J. of Aquaculture
Vol. 20(1) : 56-59, 2007

한국양식학회지
Journal of Aquaculture

Effect of Dietary Nutrient Composition on Growth and Body Composition of Juvenile Olive Flounder *Paralichthys olivaceus* with Different Feeding Strategy

Sung Hwoan Cho
Division of Marine Environment and Bioscience, College of Ocean Science and Technology, Korea Maritime University, Busan 606-791, Korea

Effect of dietary nutrient composition on growth and body composition of juvenile olive flounder *Paralichthys olivaceus* with different feeding strategy was determined. Twenty-five fish averaging 16 g were randomly distributed into 12, 180 L flow-through tank each. Four treatments in triplicates were prepared: fish were fed to satiation twice daily by the control diet for 8 weeks as the control group (Con) and fish were fed to satiation twice daily by the control and high nutrient diets for 6 weeks after 2-week fasting (2WS-6WFC, 2WS-6WFHN, respectively) and finally, fish were fed to satiation twice daily by the high nutrient diet for the consecutive 3 days after 4-day fasting for 8 weeks (4DS-3DFHN). No significant difference was found in either survival or weight gain of flounder among treatments. Feed efficiency ratio (FER) for fish in the 2WS-6WFHN treatment was significantly higher than that for fish in the Con and 2WS-6WFC treatments. Protein efficiency ratio (PER) of fish in the 2WS-6WFHN and 4DS-3DFHN treatments was significantly higher than that of fish in the 2WS-6WFC treatment. In conclusion, manipulation of dietary nutrient composition and/or feeding strategy can effectively improve growth of juvenile olive flounder without growth retardation at restricted feeding regime.

Keywords: Olive flounder, *Paralichthys olivaceus*, Dietary nutrient composition, Feeding strategy

Introduction

Olive flounder *Paralichthys olivaceus* is the most commercially important marine fish species for aquaculture in Korea over the last two decades. Therefore, many feeding trials on determining dietary nutrient requirements, optimum feed allowance, dietary additives and feeding strategy have been performed for the production of flounder (Kim et al., 1998; Lee et al., 2000a, b; Kim et al., 2002b; Cho, 2005; Cho et al., 2006a, b).

Not only nutrient content in a diet, but also feeding strategy are critical in the production of fish because these factors largely affect feed cost, feed efficiency, fish growth, labor cost and water quality. Thus, manipulation of dietary nutrient content at different feeding strategy or vice versa should be carefully considered to achieve the effective fish production. Juvenile flounder have an ability to achieve full compensatory growth when fed the fishmeal-based diet containing 46.9% crude protein and 8.0% crude lipid for 6 weeks after 2-week fasting (Cho et al., 2006b). In addition, Kim et al. (2002a) reported that growth of juvenile flounder fed the moist pellet with alternative day feeding was comparable to that of fish with daily feeding, but the former was more effective for feed utilization than the latter. Also, Cho and Park (2004) showed that growth of juvenile flounder fed the commercial feed for 5 days a week was comparable to that of fish fed for 6 days a week. Fish grew better on the high nutrient diet than the low nutrient diet at a restricted feeding rate (Li and Lovell, 1992; Harpaz et al., 1999; McGoogan and Gatlin, 1999; Boujard et al., 2004). Different feeding strategy to achieve effective fish production requires different dietary nutrient composition or vice versa.

In this study, therefore, effect of dietary nutrient composition on growth and body composition of juvenile olive flounder *Paralichthys olivaceus* with different feeding strategy was determined.

Materials and Methods

Fish and the experimental conditions

Juvenile flounder were purchased from a private hatchery and transferred into the Lab. Before the initiation of the feed-

*Corresponding author: chosunh@hhu.ac.kr

ing trial, fish were acclimated to the experimental conditions for a week. Twenty-five fish (An initial body weight of fish: 16 g) were randomly distributed into 12, 180 L flow-through tank (water volume; 150 L) each. During the acclimation period, fish were hand-fed twice daily by the commercial feed (Ewha Oil & Fat Industry Co. Ltd., Korea). The water flow rate of each tank was 6.5 L/min/tank. Water temperature ranged from 16.0 to 25.5°C (Mean±SD: 23.6±0.26°C).

