Journal of Animal and Veterinary Advances 9 (9): 1395-1399, 2010
ISSN: 1680-5593

Effect of Dietary Supplementation of Different Rates of Spirulina (*Spirulina platensis*) on Growth and Feed Conversion in Guppy (*Poecilia reticulata* Peters, 1860)

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Abstract: In this study, effect of dietary supplementation of different rates (10% Group B, 20% Group C, 30% Group D, 40% Group E) of spirulina (*Spirulina platensis*) on growth and feed conversion in guppy (*Poecilia reticulata*) was compared with a commercial stamp food (Group A). Fish fed 40% spirulina performed better than those fed lower levels. At the end of the experiment, there were no significant differences between the all groups in terms of average final weights ($p>0.05$). No significant differences were observed in specific growth rate, feed conversion rate and weight gain. However, there were significant differences in terms of feed conversion rate between groups ($p<0.05$) and it was the highest in Group E (1.090±0.044) and the lowest in Group A (2.312±0.071). Therefore, the best growth rate (1.933±0.009) and live weight gain (0.085±0.006) were recorded in Group E. As a result of the study, 40% spirulina supplementation in the diet for guppy has a positive effect on growth and feed conversion rates.

Key words: Guppy, *Poecilia reticulata*, spirulina, *Spirulina platensis*, growth performance, feed conversion

INTRODUCTION

Algaes are important since they are the first ring of the food chain in nature. In general, macro and micro algaes show distribution in marine, fresh and brackish water. Their pigments, protein, vitamins and minerals contents make them as dust and live food for feeding of terrestial and aquatic organisms and they can also be used in many various fields like refining of water and as a source of fertilizer (De Groot, 1991).

There are >3000 microalgae which can be cultured and among them only 100 species can be evaulated economically (Sukatar, 2002). In the scope of commercial algae production activities, spirulina is one of the most common cultured microalgaes (Koru, 2009) and it is the most concentrated natural sources of nutrition for all animals.

Early interest in spirulina focused mainly on its potential as a source of protein and vitamins (James *et al*., 2006). The composition of commercial spirulina powder is 60% protein, 20% carbohydrate, 5% fats, 7% minerals and 3-6% moisture making it a low-fat, low calorie and cholesterol-free source of protein. Spirulina protein has a balanced composition of amino acids with concentrations of methionine, tryptophan and other amino acids almost similar to those of casein although, this depends upon the culture media used (Habib *et al*., 2008).

Spirulina has high quality protein content (59-65%) which is more than other commonly used plant sources such as dry soybeans (35%), peanuts (25%) or grains (8-10%). A special value of spirulina is that it is readily digestible due to the absence of cellulose in its cell walls and after 18 h >85% of its protein is digested and assimilated (Sasson, 1997).

Spirulina can be used as a partial supplementation or complete replacement for protein in aquafeeds and is a cheaper feed ingredient than other animal origin (Habib *et al*., 2008).

FAO fisheries statistics show a clear increase in production of spirulina over the recent years. For example, production in China was first recorded at 16483 tons in 2003 and rose sharply to 66920 tons in 2007, worth around US $6.59 and 30.78 millions, respectively (FAO, 2009).

The guppy *Poecilia reticulata*, native to fresh and brackish waters of North eastern South America and adjacent islands of the Caribbean is one of the famous tropical ornamental fish in the world (Karayucel *et al*., 2008).

The live-bearer guppy fish (*Poecilia reticulata*) are the most popular among hobbyists because of their vibrant colours and the fact that they are easy to breed and keep (Harpaz *et al*., 2005). *Poecilia reticulata* has been used as biological model in a variety of studies

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including behavior (Smith *et al*., 2002), life history evolution (Bronikowski *et al*., 2002), water quality (Araujo *et al*., 2006), genetics (Magellan and Magurran, 2007) and vital statistics (Garcia *et al*., 2008). The aim of the present study was to determine the effects of dietary supplementation with different rates of spirulina (0, 10, 20, 30 and 40%) on growth performance and feed conversion in guppy.

