OPTIMUM DIETARY PROTEIN AND LIPID LEVELS FOR JUVENILE ROCKFISH (*SEBASTES SCHLEGELI)*

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OPTIMALNE POTREBE JUVENILNIH MORSKIH GRGEČA *SEBASTES SCHLEGELI* U PROTEINIMA I LIPIDIMA

Apstrakt

U ovom istraživanju su analizirane optimalne potrebe juvenilnih morskih grgeča *Sebastes schlegeli* u proteinima i lipidima. 810 juvenilnih riba je izabrano po principu slučajnosti i distribuirano u 27 tankova od po 50 L sa protočnih sistemom. Pripremljeno je 9 eksperimentalnih smeša u vidu 3x3 faktorijalne eksperimentalne postavke: tri nivoa proteina (45, 50 i 55%) x tri nivoa lipida (11, 15 i 19%). Nivo proteina je imao uticaj na prirast riba, dok nivo lipida nije. Prirast riba hranjenih smešom u odnosu 50P-15L (50% proteina i 15% lipida) je bio veći nego prirast riba hranjenih smešama sa 45% proteina, bez obzira na nivo lipida, ali je bio isti kao kod riba hranjenih sa smešama 50P-11L, 50P-19L, 55P-11L, 55P-15L i 55P-19L. Stopa efikasnosti hrane (FER) riba je bila pod uticajem proteina u hrani ali ne i nivoa lipida. Stopa efikasnosti proteina (PER) riba je takođe bila pod uticajem proteina u hrani ali ne i nivoa lipida. Može se zaključiti da je za juvenilne Sebastes schlegeli optimalan nivo proteina i lipida za dobar prirast i iskoristljivost hrane (PER and NRE) 50% i 15% odnosno 45% i 19%, dok je optimalan odnos proteina i energije 27.4 i 23.9 mg protein/kJ.

Ključne reči: morski grgeč, Sebastes schlegeli, optimalan nivo proteina, optimalan nivo lipida, optimalan odnos proteina i energije
Keywords: rockfish, Sebastes schlegeli, optimum protein level, optimum lipid level, optimum protein to energy ratio

INTORDUCTION

Rockfish (*Sebastes schlegeli*, Hilgendorf 1880) is a commercially important marine fish species in Korea and its annual aquaculture production in 2012 reached 17,338 metric tons (MFAFF 2014). Therefore, many feeding trials to determine the dietary requirements (Kim et al., 2001), alternative animal and/or plant protein sources for substitution of fishmeal in the diets (Lee et al., 1996), optimum feeding frequency (Lee et al., 2000), feeding strategy (Oh et al., 2008) and dietary additive to improve immune response (Kim et al., 1999) of rockfish have been performed.

Generally speaking proteins are one of the most expensive components of commercial feed affecting fish performance. In addition, dietary energy level is a critical factor influencing feed consumption and level of lipids in fish. Therefore, the ratio of energy to protein in the diet must be kept in balance. When the dietary energy to protein ratio is low, dietary proteins are utilized as an energy source in fish to satisfy dietary energy requirement. Eventually this would increase fish production cost and deterioration of water quality. On the contrary, when dietary energy to protein ratio is high, feed consumption decreases and it results in reduction of growth due to lack of necessary other nutrients such as essential amino acids and fatty acids for the maximal growth (Lovell, 1989). Therefore, determination of the optimum dietary protein and lipid levels should be made prior to other feeding trials. Limited studies on the optimum dietary protein to energy ratio for growth of juvenile rockfish has been performed, except for the study of Kim et al. (2004a). They determined that the optimum dietary protein to energy ratio fell into 21.5-35.4 mg protein/kJ gross energy for juvenile rockfish, but its range was quite wide and fish performance, such as weight gain (147-187%) and feed efficiency ratio (0.62-0.72) were relatively poor. Thus, the determination of optimum dietary protein and levels for juvenile rockfish needs to be re-evaluated. Therefore, the aim of this study was to determine the effect of different levels of protein and lipid in the diet on growth, body composition and plasma chemistry of juvenile rockfish in order to identify optimum dietary protein-to-energy.

