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Communication

Effect of feeding *Spirulina platensis* on growth and carcass composition of hybrid red tilapia (*Oreochromis mossambicus* × *O. niloticus*)

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Abstract: The present study was designed to evaluate the use of spirulina (*Spirulina platensis*) as a protein source for hybrid red tilapia. Spirulina was incorporated into four isonitrogenous and isocaloric diets at 0, 5, 10 and 20% of the fishmeal-based diet. The test diets were fed to the fish at 2% body weight twice a day for 120 days. The final weight gain, specific growth rate, feed conversion ratio and survival rate of fish were not affected by spirulina supplementation ($p>0.05$). There was no significant difference ($p>0.05$) in carcass proximate composition of the fish fed on spirulina diets as compared to those on control diet. This study demonstrates that up to 20% of spirulina can be substituted for fishmeal in a fishmeal-based diet for hybrid red tilapia without any adverse effect on fish growth.

Keywords: spirulina, *Spirulina platensis*, hybrid red tilapia, fishmeal-based diet, carcass composition

Introduction

Fishmeal, a major ingredient of fish feed, has to be imported, especially that with a protein content over 60%. Low domestic fishmeal production is the result of many factors such as decreases in fishing area and catch. The high protein content of spirulina is one of the main reasons for it being considered as an unconventional source of protein. In addition, the amino acid pattern of the alga compares favourably with that of other food proteins, its cells being capable of synthesising all amino acids, thus providing all the essential ones to humans and animals [1].

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Earlier studies involved examination of how supplementing a diet with dry spirulina powder affects the taste and quality of fish. Hirano and Suyama [2] reported that using spirulina in the feed of ayu results in a good growth with better flavour, firmer flesh and brighter skin colour. Other studies suggested that a 5% dietary spirulina supplementation depresses the lipid in the muscle and improves the taste and texture of striped jack [3-4]. As a pigmentation additive, spirulina was also found to improve the colour of red tilapia. Feeding raw spirulina as uni-feed to tilapia resulted in a slightly better evaluation of colour, texture and fatness than that obtained from commercial diets [5].

Other studies suggested that spirulina supplemented in the feed of freshwater fish has the effect of improving growth and promoting gonad development and maturation [6]. Tilapia fed solely on raw spirulina could maintain normal reproduction from parents to progeny throughout three generations [7]. It has been verified that larval tilapia fed solely on raw spirulina cultivated in photo-bioreactors can grow normally from the onset of exogenous feeding without any nutrient supplements [8]. Nandeesha et al. [9] reported that the final weight gain, specific growth rate and food conversion ratio of common carp are not affected by spirulina supplementation. A 3% supplementation of the algal meal in moist pellets produced a significant enhancement of growth and feed utilisation efficiency in red sea bream [10]. Therefore, an innovation of cost-effective technologies for cultivation of spirulina should help in the exploitation of this alga as a fish feed ingredient.

This study was designed to evaluate the use of spirulina as a partial replacement for fishmeal protein in practical diets for hybrid red tilapia in terms of growth and carcass proximate composition.

Materials and Methods

Experimental diets

Spirulina (*Spirulina platensis*) was produced from the culture medium consisting of dry egg-laying chicken manure collected from a closed-system house supplemented with urea [11].

Four isonitrogenous (30% crude protein) and isocaloric (16.3 kJ/g) practical diets were formulated with different percentages of spirulina (0, 5, 10 and 20% of dry matter) as presented in Table 1. All ingredients were blended in a mixer and pelleted by a commercial meat grinder. The pellets were dried in a convection oven for 8 h at 65^{o}C before being sealed in plastic bags and stored at -18^{o}C until use. Each diet was fed to fish twice daily (0900 and 1500 h) at 2% body weight, and feeding rate was adjusted fortnightly.

Experimental units

Twelve 4m × 5m × 1.2m (width × length × depth) polyethylene net cages (1-cm mesh size) were set up by attaching the net to staked bamboo poles in a 1,000-m^2 earthen pond. The net was suspended at a 30-cm height above the water level and the cage bottom was kept at least 50 cm above the pond floor.

