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Evaluation of Commercial Diets and Replacement of Raw Fish with Formulated Diets in Moist Pellet for Olive Flounder (*Paralichthys olivaceus*)

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市販 넙치飼料의 評價와 모이스트펠릿飼料中 冷凍魚類를 粉末配合飼料로 代置

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要 約

6種의 시판 넙치 사료 (C1~C6)를 실험실에서 만든 배합사료 (S)와 비교하여 그 품질을 평가하고 넙치 사육에서 모이스트펠릿 제조시 냉동 어류를 배합 사료로 완전 대치할 수 있는지를 연구하기 위하여 두가지 실험을 실시하였다. 실험 1에서는 넙치 (42 g) 20 마리를 넣은 수조 3개를 S 및 C1~C6에 각각 배치하여 수온 17℃에서 4주간 실험 사료를 먹였다. 실험 2에서는 넙치 (78 g) 400 마리를 넣은 수조 3개를 각각 100 % 실험실 배합 육성 사료 (G), 50 % G+50 % 냉동 고등어 (70 % 수분), 50 % C6+50 % 냉동 고등어 구에 배치하여 6주간 실험 사료를 먹였다. 실험 1에서 S를 먹인 넙치의 체중 증가율은 C2 나 C3를 먹인 넙치의 체중 증가율 보다 현저히 (P<0.05) 높았으며 (4주간 한마리 당 각각 26.7 vs 15.4 와 17.5 g), S와 기타 시판 넙치 사료 간에는 유의차가 없었다 (P>0.05). 사료 효율은 C2 사료만이 S에 비해 현저히 (P<0.03) 낮았다. 실험 2에서는 실험실 배합 사료 100 %, 50 % G 혹은 50 % C6+냉동 고등어로 된 모이스트펠릿 사료를 먹인 넙치 간에는 체중 증가나 사료 효율에서 유의차 (P>0.05)가 없었다. 이 연구 결과는 시판 넙치 사료는 실험실 배합 사료와 비교할 때 개선의 여지가 있음을 말해 주고, 냉동 어류를 사용하지 않고도 100 % 배합 사료만으로 넙치 사육이 가능함을 암시해 준다.

INTRODUCTION

Aquaculture in Korea started to grow rapidly in 1970's as demand for live fish increased with

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the fast growing economy, while fisheries production have not significantly changed due to decreased resources in the coastal seas in spite of increased efforts. As a result, fish production through aquaculture has increased, by expanding both number of species and amount of main culture species.

Production of olive flounder (*Paralichthys olivaceus*) has also rapidly increased for the last 5~6 years and currently reached to the amount of approximately 7,000 tons per year. However, no commercial diets can exclusively guarantee satisfactory growth of the flounder unless frozen raw fish is used. Hence most flounder farmers use moist pellet (MP) made from raw fish and formulated powder (so-called commercial diet), resulting in not only increased disease breakouts, but also higher production cost due to the purchase and maintenance of freezers and related labor cost.

The following studies were undertaken to evaluate commercial diets, and to examine the possibility of using MP prepared with or without raw fish in olive flounder.

MATERIALS AND METHODS

Animals and diets: In Experiment 1 to evaluate commercial flounder diets, three tanks (surface area×depth, 0.3 ㎡×0.35 m), each containing twenty 42 g olive flounder (*Paralichthys olivaceus*) were assigned to control (laboratory formulated, S) and each of six different commercial diets (C1~C6) as shown in Table 1. These diets were made into MP after being mixed with 30 % water. For Experiment 2, to examine the possibility of using MP made of a complete mixed diet without raw fish for flounder feeding, three tanks (10 ㎡×0.5 m), each containing four hundred 78 g

Table 1. Composition of diets (%) – Experiment 1

Diet[1]	S	C1	C2	C3	C4	C5	C6
Fish meal	70.0						
Corn starch	16.5						
Squid oil[2]	10.0						
Vitamin mix[3]	0.5						
CM cellulose	3.0						
Choline chloride	0.7						
DM basis							
Crude protein	45.0	45.0	47.0	47.0	48.0	50.0	48.0
Ether extract	15.0	3.0	5.0	3.0	5.0	5.2	3.0
Ash	14.0	17.0	16.0	19.0	18.0	10.0	17.0

[1]S, Laboratory-formulated diet. C1~C6, commercial flounder diets, ingredients of which were not clearly defined (closed formula). Diets were made into moist pellet after being mixed with 30 % water and the moist pellet was frozen at 20 ℃ until fed.

[2]Alpha-tocopherol acetate (0.5 g/kg diet) was added to squid oil.