MATERIALS AND METHODS

Eight hundred ten juvenile (initial body weight of 3.2 g) fish were randomly chosen and distributed into 27 of 50 l flow-through tanks (water volume: 40 l) (30 fish per tank). The flow rate of water in each tank was 600-ml/min/tank. The water source was sand-filtered natural seawater and aeration was supplied into each tank. Water temperature monitored daily from 16.0 to 24.9°C (mean ± SD: 20.8 ± 2.61°C) and photoperiod followed natural conditions.

Nine experimental diets were prepared (Table 1) according to a 3 × 3 factorial experimental design: three crude protein levels (45, 50 and 55%) × three crude lipid levels (11, 15 and 19%). Fishmeal, casein and dehulled soybean meal were used as the protein source in the experimental diets. Dextrin, squid liver and soybean oils were used as the carbohydrate and lipid sources, respectively.

The following variables were calculated: feed efficiency ratio (FER) = Weight gain of fish/feed consumed, protein efficiency ratio (PER) = Weight gain of fish/protein consumed, nitrogen retention efficiency (NRE) = Nitrogen gain×100/nitrogen intake.

Two-way ANOVA and Duncan`s multiple range test were used to analyze the significance of the difference among the means of treatments through SAS version 9.3 (SAS Institute, Cary, NC, USA).

RESULTS

Survival of fish ranging from 95.6 to 98.9% was not significantly ($P > 0.05$) affected by either dietary protein or dietary lipid level (Table 2). However, weight gain of fish was significantly ($P < 0.006$ and $P < 0.005$) affected by dietary protein level, but not ($P > 0.05$) by dietary lipid level. Weight gain of fish fed 50P-15L (50% protein and 15% lipid) diet was significantly ($P < 0.05$) higher than that of fish fed the 45% protein diets regardless of lipid level, but not significantly ($P > 0.05$) different from that of fish fed the 50P-11L (50% protein and 11% lipid), 50P-19L (50% protein and 19% lipid), 55P-11L (55% protein and 11% lipid), 55P-15L (55% protein and 15% lipid) and 55P-19L (55% protein and 19% lipid) diets.

Feed consumption (g/fish), feed efficiency ratio (FER), protein efficiency ratio (PER) and nitrogen retention efficiency (NRE) of juvenile rockfish fed experimental diets with various protein and lipid levels are given in Table 3. Feed consumption of fish was significantly ($P < 0.02$) affected by dietary protein level, but not ($P > 0.05$) by dietary lipid level. FER of fish was significantly ($P < 0.0001$) affected by dietary protein level, but not ($P > 0.05$) by dietary lipid level.

FER of fish fed the 45 and 50% protein diets was significantly ($P < 0.05$) higher than that of fish fed with the 55% protein diets at all lipid levels. PER of fish was significantly ($P < 0.0001$) affected by dietary protein level, but not ($P > 0.05$) by dietary lipid level. PER of fish fed the 45% protein diet was significantly ($P < 0.05$) higher than that of fish fed the 50 and 55% protein diets regardless of dietary lipid level. In addition, PER of fish fed the 50% protein diet was significantly ($P < 0.05$) higher than that of fish fed the 55% protein diet regardless of dietary lipid level. NRE of fish fed the 45P-19L diet was significantly ($P < 0.05$) higher than that of fish fed the 45P-11L, 50P-11L, 50P-15L, 50P-19L, 55P-11L, 55P-15L and 55P-19L diets, but not significantly ($P > 0.05$) different from that of fish fed the 45P-15L diet. The lowest NRE was observed in fish fed the 55P-15L diet.

