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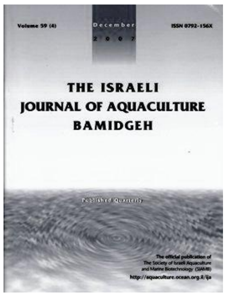

Effects of Dietary Fish Oil Substitution with Palm Oil on Growth, Survival, and Muscle Proximate Composition of *Cirrhinus mrigala* (Hamilton, 1822)

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Key words: palm oil, cod liver oil, *Cirrhinus mrigala*, proximate composition

Abstract

A 60-day growth experiment was carried out to evaluate the effect of replacing dietary cod liver oil with palm oil on the growth, survival, and muscle proximate composition of the Indian major carp, *Cirrhinus mrigala*. Five diets were fed to triplicate groups of 20 advanced *C. mrigala* fry (2.16±0.01 g): 100% cod liver+0% palm (control), 25% palm+75% cod liver, 50% palm+50% cod liver, 75% palm+25% cod liver, and 100% palm+0% cod liver. At the end of the experiment, mean weight gain, average daily growth, specific growth rate, feed conversion efficiency, feed conversion ratio, and percentage survival were assessed. Growth performance and survival were not compromised when fish oil was substituted with palm oil up to 25%. However, beyond this level, growth was significantly retarded ($p<0.01$). There were no significant ($p>0.01$) differences in feed efficiency or muscle proximate composition. Results confirm the feasibility of substituting up to 25% dietary fish oil by palm oil in diets for *C. mrigala* advanced fry without negatively affecting growth or feed utilization efficiency.

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Introduction

Marine fish oil is used in fish feeds as a source of energy and essential fatty acids. Conventional sources of dietary oils for aquafeeds derive from small pelagic fish, a finite fishery resource. The major reason for replacing marine fish oil in aquafeeds is to reduce feed costs, while still obtaining feeds with optimum energy and well-balanced essential fatty acids.

Vegetable oils are promising candidates for fish oil replacement. Production of vegetable oils is steadily increasing, they are widely available, and they have economic value. Some vegetable oils (e.g., soybean and rapeseed oils) are possible alternative lipid sources for freshwater and marine fish because they are rich in polyunsaturated fatty acids (PUFA) but devoid of n-3 highly saturated fatty acids (HUFA; Mourente et al., 2005). Substantial quantities of vegetable oils can be used to substitute fish oil in fish diets without negatively affecting growth (Ng et al., 2003; Karayücel and Dernekbaşi, 2010). A combination of L-carnitine and olive pomace oil improved feeding efficiency in African catfish (Yilmaz et al., 2004).

Palm oil is a potential candidate due to its relatively low level of 18:2 n-6 and abundance of 16:0 and 18:1 n-9 (Ng et al., 2003). Research on the use of palm-oil-based products for fish shows it has many advantages over other vegetable or fish oils. Together with the protective effects of potent natural antioxidants in palm oil, feed rancidity can be substantially reduced when palm oil is used in aquafeeds (Ng, 2007).

Generally, 7-9% dietary lipid is optimum for grow-out stages of carps (Mukhopadhyay and Rout, 1996). All three Indian major carps grow well when their diet contains 1% n-3 and n-6 fatty acids (Murthy, 2002). Freshwater fish require a lower amount of n-3 fatty acids than is present in marine fish oil and, therefore, palm oil can be used instead of marine oil in their diets. Unlike soybean and rapeseed oils that contain abundant saturates (48%) and monoenes (42%), palm oil is unique in containing tocotrienols (70-80% of the vitamin E content) which add value to the fish fillet. Considering the availability and low price of palm oil in the tropics, its potential as an alternative dietary lipid source for fish warrants further investigation. Hence, the present study evaluated palm oil as a partial substitute of cod liver oil in diets for advanced fry of *Cirrhinus mrigala*.

Materials and Methods

The experiment was carried out for 60 days in 200-l FRP tanks installed at the wet laboratory of the fish farm complex at the Fisheries College and Research Institute (FC&RI), Thoothukudi, India. Mrigal (*Cirrhinus mrigala*) seed were procured from a private hatchery at Kallidaikurichi, Tirunelveli, Tamil Nadu, India, and transported to the rearing facility of the institute where they were fed commercial crumble pelleted feed (Godrej India Private Limited, Andhra Pradesh, India).