Experimental fish

Sex-reversed hybrid red tilapia (*Oreochromis mossambicus* × *O. niloticus*) were obtained from a commercial hatchery in Chiang Mai. At the beginning, fingerlings with an initial weight of 10.89 ± 0.16 g were soaked in NaCl solution (5 g of NaCl/litre of water) before being randomly assigned to the

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twelve net cages at a density of 50 fish/m^2. Commercial catfish pellets (30% crude protein) were fed during the first week to help the fish adapt to their new environment before the experiment.

Table 1. Ingredients and proximate composition of experimental diets on dry weight basis

Ingredient (%)	Diet			
	S00	S05	S10	S20
Spirulina powder [a]	0.00	5.00	10.00	20.00
Fishmeal [b]	27.70	23.96	20.22	12.74
Rice bran	35.00	35.00	35.00	35.00
Soybean meal	20.00	20.00	20.00	20.00
Broken rice	16.80	15.54	14.28	11.76
Vitamin C	0.50	0.50	0.50	0.50
Proximate composition (% of dry matter)				
Crude protein	30.18 ± 0.14	30.10 ± 0.20	30.12 ± 0.15	30.19 ± 0.15
Crude lipid	8.74 ± 0.18	8.89 ± 0.14	8.63 ± 0.21	8.86 ± 0.20
Ash	10.24 ± 0.04	10.25 ± 0.10	10.06 ± 0.02	9.86 ± 0.02
Crude fibre	5.87 ± 0.30	5.38 ± 0.08	5.83 ± 0.34	5.42 ± 0.16
NFE [c]	44.96 ± 0.51	45.37 ± 0.41	45.36 ± 0.18	45.35 ± 0.22
Gross energy (KJ/g)	16.32 ± 0.04	16.37 ± 0.03	16.33 ± 0.06	16.37 ± 0.06

[a] Crude protein 45.2, crude lipid 2.7%
[b] Crude protein 57.9, crude lipid 11.1%
[c] Nitrogen-free extract

Analytical methods

At the end of the experimental period of 120 days, nine whole fish from each cage were minced together and a sample was taken from the mince for proximate analysis of the carcass composition. The proximate composition of the experimental diets and fish carcasses was determined according to AOAC methods [12]. Crude protein was determined by micro Kjeldahl method; total lipid by Soxhlet extraction; crude fibre by acid detergent method; and ash by combustion at 550^{o}C for 12 h. Carbohydrate as nitrogen-free extract (NFE) was calculated as weight of sample less crude protein, total lipid, crude fibre and ash. The water quality in the cage was monitored fortnightly by recording of water temperature (at 1600 h), dissolved oxygen (at 0600 h), total ammonia (at 1600 h), nitrite (at 1600 h) and pH (at 0600 h). An oxygen meter (YSI model 59), a spectrophotometer (Hach DR/2000) and a pH meter (Schott-Gerate CG 840) were utilised in acquiring such data.

Statistical analysis

Statistical analyses were performed on the data obtained from completely randomised design with three replications after 120 days of the experimental period. One-way ANOVA was used to test the effect of the dietary treatment. Tukey's test was also applied to compare the means when a significant difference ($p<0.05$) was detected by ANOVA.

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Results and Discussion

The water quality in the present study (Table 2) was within an acceptable range for tilapia culture [13]. The growth performance of hybrid red tilapia fed on the experimental diets were not significantly different ($p>0.05$) (Table 3). Furthermore, fish survival was not statistically different among dietary treatments. Lu and Takeuchi [7] and Lu et al. [14] reported that compared to those fed on a commercial diet, tilapia fed solely on raw spirulina can maintain normal growth for 150 days to 30 weeks of the rearing period. Nandeesha et al. [9,15] reported that fishmeal protein can be effectively replaced by spirulina powder without sacrificing the growth of common carp, catla and rohu. El-Sayed [16] recorded that dried *Spirulina maxima* is an excellent substitute for fishmeal in silver seabream diets, even at a high substitution level (75%). Because it is rich in proteins, vitamins, minerals, essential amino acids and fatty acids [17], spirulina has been identified as a potential protein source for fish feed [9]. However, Takeuchi et al. [18] found that juvenile tilapia fed solely on the alga show a lower feed efficiency and protein efficiency ratio than commercial-diet-fed tilapia.