Preparation of the experimental diets

Two experimental diets were prepared: control (C) and high nutrient (HN) diets (Table 1). Fishmeal, a-starch and wheat flour, and pollack liver oil were used as the main protein, carbohydrate and lipid source in the C diet, which met dietary nutrient requirements for juvenile flounder (Kim et al., 2002a, b; Lee et al., 2002). Fishmeal, a-starch and soybean oil were supplemented into the HN diet at the expense of cellulose and wheat flour to increase dietary protein and energy levels.

Design of the experiment

Fish were hand-fed to apparent satiation as much as fish voluntarily eat, twice daily (09:30, 17:00) by the control (C) diet for 6 days a week during 8 weeks as the control group

Table 1. Ingredients of the experimental diets

	Experimental diets	
	Control (C)	High nutrient (HN)
Ingredients (%)		
Fishmeal[1]	60	68
Cellulose	10	
α-starch	5	9
Wheat flour	19.3	15.3
Pollack liver oil	2	2
Soybean oil		2
Vitamin premix[2]	1.5	1.5
Mineral premix[3]	2	2
Choline	0.2	0.2
Nutrients (DM basis, %)		
Crude protein	46.9	51.9
Crude lipid	8.0	10.7
NFE	22.1	24.0
Estimated energy (kcal/g)[4]	3.48	4.00
n-3 HUFA[5]	1.4	1.5

[1]Fishmeal imported from Chile.
[2,3]Same as Lee et al. (2000a).
[4]Estimated energy calculated based on 4 kcal/g for protein and NFE, and 9 kcal/g for lipid (Garling and Wilson, 1976).
[5]n-3 HUFA: Sum of n-3 highly unsaturated fatty acids (C ≥ 20).

(Con; 8WFC). Fish were fed to satiation twice daily by the C diet for 6 weeks after 2-week fasting (2WS-6WFC) according to the previous study that juvenile flounder have ability to achieve full compensatory growth after 2-week fasting (Cho 2005; Cho et al., 2006b). Also, fish were fed to satiation twice daily by the HN diet for 6 weeks after 2-week fasting (2WS-6WFHN). Fish were fed for 6 days a week. Finally, fish were fed to satiation twice daily by the HN diet for the consecutive 3 days after 4-day fasting in a week basis for 8 weeks (4DS-3DFHN).

Chemical and statistical analysis

Fifteen fish at the initiation and five fish from each tank at the termination of the feeding trial were sampled for proximate analysis. Chemical composition of the experimental diets and fish were followed by AOAC (1990)'s method.

One-way ANOVA and Duncan`s multiple range test (Duncan, 1955) were used to analyze the significance of the difference among the means of treatments using SAS program (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

Performance and feed utilization of olive flounder fed the experimental diets with different feeding strategy were given in Table 2. No significant difference was found in either survival or weight gain of juvenile flounder although the highest survival and weight gain was achieved in fish in the 2WS-6WFHN treatment. Li and Lovell (1992) reported that weight gain of channel catfish *Ictalurus punctatus* under restricted feeding increased linearly with increasing dietary protein level when fish were fed the 26~38% protein diets at restricted feeding rate. The higher weight gain was achieved in European sea bass *Dicentrachus labrax* fed the higher lipid diets at restricted feeding rate when fish were fed the 54% protein diets with 10, 20 and 30% lipid levels (Boujard et al., 2004).

No difference in weight gain of between fish fed for 8 weeks (Con) and fish fed for 6 weeks after 2-week fasting (2WS-6WFC or 2WS-6WFHN) or fish fed for 3 days after 4-day fasting (4DS-3DFHN) in the present study probably indicated that flounder achieved compensatory growth in both cases and manipulation of dietary nutrient content and/or feeding regime could improve fish production. Similarly, juvenile flounder achieved full compensatory growth up to 2-week fasting in the 8-week feeding trial (Cho et al., 2006b). Also, compensatory growth of fingerling channel catfish was improved

Table 2. Performance and feed utilization of olive flounder fed the experimental diets with different feeding strategy[1]