Three hundred healthy advanced fry (2.16±0.01 g) were selected and randomly distributed into 15 experimental tanks (20 fish x 5 treatments x 3 replicates) supplied with round-the-clock aeration. Five isonitrogenous diets (30% protein) were formulated with different inclusion levels of palm oil: 0% (control), 25%, 50%, 75%, and 100% (Table 1). The principal feed ingredients were procured from local markets in Thoothukudi, dried in sunlight for two days, pulverized, then mixed thoroughly with a sufficient quantity of water (10%) and put into a BTPL Lab Twin Screw Extruder (Model no. BT/1) with a 2-mm die. The extruded noodles were collected, dried in the shade for 2 h, labeled, and stored in air-tight plastic containers. The proximate compositions of the feed ingredients and test diets were analyzed using standard procedures (AOAC, 1995).

Diets were hand fed to the fish twice daily (09:00 and 16:00) for 60 days. Uneaten feed and fecal matter were siphoned out of the tanks daily using a plastic hose and feed intake was determined. Water was exchanged (50%) every 15 days and water quality was assessed using standard methods (APHA, 1995). Mean temperature ranged 31.21-31.53°C, pH 7.17-7.54, dissolved oxygen 6.23-6.72 ppm, alkalinity 89.04-91.37 ppm, hardness 109.62-112.54 ppm, NH_3-N 0.39-0.46 µg/l, and NO_2-N 0.031-0.049 µg/l. Fish were sampled at 60 days to determine growth performance and survival using standard

Table 1. Ingredients and proximate composition of the experimental diets (g/100 g dry diet).

	Diet (% palm oil/% cod liver oil)				
	0/100 (control)	*25/75*	*50/50*	*75/25*	*100/0*
Ingredient					
Groundnut oil cake	61	61	61	61	61
Fishmeal	20	20	20	20	20
Rice bran	10	10	10	10	10
Palm oil	0	2	4	6	8
Cod liver oil	8	6	4	2	0
Vitamin-mineral mix*	1	1	1	1	1
Proximate composition					
Moisture	06.38±0.02	06.54±0.01	06.92±0.01	05.98±0.03	06.09±0.02
Dry matter	93.62±0.12	93.46±0.23	93.08±0.24	94.02±0.31	93.91±0.17
Crude protein	29.98±0.08	29.98±0.02	29.60±0.10	30.10±0.07	30.10±0.01
Crude fat	08.35±0.07	07.98±0.02	08.05±0.01	07.95±0.03	08.43±0.01
Crude fiber	04.90±0.03	05.85±0.02	06.34±0.02	06.37±0.01	06.82±0.01
Ash	14.94±0.01	08.69±0.01	09.90±0.02	13.00±0.01	13.99±0.04

*Mineral premix (%): $KAl(SO4)_2$ 0.159; CaCO3 18.101; $MgSO_4$ 5.216; $CoCl_2$ 0.07; KCl 16.553; ferric citrate ($5H_2O$) 1.338; sodium selenite 0.004; $MnSO_4$.H2O 0.07; KI 0.014; $ZnSO_4$ 0.192; NaH_2PO_4 13.605; $CuSO_4.5H_2O$ 0.075

Vitamin premix: thiamine hydrochloride 10 mg/kg; riboflavin 20 mg/kg; calcium pantothenate 40 mg/kg; nicotinic acid 50 mg/kg; pyridoxine hydrochloride 10 mg/kg; folic acid 5 mg/kg; inositol 400 mg/kg; choline chloride 2000 mg/kg; menadione 10 mg/kg; cholecalciferol 1500 IU; biotin 1 mg/kg; vitamin B12 0.02 mg/kg; vitamin A 3000 IU; vitamin E 50 IU; vitamin C 200 mg/kg

formulas: mean weight gain (g) = mean final wt - mean initial wt; average daily growth (g/day) = (mean final wt - mean initial wt)/days of culture; specific growth rate (%/day) = 100(ln final wt - ln initial wt)/no. of days; feed conversion ratio = total dry feed intake/wet wt gain; feed conversion efficiency (%) = 100(wet wt gain/dry feed fed); and survival (%) = 100(initial no. fish - final no. fish).

Data were analyzed using SPSS version 16.0 for Windows. One-way analysis of variance (ANOVA) was used to compare treatments. Significant differences between means were measured by Duncan's multiple range test. Differences were considered significant at $p<0.01$ and results are presented as means±standard error.

Results

Mean weight gains and average daily growth were significantly lower in fish fed diets

Table 2. Growth performance and proximate composition of *Cirrhinus mrigala* fed palm oil substituted experimental diets for 60 days period (means±SE, n = 3).

