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Effects of dietary protein and energy levels on growth and body composition of juvenile turbot (*Scophthalmus maximus* L.) reared under optimal salinity condition

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Introduction

Several nutrients in feed are needed for growth and maintenance of fish and protein among them is probably the most important factor influencing its growth and determining feed cost due to high proportion. Besides, dietary energy level is critical because protein source in the feed was utilized as energy source when the feed deficient in energy was fed to fish, whereas when the feed excess in energy was fed to fish, feed consumption decreased and resulted in growth reduction due to lack of necessary other nutrients for the normal growth (Lovell 1989). Therefore, it is critical to determine the optimum dietary protein level, energy level or their ratio for performance of fish. Turbot is known as a relatively eurythermal and euryhaline species (Burel et al., 1996; Imsland et al., 2001). Dietary protein level for growth of turbot largely varied, 35~69.8% depending on fish size, dietary protein source and energy level (Adron et al., 1976; Caceres-Maartinez et al., 1984) and is still controversial. Imsland et al., (2001) recently reported that optimal temperature and salinity combination for growth of juvenile turbot were 21.8℃ and 18.5‰, respectively when fish were raised at the various temperature and salinity conditions. Therefore, in this study, the effect of dietary protein and energy levels on growth of juvenile turbot was determined under the optimum rearing condition, especially salinity in this study.

Materials and methods

Juvenile turbot was acclimated into the experimental condition for a week. Twenty juvenile (an initial weight of 47 g) turbot were randomly distributed into 250 L fiber FRP tanks. Filtered seawater and freshwater was mixed into a 2-ton tank to maintain constant salinity, 15‰ and pumped into each tank. Salinity of brackishwater (15 ‰) was monitored and supplied at a flow rate of 10 L min^{-1} into each tank. Water was aerated continuously and water temperature ranged from 18.0 to 20.4℃ (19.2℃±0.74 ℃, Mean±SD). Fish were hand-fed to satiety twice daily (0900 and 1700) for 4 weeks. A 3 protein levels (55, 60 and 65%) × 2 energy levels (490 and 540 kcal/100 g diet of gross energy, GE) factorial experiment with 3 replications was designed. Each protein level had two energy levels of 490 and 540 kcal/100 g diet of GE calculated based on 4, 9 and 4 kcal/g for protein, lipid, and nitrogen free extract, respectively (Garling and Wilson, 1976). Herring meal and casein were used as the primary protein source and dietary protein levels increased mainly at the expense of cellulose. Squid liver oil and soybean oil were used as dietary lipid source. Energy level was adjusted by supplementation of soybean oil into the high energy diet at the expense of α-starch. The content of n-3 HUFA in the experimental diets was 1.55%. Ten fish were sampled at the initiation of the feeding trial and stored at -40℃in freezer for later analysis and five fish at the termination were sacrificed for proximate analysis according to standard method (AOAC 1990). The significance of variables was determined by using One-way ANOVA, Duncan's test (1955) and Two-way ANOVA analysis on SAS program (SAS Institute, Cary, North Carolina).

Results

Survival of turbot was not significantly affected by either dietary protein or dietary energy level. However, weight gain (g/fish) and specific growth rate (SGR) of fish were significantly ($P<0.05$) affected by dietary energy level, but not by dietary protein level. Weight gain and SGR of turbot fed the 55, 60 and 65 % protein diets containing GE level of 540 kcal/g diet was significantly ($P<005$) higher than that of fish fed the 60% protein diet with 490 kcal/g diet. Daily feed intake (DFI) was significantly ($P<0.05$) affected by both dietary protein and energy levels. DFI for turbot fed the 55% protein diet with 540

kcal/g diet was significantly ($P<0.05$) higher than that of fish fed any feed of the rest. Significant interaction of dietary protein and energy levels on DFI was observed. Feed efficiency ratio (FER) and Protein efficiency ratio (PER) was significantly ($P<0.05$) affected by dietary energy level, but not by dietary protein level. FER and PER of fish fed the 55% protein diet with 490 kcal/g diet was significantly ($P<0.05$) lower than that of fish fed the other diets. Significant interaction of dietary protein and energy levels on FER and PER was observed. Moisture content of fish was significantly ($P<0.05$) affected by dietary energy level, but not by dietary protein level. Protein and ash content of fish was not significantly ($P>0.05$) affected by either dietary protein or dietary energy level. However, ash content of fish was significantly ($P<0.05$) affected by dietary energy level, but not by dietary protein level. According to the results of this study, the optimum dietary protein and energy levels seemed to be 55% and 540 kcal/g diet, respectively, in which their ratio (E/P) is 9.82 kcal/g protein.

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