Table 1. Feed consumption (g/fish), feed efficiency ratio (FER), protein efficiency ratio (PER) and nitrogen retention efficiency (NRE) of juvenile rockfish (*Sebastes schlegeli*) fed the experimental diets with the various protein and lipid levels

Experimental diets	Feed consumption	FER[1]	PER[2]	NRE[3]
45P-11L	8.4 ± 0.17	0.97 ± 0.008^{a}	2.1 ± 0.03^{a}	34.6 ± 1.76^{b}
45P-15L	8.5 ± 0.41	0.96 ± 0.001^{a}	2.1 ± 0.01^{a}	36.9 ± 0.38^{ab}
45P-19L	8.7 ± 0.58	0.96 ± 0.006^{a}	2.1 ± 0.04^{a}	37.7 ± 1.51^{a}
50P-11L	8.9 ± 0.33	0.96 ± 0.005^{a}	1.9 ± 0.02^{b}	30.6 ± 0.14^{de}
50P-15L	9.6 ± 0.14	0.97 ± 0.003^{a}	1.9 ± 0.03^{b}	33.9 ± 0.76^{bc}
50P-19L	9.4 ± 0.39	0.96 ± 0.004^{a}	1.9 ± 0.04^{b}	31.3 ± 0.91^{cd}
55P-11L	9.8 ± 0.62	0.94 ± 0.008^{b}	1.6 ± 0.06^{c}	28.3 ± 0.88^{de}

55P-15L	9.4 ± 0.42	0.95 ± 0.003^{b}	1.7 ± 0.02^{c}	28.1 ± 0.43^{e}
55P-19L	9.5 ± 0.27	0.94 ± 0.004^{b}	1.7 ± 0.03^{c}	31.0 ± 0.77^{cde}
Two-way ANOVA				
Protein	$P < 0.02$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$
Lipid	NS	NS	NS	$P < 0.03$
Interaction	NS	NS	NS	NS

Values (means of triplicate ± SE) in the same column sharing a common superscript are not significantly different ($P > 0.05$).

DISCUSSION

Weight gain of rockfish was affected by dietary protein level, but not by dietary lipid level. The highest weight gain of fish fed the 50P-15L diet indicated that the optimum dietary protein and lipid levels for juvenile rockfish were 50% and 15%, respectively, and ratio of protein to energy was 27.4 mg protein/kJ in this study. Our results agree with the results of Kim et al. (2004a) study determining the optimum dietary protein to energy ratio of 21.5-35.4 mg protein/kJ gross energy. Weight gain of fish in our study ranging from 249.3% to 284.3% was relatively higher than that of fish in the study of Kim et al. (2004a).

FER of rockfish fed 45 and 50% protein diets was higher than that of fish fed the 55% protein diets at all lipid levels. Similarly, FER was reported to decrease when protein levels in the diets were over dietary protein requirement in olive flounder (Lee et al., 2002) and turbot (*Scophthalmus maximus*) (Lee et al., 2003).

PER of fish was significantly affected by dietary protein level, but not by dietary lipid level. PER of fish fed 45% protein diet was higher than that of fish fed 50 and 55% protein diet regardless of dietary lipid level. In addition, PER of fish fed 50% protein diet was higher than that of fish fed 55% protein diet regardless of dietary lipid level. Generally speaking PER tended to decrease as dietary protein level increased (Lee et al., 2002; Kim et al., 2004).

NRE of fish was significantly affected by both dietary protein and lipid levels. Significantly improvement in NRE of fish fed 50% protein diet at 15% lipid level compared to that of fish fed 50% protein diet at 11% lipid level indicated "protein-sparing effect" of lipid, is in line with other studies (Manuel-Vergara et al., 1996; Van der Meer et al., 1997; Helland and Grisdale-Helland, 1998; Lee et al., 2000; Kim et al., 2004). However, further increase in lipid levels from 15% to 19% in 50% and 55% protein diets tended to lower feed efficiency.

CONCLUSION

Optimum protein and lipid levels for growth (SGR) and feed utilization (PER and NRE) for juvenile rockfish were 50 and 15%, and 45 and 19%, respectively, and the optimum dietary protein to energy ratio of 27.4 and 23.9 mg protein/kJ.

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