	Diet (% palm oil/% cod liver oil)				
	0/100 (control)	*25/75*	*50/50*	*75/25*	*100/0*
Mean initial wt (g)	2.389±0.05	1.677± 0.11	2.426±0.53	2.257±0.19	2.065±0.44
Mean final wt (g)	6.015±0.20	5.214± 0.09	4.887±0.26	4.643±0.65	4.313±0.80
Mean wt gain (g)	3.626±0.15^{a}	3.537±0.015^{a}	2.461±0.73^{b}	2.386±0.84^{b}	2.248±0.36^{c}
Avg daily growth (g/day)	0.060±0.002^{a}	0.019±0.000^{a}	0.041±0.01^{b}	0.039±0.014^{b}	0.037±0.006^{b}
Specific growth rate	1.537±0.02^{a}	1.892±0.07^{a}	1.156±0.07^{b}	1.195±0.37^{b}	1.233±0.04^{b}
Feed conversion efficiency	40.30±0.36^{a}	38.82±0.18^{ab}	35.25±0.21^{b}	36.29±0.30^{b}	34.59±0.49^{b}
Feed conversion ratio	1.579±0.084^{a}	1.426±0.006^{a}	3.213±0.86^{b}	3.114±0.78^{b}	2.810±0.46^{b}
Survival	85.76±9.43^{a}	83.33±6.67^{ab}	81.11±11.70^{b}	91.66±1.66^{c}	92.77±3.46^{c}
Muscle proximate comostion (g/100 g)					
Moisture	77.38±0.15	77.18±0.19	77.10±0.23	77.00±0.10	77.26±0.24
Dry matter	22.62±0.15	22.82±0.19	22.90±0.23	23.00±0.10	22.74±0.24
Protein	17.39±0.28	17.10±0.21	17.30±0.39	17.71±0.18	17.56±0.20
Lipid	1.07±0.40	1.06±0.32	1.06±0.26	0.99±0.29	1.06±0.38
Ash	1.76±0.18	1.90±0.24	1.91±0.28	1.94±0.15	1.95±0.29
Fiber	0.49±0.24	0.50±0.15	0.52±0.32	0.53±0.29	0.56±0.14
P value	0.083	0.067	0.018	0.102	0.721

Values in a column with different superscripts significantly differ ($p<0.01$).

containing 50% or more palm oil than in the control (Table 2). The mean weight gain had a highly significant ($p<0.01$) negative correlation with the level of palm oil (r = -0.8703). The feed efficiency and feed conversion ratios were best in the fish fed the 25% palm oil diet. Survival showed a positive correlation with the palm oil inclusion level (r = 0.457) while muscle proximate compositions did not significantly differ between treatments.

Discussion

Weight gain was not significantly ($p>0.05$) lower in fish fed the diet with 25% palm oil than in fish fed the control, similar to earlier studies on *Labeo rohita* (Athithan and Singh, 2010), *Catla catla* (Singh et al., 2009), and *Clarias batrachus* (Ng et al., 2004). Dietary fish oil can be substituted with 50% palm oil without compromising growth and survival in Japanese seabass, *Lateolabrax japonicas* (Gao et al., 2012) and Malaysian mahseer, *Tor tambroides* (Kamarudin et al., 2011). Mean weight gain had a highly significant ($p<0.01$) negative relationship with the inclusion level of palm oil. This contrasts with studies in which there were no significant differences in fish weight gain (Torstensen et al., 2000; Rosenlund et al., 2001) but confirms findings in juvenile Nile tilapia, *Oreochromis niloticus*, fed diets containing palm oil (Ochang et al., 2007) and Murray cod, *Macculochella peeli peeli*, fed diets with graded levels of canola and linseed oil (Francis et al., 2007). High levels of palm oil can be detrimental. Palm oil exceeding 69% compromised growth and feed utilization and caused intense liver lipid accumulation in gilthead bream, *Sparus aurata* (Fountoulaki et al., 2009).

The better survival at the higher inclusion level observed in our study agrees with Gao et al. (2012). In *Clarias gariepinus*, dietary supplementation of palm oil offers protection against muscle lipid peroxidation: antioxidants in the palm oil reduce the risk of oxidative stress and increase survival without affecting feed efficiency (Ng et al., 2004), similar to observations in Chinook salmon, *Onchorhynchus tshawytscha*, fed dietary canola oil (Grant et al., 2008).

There were no significant alterations in muscle proximate composition in our study, similar to earlier findings in tilapia, *Oreochromis spp*., fed a palm oil based diet (Bahurmiz and Ng, 2007).

In conclusion, the present study indicates that dietary fish oil in *Cirrhinus mrigala* diets can be replaced by palm oil up to 25% without adversely affecting growth, survival, or muscle proximate composition. This study provides a cost-effective avenue for replacing costly fish oil in dietary formulations for freshwater carp farming.

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