	Treatments			
	Con (8WFC)	2WS-6WFC	2WS-6WFHN	4DS-3DFHN
Initial weight (g/fish)	15.9±0.01	16.0±0.02	16.0±0.00	15.9±0.04
Final weight (g/fish)	48.9±4.67	41.6±2.27	50.1±0.33	42.7±2.12
Survival (%)	96.0±0.00[n.s.]	96.0±2.31	100.0±0.00	98.7±1.33
Weight gain (%)	207.2±29.43[n.s.]	159.7±14.38	213.4± 2.06	168.0±13.05
Feed consumption (g/fish)	42.3±4.18[a]	36.0±2.06[ab]	36.1±0.34[ab]	29.9±0.93[b]
Feed efficiency ratio[2]	0.79±0.040[bc]	0.71±0.025[c]	0.95±0.004[a]	0.90±0.048[ab]
Protein efficiency ratio[3]	1.62±0.083[ab]	1.47±0.053[b]	1.78±0.007[a]	1.69±0.090[a]

[1]Values (Mean±SE) in the same row sharing a common superscript are not significantly different ($P<0.05$).
[2]Feed efficiency ratio = Weight gain of fish/feed consumed.
[3]Protein efficiency ratio = Weight gain of fish/protein consumed.

by dietary protein supplementation when fish were fed to satiation for 11 days after starved for 3 days in 2-week interval during 6 weeks (Gaylord and Gatlin, 2001).

For the easy management and convenience of fish farmers, the 4DS-3DFHN treatment is recommendable although slight low weight gain of fish was obtained compared to that of fish in the Con and 2WS-6WFHN treatments in the present study because satiation feeding is difficult for farmers to achieve each meal in fish farm and improvement in feed utilization was achieved in the former. Similarly, Kim et al. (2002a) recommended alternative day feeding strategy for the improved feed utilization because growth of juvenile flounder with alternative day feeding was comparable to that of fish with daily feeding when fish were fed three times a day by the moist pellet.

Feed consumption of fish in the Con treatment was significantly ($P<0.05$) higher than that of fish in the 4DS-3DFHN treatment, but not significantly ($P>0.05$) different from that of fish in the 2WS-6WFC and 2WS-6WFHN, in which fish were fed for 6 weeks after 2-week fasting. Lower feed consumption, but comparable weight gain of fish in the 4DS-3DFHN treatment compared to those of fish in the Con treatment in this study indicated that high nutrient content in the 4DS-3DFHN treatment could be effectively utilized for growth of fish. Similarly, feed consumption of fish with alternative day feeding was lower than that of fish with daily feeding, but comparable weight gain in the 8-week feeding trial (Kim et al., 2002a).

Feed efficiency ratio (FER) of fish in the 2WS-6WFHN treatment was significantly ($P<0.05$) higher than that of fish in the Con and 2WS-6WFC treatments, but not significantly ($P>0.05$) different from that of fish in the 4DS-3DFHN treatment. The lowest FER was obtained in fish in the 2WS-6WFC treatment. Protein efficiency ratio (PER) of fish in the 2WS-6WFHN, which was highest, and 4DS-3DFHN treatments was significantly ($P<0.05$) higher than that of fish in the 2WS-6WFC treatment, but not significantly ($P>0.05$) different from that of fish in the Con treatment. Significant improvement in FER and PER of flounder in the 2WS-6WFHN treatment compared to those of fish in the 2WS-6WFC in the present study is consistent with the results of other studies showing that fish responded better on the high nutrient diet than low nutrient diet at restricted feeding rate (Li and Lovell, 1992; Harpaz et al., 1999; McGoogan and Gatlin, 1999; Boujard et al., 2004).

Chemical composition (moisture, crude protein, crude lipid and ash) of the whole-body of olive flounder at the end of the 8-week feeding trial was not significantly ($P>0.05$) different among treatments in this study. Similarly, chemical composition of the whole-body of fish was not affected by either feeding strategy or dietary nutrient content (Kim et al., 2002a; Boujard et al., 2004; Zhu et al., 2004; Cho, 2005).

In considering these results, it can be concluded that manipulation of dietary nutrient composition and/or feeding strategy can effectively improve growth of juvenile olive flounder without growth retardation at restricted feeding regime.

References

AOAC (Association of Official Analytical Chemists), 1990. Official Methods of Analysis, 15th edn., Association of Official Analytical Chemists. Arlington, Virginia, USA.

Boujard, T., A. Gelineau, D. Coves, G. Corraze, G. Dutto, E. Gasset and S. Kaushik, 2004. Regulation of feed intake, growth, nutrient and energy utilization in European sea bass (*Dicentrarchus larbrax*) fed high fat diets. Aquaculture, 231, 529–545.