MATERIALS AND METHODS

Experimental fish, rearing condition and feeding regime: The guppy juveniles (*Poecilia reticulata*) used in this study were produced in Faculty of Fisheries Laboratories, Sinop University, Turkey, where the experiments were also carried out. In the experiment, 15 circular plastic aquarium with a volume of 10 L were used and 20 juveniles for each aquarium were put in. The guppy juveniles were acclimated to the laboratory conditions for 1 week by feeding them with a commercial stamp diet (control diet). The aquariums were placed to be three replicate for each group in a 1000 L experimental tank to ensure the same environmental conditions and stable temperature. The fish were kept at 26±1°C under natural photoperiod for 90 days. They were fed two times a day *ad libitium* with the experimental diets. All aquariums were cleaned daily by siphoning for the uneaten food and excreta and 10% of the water in each aquarium was exchanged. Fish were weighed and recorded every 2 weeks from the beginning of the experiment. Before weighing, fish were starved for 24 h allowing the gut to be emptied.

Experimental diets: In the experiment a commercial stamp diet was used as control diet (Group A) and spirulina added to the commercial stamp diet at different rates (10% Group B, 20% Group C, 30% Group D, 40% Group E) as experimental diets. After spirulina addition, all diets were brought into the dust feed by grinding in a grinder.

Chemical analysis: Chemical composition of the dried samples of the experimental diets were analyzed by standard methods (AOAC, 1995), dry matter after drying at 105°C for 24 h, crude protein by the Kjeldahl method after acid digestion (N×6.25), crude lipid after extraction with petroleum ether by the Soxhlet method and ash by incineration at 550°C in a muffle furnace for 12 h.

Data processing: Fish performance in terms of Weight Gain (WG), Specific Growth Rate (SGR) and Feed Conversion Ratio (FCR) were determined by using the following formulae:

$$WG\ (\%) = \frac{(\text{Final weight (g)} - \text{initial weight (g)})}{\text{Initial weight (g)}} \times 100$$

$$FCR = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

$$SGR\ [(\%)\ \text{day}\ 1] = \frac{(\ln \text{final} \times \text{fish weight}) - (\ln \text{initial} \times \text{fish weight})}{\text{Experimental days}} \times 100$$

Satistical analysis: All data were expressed as the mean±SE. Growth parameters and arcsine transformed survival rate data of groups were analysed for significant differences by Analyses of Variances (ANOVA). A $p<0.05$ was considered as significant. Analyses were performed using Minitab 13 software for Windows.

RESULTS AND DISCUSSION

The proximate composition of feed materials used in the experiment was shown in Table 1. All values except of crude lipid changed in the experimental diets. Moisture increased to almost 100% and the crude ash decreased to 2/3 ratio. However, crude protein rate was significantly increased depending on the increased spirulina meal content in the experiment diets ($p<0.05$). Compared with the control feed except of crude lipid, crude protein, crude ash and moisture rates were significantly different ($p<0.05$).

In terms of growth parameters, there were not significant differences among the all groups ($p>0.05$) but group E showed better development than the other groups. The FCR were significantly affected by the dietary treatment ($p<0.05$) and was the highest (1.09±0.04) in group E. At the end of the experiment, high survival rates were observed in the all treatment groups (Table 2).

Use of plant products as protein sources in fish feeds shows considerable application potential for aquaculture worldwide (Yagci *et al*., 2009). Spirulina is a multicellular and filamentous blue-green algae that has gained considerable popularity in the health food industry and increasingly as a protein and vitamin supplement to aquaculture diets (Habib *et al*., 2008). In the present study, use of spirulina in guppy diet was evaulated and it was found that increasing level of it in diet provided better growth comparing to the other commercial feeds and they were consumed fondly.

James *et al*. (2006) evaluated the effect of dietary spirulina level on growth performance and feed intake in red swordtail (*Xiphophorus helleri*) and they reported that SGR, feed intake and mean body weight increased with increasing level of spirulina. Fish fed 8% spirulina also performed better than those fed lower levels.

Table 1: The proximate composition of the experimental diets

Composition (%)	Group A control	Group B 10%	Group C 20%	Group D 30%	Group E 40%
Moisture	6.0[a]	11.32[b]	11.02[b]	11.13[b]	10.99[b]
Crude protein	14.0[a]	21.34[b]	24.24[c]	30.47[d]	33.53[e]
Crude lipid	3.5[a]	3.74[a]	3.74[a]	3.53[a]	3.60[a]
Crude ash	6.0[a]	4.27[b]	4.42[b]	4.46[b]	4.59

Values (mean±SE) with different superscripts in the same row are significantly different at the 5% level

