3 Data analysis

Fish response parameters used to assess the performance of *H. longifilis* fingerlings were growth measurements in terms of final individual fish weight (g) and body length (cm), weight gain (g) = wet final weight (g) – wet initial weight, g; weight gain (%)= 100 x wet final weight (g)- wet initial weight (g)/wet initial weight(g), specific growth rate (SGR), % day^{-1} = 100 [(l_n wet final weight) – (I_n wet initial weight)] / time in days, where l_n = natural logarithm, condition factor (K) = 100 w/l^3 where w = total weight (g) and l = total length (cm), feed conversion ratio (FCR) was calculated as weight of feed fed (g)/wet weight gain (g), protein efficiency ratio (PER) = wet weight gain (g)/protein fed (g) and survival (%) = 100 (number of survivors) / total number of fish stocked. The economy of feed was calculated as cost of feed fed N /body weight gain of fish (g), [17].

2.4 Statistical analysis

The data obtained were subjected to one- way analysis of variance (ANOVA) according to [18]. Means were compared by least significant difference method at P<0.05. General linear model procedure of [19] Statistical Analysis System software (SAS Inc., Cary, North Carolina) was used in the analyses.

3. RESULTS

The summary of the results obtained for growth response and feed utilization of *H. longifilis* in this study is shown in Table 2. The mean weight gain and % weight gain for fish fed soybean oil diet were highest (0.52±0.09 g, 63.41%) compared to fish fed with palm oil (0.51±0.14g, 57.30%), cod liver oil (0.45±0.10g, 59.21%) and pork lard (0.48±0.11g, 61.54%). The specific growth rate was highest with soybean oil diet (3.71±0.35% day^{-1}), followed by pork lard, palm oil and cod liver oil diets. The values of fish condition showed an order of cod liver oil (8.05±0.89) > pork lard (7.96±0.63) > palm oil (7.80±0.23) > soybean oil (6.53±1.11) diets. Feed conversion ratio (FCR) showed a pattern where cod liver oil fed fish was least efficient with 0.90±0.39 while palm oil and pork lard had similar values, 0.78±0.23 and 0.72±0.24.

The best FCR of 0.58±0.11 was observed for soybean oil fed fish. The protein efficiency ratio appeared similar for all diets although soybean oil was slightly higher than others. Fish survival was high and ranged 81.43±7.05-89.05±3.90% in this study. Values of physico-chemical parameters measured are shown in Table 3. Temperature was similar for all diets (26.40±0.46-26.60±0.24^{o}C), while pH ranged from 5.91±0.78 (soybean oil)-6.11±0.79 for pork lard.

Table. 2: Growth and feed utilization of H. longifilis fingerlings fed diets containing different lipid sources.

Parameter	Experimental diets			
	Cod liver oil	Palm oil	Soybean oil	Pork lard
Initial length (cm)	0.46±0.04^{a}	0.48±0.03^{a}	0.47±0.07^{a}	0.48±0.03^{a}
Length increase (cm)	0.17±0.04^{a}	0.15±0.03^{a}	0.14±0.03^{a}	0.17±0.04^{a}
Initial weight (g)	0.76±0.10^{a}	0.89±0.14^{a}	0.82±0.14^{a}	0.78±0.11^{a}
Mean weight gain (g)	0.45±0.10^{a}	0.51±0.14^{a}	0.52±0.09^{a}	0.48±0.11^{a}
Weight gain (%)	59.21	57.30	63.41	61.54
Specific growth rate(% day^{-1})	2.58±0.29^{c}	2.74±0.12^{b}	3.71±0.35^{a}	3.14±0.24^{ab}
Condition factor (K)	8.05±0.89^{a}	7.80±0.23^{a}	6.53±1.11^{b}	7.96±0.63^{a}
Feed conversion ratio	0.90±0.39^{a}	0.78±0.23^{a}	0.58±0.11^{b}	0.72±0.24^{a}
Protein efficiency ratio	4.45±0.70^{a}	4.43±0.74^{a}	4.98±0.53^{a}	4.82±0.75^{a}
Survival (%)	81.43±7.05^{b}	89.05±2.69^{a}	87.62±3.69^{a}	89.05±3.90^{a}
Economy of feed (g. weight gain)	117.42	28.75	34.17	40.24

Table 3: Values of physico-chemical parameters obtained during growth trial of *H. longifilis* fingerlings.