Cho, S. H. and I. S. Park, 2004. Effect of different days of feeding in a week-basis on growth and body composition of juvenile flounder *Paralichthys olivaceus*. Kor. J. Ichth, 16, 210–214.

Cho, S. H., 2005 Compensatory growth of juvenile flounder *Paralichthys olivaceus* L. and changes in biochemical composition and body condition indexes during starvation and after refeeding during the winter season. J. World Aquacult. Soc., 36, 508–514.

Cho, S. H., S. Lee, B. H. Park and S. Lee, 2006a. Effect of feeding ratio on growth and body composition of juvenile olive flounder *Paralichthys olivaceus* fed extruded pellets during the summer season. Aquaculture, 251, 78–84.

Cho, S. H., S. Lee, B. H. Park, S. Ji, J. Lee, J. Bae and S. Oh, 2006b. Compensatory growth of juvenile olive flounder *Paralichthys olivaceus* L. and changes in proximate composition and body condition indexes during fasting and after refeeding in summer season. J. World Aquacult. Soc., 37, 168–174.

Duncan, D. B., 1955. Multiple range and multiple F tests. Biometrics, 11, 1–42.

Gaylord, T. G. and D. M. Gatlin, 2001. Dietary protein and energy modifications to maximize compensatory growth of channel catfish (*Ictalurus punctatus*). Aquaculture, 194, 337–348.

Garling, D. L. and R. P. Wilson, 1976. Optimum dietary protein to energy ratios for channel catfish fingerlings, *Ictalurus punctatus*. J. Nut., 106, 1368–1375.

Harpaz, S., S. Sklan, I. Karplus, A. Barki and Y. Noy, 1999. Evaluation of juvenile silver perch *Bidyanus bidyanus* (Mitchell) nutritional needs using high- and low-protein diets at two feeding levels. Aquacult. Res., 30, 603–610.

Kim, D. S., J. H. Kim, C. H. Jeong, S. Y. Lee, S. Lee and Y. B. Moon, 1998. Utilization of Obosan (dietary herbs) I. Effects of survival, growth, feed conversion ratio and condition factor in olive flounder, *Paralichthys olivaceus*. J. Aquaculture, 11, 213–221.

Kim, J., S. Shin, K. Cho and S. Lee, 2002a. Effect of daily and alternate day feeding regimens on growth and food utilization by juvenile flounder *Paralichthys olivaceus*. J. Aquaculture, 15, 15–21.

Kim, K. D., S. Lee, H. G. Park, S. Bai and Y. H. Lee, 2002b. Essentiality of dietary n-3 highly unsaturated fatty acids in juvenile Japanese flounder (*Paralichthys olivaceus*). J. World Aquacult. Soc., 33, 432–440.

Lee, S. M., S. H. Cho and K. D. Kim, 2000a. Effects of dietary protein and energy levels on growth and body composition of juvenile flounder (*Paralichthys olivaceus*). J. World Aquacult. Soc., 31, 306–315.

Lee, S. M., S. H. Cho and D. Kim, 2000b. Effects of feeding frequency and dietary energy level on growth and body composition of juvenile olive flounder (*Paralichthys olivaceus*). Aquacult. Res., 12, 917–923.

Lee, S. M., C. S. Park and I. C. Bang, 2002. Dietary protein requirement of young Japanese flounder *Paralichthys olivaceus* fed isocaloric diets. Fish. Sci., 68, 158–164.

Li, M. and R. T. Lovell, 1992. Comparison of satiate feeding and restricted feeding of channel catfish with various concentration of dietary protein in production ponds. Aquaculture, 103, 165–175.

McGoogan, B. B. and D. M. Gatlin, 1999. Dietary manipulations affecting growth and nitrogenous waste production of red drum, *Sciaenops ocellatus*. I. Effects of dietary protein and energy levels. Aquaculture, 178, 333–348.

Zhu, X., S. Xie, Z. Zou, W. Lei, Y. Cui, Y. Yang and R. J. Wootton, 2004. Compensatory growth and food consumption in gibel carp, *Carassius auratus gibelio* and Chinese longsnout catfish, *Leiocassis longirostris*, experiencing cycles of feed deprivation and re-feeding. Aquaculture, 241, 235–247.

Manuscript Received: December 18, 2006
Revision Accepted: February 22, 2007