Table 2: Growth performance and survival rate of lepistes fed with the experimental diets

Growth performance	Group A control	Group B 10%	Group C 20%	Group D 30%	Group E 40%
Initial weight (g)	0.018±0.00[a]	0.017±0.00[a]	0.018±0.00[a]	0.017±0.00[a]	0.018±0.001[a]
Final weight (g)	0.082±0.01[a]	0.081±0.01[a]	0.092±0.01[a]	0.090±0.01[a]	0.103±0.01[a]
Weight gain (g)	0.064±0.01[a]	0.065±0.01[a]	0.075±0.01[a]	0.073±0.01[a]	0.085±0.01[a]
SGR (%)	1.64±0.08[a]	1.76±0.06[a]	1.86±0.04[a]	1.87±0.09[a]	1.93±0.09[a]
FCR	2.31±0.07[d]	1.53±0.08[c]	1.52±0.05[c]	1.38±0.04[b]	1.09±0.04[a]
Survival (%)	98	97	98	96	97

Values (mean±SE) with different superscripts in the same row are significantly different at the 5% level

Scaria *et al.* (2000) notified that the ornamental guppy and platy (*Xiphophorus maculatus*) consumed more feed inclusing spirulina than feed inclusing mushrooms or azolla. Growth rate was higher in major carp (*Cirrhinus mrigala*) fingerlings and in striped jack consumed feed containing spirulina (Daniel and Kumuthakalavalli, 1991; Okada *et al*., 1991).

Jaime-Ceballos *et al.* (2005) studied the effect of *Spirulina platensis* meal inclusion in microdiets for white shrimp *Litopenaeus schmitti* larvae. In this study, survival was around 80% for all treatments. When compared to the control, final postlarval size was significantly smaller.

However, the development index showed that larvae fed with diets containing 5% *Spirulina platensis* meal was superior to the rest of the diets and similar to the *Artemia nauplii*. In other study, Ramakrishnan *et al.* (2008) investigated the effects of two probiotics and spirulina with rates of 1, 2 or 3% on survival, growth and FCR in common carp (*Cyprinus carpio*). Fish fed with diets containing 3% *Spirulina maximus* showed the best survival, growth and FCR. In present study, FCR increased with increasing dietary spirulina meal level and ranged from 2.31-1.09. The best FCR was obtained from group E which had better growth and the best FCR. This results agreed with the results of spirulina studies on different species (Mustafa *et al*., 1994).

It was proved that zeaxanthin, one of the basic pigment substance of spirulina, is converted rapidly to astaxanthin which accumulates in herbivore fish culture and crustaceans tissues, thus increases growth (Cirik *et al*., 1997). Lu *et al.* (2002) used at different rates of raw spirulina at the onset of exogenous feeding of 13 days old tilapia larvae. Growth rate of larvae fed with Spirulina showed more increased lenght than standart length during the first week but after 10 weeks, the growth stopped and development continued normally. Therefore, feeding of tilapia with spirulina in the first period of larval development could accelerate their growth. In the study using the powder feed, wet feed and powder feed + spirulina on artificial feeding of mirror carp larvae, the larvae fed with 20% spirulina addition powder feed gave the best live weight gain than larvae fed with only wet and powder feed during the 28 days trial (Kaplan, 2003).

Palmegiano *et al.* (2005) reported that sturgeon (*Acipenser baeri*) fed by diets containing spirulina meal had better growth than the control diet and particularly 50% inclusion seemed to result the best performance: a high increase in biomass gain and growth rate, the best FCR and a high protein efficiency rate.

In the present study, spirulina meal was an excellent substitute for commercial diet in lepistes diet as even at the high substitution level (40%). In a study by Rogatto *et al.* (2004), the influence of spirulina intake on metabolism of exercised rats were determined and reported that this seaweed might be a good alternative source of protein.

CONCLUSION

As a result, production and requisition of spirulina have been raising since the prolifiration of its usage recently arising of its functions on human health due to its contents, having no toxicity effect of it. Like the other fields arising of its functions in terms of aquaculture will increse the demand to this microalgae. Using guppy as a model, the present study showed the usage of spiriluna inclusion up to 40% can be possible in the other aquarium fish diet.

ACKNOWLEDGEMENT

Researchers would like to thank the Owner of the Sinop Doğa Akvaryum, Mr. Ali Haydar Dernekbasi, for supplying experimental diets.

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