Table 2. Water quality in the experimental cages (Mean ± SE*)

Diet	Temperature (°C)	pH	DO (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)
S00	30.77 ± 0.03	7.50 ± 0.00	3.29 ± 0.08	0.736 ± 0.031	0.279 ± 0.005
S05	30.83 ± 0.09	7.43 ± 0.03	3.14 ± 0.10	0.734 ± 0.024	0.288 ± 0.002
S10	30.63 ± 0.03	7.43 ± 0.03	3.17 ± 0.01	0.722 ± 0.005	0.276 ± 0.004
S20	30.63 ± 0.07	7.40 ± 0.00	3.00 ± 0.03	0.754 ± 0.010	0.282 ± 0.007
P-value	0.111	0.085	0.084	0.748	0.443

* Standard error

Table 3. Growth performance and % survival of hybrid red tilapia fed on experimental diets (Mean ± SE)

Diet	Initial weight (g)	Final weight (g)	Weight gain (WG) (g)	Specific growth rate (SGR) (%/day)	Feed conversion ratio (FCR)	Survival (%)
S00	11.00 ± 0.00	158.61 ± 3.41	147.61 ± 3.41	1.78 ± 0.01	1.76 ± 0.01	91.11 ± 1.11
S05	10.89 ± 0.11	152.49 ± 8.09	141.60 ± 8.02	1.76 ± 0.03	1.78 ± 0.08	91.11 ± 1.11
S10	10.89 ± 0.11	143.49 ± 1.34	132.61 ± 1.36	1.72 ± 0.01	1.86 ± 0.01	92.22 ± 1.11
S20	10.78 ± 0.11	155.71 ± 2.26	144. 93 ± 2.16	1.78 ± 0.00	1.82 ± 0.03	90.00 ± 1.92
P-value	0.487	0.186	0.182	0.139	0.483	0.728

Table 4 shows the proximate composition of carcasses of the hybrid red tilapia fed on experimental diets. All proximate constituents of the carcasses were not significantly affected ($p>0.05$) by the different dietary treatments. In a previous study, spirulina meal incorporation up to 75% did not affect the body composition of silver seabream [16]. Nandeesha et al. [9] recorded no difference in the moisture and protein content in carcasses of common carp fed on diets incorporated with up to 55% spirulina powder. However, the fat content decreased concomitant with an increased spirulina supplementation level. In contrast, the feeding of algae was reported to elevate the body lipid in red

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seabream [19]. For Nile tilapia (*O. niloticus*), Puwastein et al. [20] and Justi et al. [21] found similar values of moisture (78.1% and 79.0%), crude protein (19.8% and 18.2%), lipid (1.8% and 1.1%) and ash (1.0% and 1.36% respectively). For *Oreochromis* sp., Chou and Shiau [22] obtained different results from those present in this study for moisture (79.50%), crude protein (12.67%), lipid (2.05%) and ash (3.89%).

Table 4. Proximate composition (% wet weight) of carcasses of hybrid red tilapia fed on experimental diets (Mean ± SE)

Diet	Moisture	Protein	Lipid	Ash	Fibre	NFE [a]
S00	73.89 ± 0.25	17.82 ± 0.21	3.04 ± 0.14	2.76 ± 0.34	0.60 ± 0.20	1.88 ± 0.40
S05	73.61 ± 0.35	18.54 ± 0.33	2.79 ± 0.42	2.16 ± 0.29	1.03 ± 0.16	1.88 ± 0.52
S10	73.60 ± 0.20	18.52 ± 0.30	2.17 ± 0.28	2.65 ± 0.40	0.34 ± 0.10	2.72 ± 0.15
S20	74.72 ± 0.35	18.82 ± 0.16	2.74 ± 0.70	1.68 ± 0.24	0.84 ± 0.20	1.20 ± 0.39
P-value	0.081	0.12	0.574	0.153	0.086	0.128

[a] Nitrogen-free extract

Conclusions

The present study suggests that up to 20% of spirulina can be substituted for fishmeal in a fishmeal-based diet for hybrid red tilapia without any adverse effects on fish growth and proximate composition of carcasses. The use of spirulina in the diet can thus reduce the amount of incorporated fishmeal, which presently is the main protein source for the culture of most fish species.

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