[3]Kim et al. (1991).

fish were assigned to each of the following diets: 1) 100 % laboratory-formulated diet (grower, G), 2) 50 % G (on an air-dry basis) + 50 % frozen mackerel containing 70 % moisture and 3) 50 % commercial diet (C6, on an air-dry basis) + 50 % frozen mackerel (Table 2). Moist pellet containing about 30 % moisture was made using pellet machine after grinding frozen fish and mixing with the formulated powder diet and water when necessary. MP used for both experiments was stored at 20 ℃ until fed. Chemical composition of the diets was analyzed by using the AOAC method (1990).

Table 2. Composition of diets (%) – Experiment 2

Diet[1]	G	C6	Frozen mackerel
Fish meal	70.00		
Wheat flour	15.93		
Squid oil	10.00		
Guar gum	3.00		
Vitamin mix[2]	1.00		
Trace mineral mix[3]	0.05		
BHT	0.02		
DM basis			
Crude protein	48.9	48.0	67.0
Ether extract	15.0	3.0	26.3
Ash	14.0	17.0	6.0

[1]G, laboratory-formulated grower diet; C6, commercial flounder diet, ingredients of which were not clearly defined; frozen Pacific mackerel containing 70 % moisture mixed with G or C6 (1 : 1 on an as-is basis).

[2]Grobig-fish (Bayer Korea Ltd, Seoul) supplemented with vitamins E and C: As IU or mg/kg diet; vitamin A 5000 IU, vitamin D_3 1000 IU, vitamin E 300, vitamin K 10, vitamin B_1 20, vitamin B_2 20, vitamin B_6 20, vitamin B_{12} 0.020, vitamin C 300, niacin 100, Ca-D-pantothenate 50, folic acid 5, choline chloride 550, biotin 0.10, inositol 100, paraaminobenzoic acid 10.

[3]As mg/kg diet; Zn 15, Mn 6.5, Cu 1.5, Co 0.05, Se 0.02, I 0.55.

Experimental conditions: Fish were fed to satiation 3 times daily (0800, 1200 and 1600). Body weight of the fish in each tank as a group was measured at the beginning and every two weeks thereafter in Experiment 1. In Experiment 2 initial and final body weights of fish in each tank were determined. Meanwhile three groups of 40 fish each were randomly selected from each tank and weighed every two weeks, and the mean was used as a representative weight of the fish in the tank. Feed consumption was also monitored. Weight gain and feed efficiency were calculated for the entire feeding period. Each tank was supplied with underground salt water (32 ‰ salinity, 17 ℃) at a flow rate of approximately 4 L/min in Experiment 1 or 40 L/min in Experiment 2. An air compressor was used to provide oxygen to near saturation (6.5 ppm).

Statistical Analysis: Data obtained in Experiment 1 were analyzed by the student t-test and those from Experiment 2 were analyzed by the analysis of variance (Snedecor and Cochran 1980).

RESULTS AND DISCUSSION

The Laboratory-formulated diet (S) enhanced ($P<0.05$) weight gain more than the commercial diets C2 and C3 (26.5 vs 15.4 and 17.5 g/fish per 4 weeks, respectively). Fish fed the commercial diets (C1, C4, C5 and C6) tended to gain less ($P<0.10$) than those fed S (Table 3). Feed efficiency was significantly ($P<0.05$) lower in fish fed C2 than in fish fed S but was not different between fish fed S and the other commercial diets. Results of Experiment 1 indicate that most of the commercial flounder diets may be improved to achieve better growth.

Table 3. Comparison of weight gains of olive flounder fed a laboratory-formulated (S) and commercial feeds (C1~C6) for four weeks[1] — Experiment 1

Diet	S	C1	C2	C3	C4	C5	C6	SE[2]
Gain[3]	26.5	18.7	15.4	17.5	19.7	20.3	20.6	2.3
Gain/feed[4]	1.08	0.89	0.60	0.87	1.13	0.87	0.77	0.10

[1]Values are means of three replicates of 20 fish each. Mean initial body weight of 21± s. e. m. was 42.1± 0.2 g for 21 tanks of 20 fish each.
[2]Pooled standard error. 4 g gain/fish fed S was higher than C2 or C3 ($P<0.05$)
[3]g gain/g dry amtter of feed.
[4]g live weight gain/g dry matter of feed.

No comparable data on body weight gain were available for flounder, but weight gain obtained in Experiment 1 was much higher than that reported for plaice (*Pleuronectes platessa*) by Cowey et al. (1972). They found weight gain of less than 10 g with 14 g plaice fed for 6 weeks. A similar weight gain was reported with turbot (*Scophthalmus maximus*) used for studies to determine the vitamin requirements (Cowey et al. 1975; Adron et al. 1978).