Parameter	Experimental diets			
	Cod liver oil	Palm oil	Soybean oil	Pork lard
Temperature (°C)	26.60±0.24^{a}	26.40±0.46^{a}	26.50±0.29^{a}	26.50±0.30^{a}
pH	6.11±0.71^{a}	6.10±0.74^{a}	5.91±0.78^{a}	6.11±0.79^{a}
Dissolved oxygen (mg/l)	6.60±0.24^{a}	6.73±0.24^{a}	6.50±0.29^{a}	6.50±0.29^{a}

Figures in same horizontal row having same superscript are not significantly different (P>0.05).

Dissolved oxygen values were similar and ranged 6.5±0.29mg/l (soybean oil and pork lard)-6.73±0.24mg/l for palm oil diet. Palm oil diet had the best economic weight gain of 28.75/g. wt. gain, followed by soybean oil (34.17/g. wt. gain). The most uneconomical diet was with cod liver oil (117.42/g. wt. gain).

4. DISCUSSION

The results of the present study suggest that with over 50% fish body increase, each of the tested oils exhibited potential and could be used as a dietary lipid source in feeds for *H. longifilis* fingerlings. The weight gain was slightly better in diets containing oils of plant origin (soybean and palm oils) than those of animal origin (cod liver oil and pork lard). Palm oil had earlier been used to completely replace fish oil with minimal adverse effect on the growth of *H. longifilis* fingerlings [20]. Best results were also obtained in survival and growth with palm oil but slower growth in *H. longifilis* fry fed cod liver oil diet [13]. Interestingly, channel catfish fed beef tallow (high in omega-3 FA's) performed as well at 20°C as did those fed menhaden fish oil (high in omega-3 FA's) in a similar study [21].

Beef tallow also out performed fish fed diets supplemented with safflower oil (high in omega-6 FA's). Palm oil contains both omega-3 and 6 essential fatty acids (EFA's) and is also the richest natural source of â-carotene, tocopherols and tocotrienols which function as antioxidants. These offer beneficial effect to growth and flesh quality when fish are fed high levels of palm oil in their diets [22]. The performance of palm oil diets in this study was not the best but it followed those of soybean oil closely. Fish that had soybean oil included in the diet were observed to be superior in growth (weight gain, SGR and condition) and feed utilization as shown in FCR and PER values. The levels of omega-3 (linolenic) and omega-6 (linoleic) FA's are higher in soybean oil than pork lard [23] and probably palm oil in this experiment. Pork lard predominantly contains saturated and monosaturated FA's. The omega-6 FA's are also more abundant in pork lard than palm oil [24]. Although cod liver oil contains a high level of 20 and 22 carbon omega-3 FA's and omega-6 series [13], biological performance of fish fed cod liver oil diet was below soybean oil fed fish in this study. Fish cannot synthesize linolenic and linoleic polyunsaturated FA's but have a requirement of them which should be provided from exogenous dietary sources [25]. These FA's along with stearic (18:0), palmitic (16:0) and oleic (18: 1n-9) series are probably important for better growth of fish [1]. Higher weight gains and tissue protein deposition have been associated with increased dietary fats and oil in fresh water fish, therefore quality lipid should be provided in the diet of fish. The better performance of *H. longifilis* fingerlings fed soybean oil diets could be due to their preference for the omega-3 and 6 FA's which are of significant amounts and in required ratio in soybean oil to meet up metabolic needs. The experimental oils are of different fatty acid composition. An excess of either omega-3 or 6 FA in the dry diet composition could lead to reduced growth in fish [13]. This reasoning probably explains the cause for the reduced performances particularly in fish fed other lipid sources in this study. Also, [11] reported that the n-3: n-6 polyunsaturated fatty acid balance seems critical in the diet of the African catfish. The conducive culture condition provided by the measured water quality parameters of temperature, pH and dissolved oxygen according to [26] aided the good survival rate observed for the test fish. The order of biological performance was observed to be soybean oil >palm oil>cod liver oil>pork lard. This showed that *H. longifilis* fingerlings had preference for plant oil sources than those of animal in this study. Feeds containing plant oils were found to be more economical with 28.75 and 34.17/g. weight gain for palm oil and soybean oil while cod liver oil was the most uneconomical. These plant oils are readily available in the Nigerian market at moderate cost and they have the potential to substitute for fish oil or cod liver oil either partially or wholly in aqua feeds for the culture of *H. longifilis* fingerlings.

5. CONCLUSION

The dietary inclusion of locally available plant oil sources such as soybean oil (high in omega-3) or palm oil at the level shown in this study suggest that they could support good growth and survival of *H. longifilis* fingerlings. These oils would be economically desirable as substitutes in place of the more expensive foreign fish or cod liver oils in catfish feeds. However, more studies are needed to determine the component fatty acids of these local lipid sources and others alike.

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