Weight gain of flounder fed 100 % laboratory-formulated grower diet (G), 50 % G+50 % frozen mackerel and 50 % C6+50 % mackerel for 6 weeks was 29.4, 31.6 and 27.5 g, respectively (Table 4). This result is promising because feeding flounder the 100 % laboratory-formulated diet without using raw fish promoted growth as well as the diets containing 50 % raw mackerel.

Table 4. Weight gain and feed efficiency of olive flounder fed 100 % laboratory-formulated (G), 50 % laboratory-formulated + 50 % Pacific mackerel (G + M) or 50 % commercial + 50 % frozen Pacific mackerel (C6 + M) diets for 6 weeks[1] — Experiment 2

Diet	G	G+M	C6+M
Gain[2]	31.3 ± 0.8	29.4 ± 1.0	27.5 ± 1.8
Gain/Feed[3]	0.53± 0.01	0.50± 0.14	0.49± 0.03

[1]Values are means± s. e. m. of three replicates of 400 fish each. Mean initial body weight± s. e. m. was 79.5± 1.0 for nine tanks of 400 fish each.
[2]g/fish.
[3]g gain/g dry matter of feed.

Recently, Watanabe et al. (1991, 1992) at the Tokyo University of Fisheries reported that they have developed a new type of pellet (soft-dry pellet) and suggested that this diet could replace the conventional MP containing large amounts of raw fish without deleterious effects in yellowtail (*Seriola quinqueradiata*) culture. The soft-dry pellet was reported to be prepared by extruding diet with twin extruder and then by adding 20~30 % oil. This type of pellet has not been tested for flounder culture.

The taste and hardness of pellet are known to be the major factors influencing palatability and acceptability of diets. Results of the studies by Watanabe et al. (1991, 1992) are considered important because they showed the possibility of replacing conventional MP with dry pellet. Using dry pellet in fish culture alleviates feed loss, contamination of water, disease breakout and other problems including high production costs.

According to the calculation by Watanabe et al (1991), about 340 kg of MP is lost to water to produce one ton of yellow tail. In addition, use of dry pellet allows fish farmers to maintain diet quality constant and to adjust diet quality according to environmental conditions, such as fish size and water temperature. Use of dry pellet also make it possible to improve products quality (e. g., texture and lipid content) by changing protein/energy ratios. Watanabe et al. (1992) showed that using soybean meal up to 30 % in soft-dry pellet had no deleterious effects on yellowtail growth.

Studies on nutrient requirements and feeding of flatfish, such as plaice, sole (*Solea vulgaris*) and turbot have been done in Europe (e. g., protein and amino acids by Cowey et al. 1970, 1971, 1972; Adron et al. 1976; Bromley 1980; and vitamins by Cowey et al. 1975; Adron et al. 1978). Limited studies were reported on flounder in Japan e. g., energy and nitrogen metabolism by Kikuchi et al. 1990, 1991). Therefore, much more research on the nutrient requirements and feeding is required for better formulation of flounder diets and their culture.

In conclusion, the results of our studies indicate that commercial flounder diets can be improved and that alternative feeding systems without using raw fish can possibly be developed. Such a change will increase productivity and reduce environmental pollution.

ABSTRACT

Two studies were carried out: to compare commercial flounder diets (C1~C6) with a laboratory-formulated diet (S), and to evaluate moist pellet (MP) prepared with or without raw fish for olive flounder culture. In experiment 1, three replicates of 20 fish (42 g in average) each were fed S or each of C1~C6 for four weeks at 17 ℃. For experiment 2, three replicates of 400 fish (78 g in average) each were fed 100 % laboratory-formulated grower diet (G), 50 % G+50 % frozen mackerel containing 70 % moisture or 50 % C6 (the same diet as that used in Exp. 1)+50 % frozen mackerel for six weeks. Weight gain of fish fed S was significantly ($P<0.05$) higher than that of fish fed C2 or C3 (26.7 vs 15.4 or 17.5 g/fish over the 4-week period, respectively). Feed efficiency was significantly ($P<0.05$) lower in fish fed C2 than in fish fed S but was not different ($P>0.05$) between the fish fed S and the other commercial diets. No significant differences in weight gain were found among the

fish fed 100 % G, 50 % G+50 % frozen mackerel or 50 % C6+frozen mackerel. The results of our studies indicate that most of the commercial flounder diets can be improved for better growth, when we compared these diets with a laboratory-formulated diet, and the growth of flounder fed MP containing no raw fish was as good as that of those fed MP prepared with raw fish.

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