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Effects of Different Dietary Carbohydrate Sources on Growth and Body Composition of Juvenile Snail (*Semisulcospira gottschei*)

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To test the effect of different carbohydrate sources, wheat flour, used as the carbohydrate source in the control diet, was replaced with 30% glucose, 30% maltose, 30% cellulose or 30% α-starch. After feeding trial for 8 weeks, no significant differences were found in growth and proximate composition of edible fraction of the snail fed diets containing different carbohydrate sources. All the tested carbohydrates are shown as good dietary carbohydrate source.

Keywords: Snail, *Semisulcospira gottschei*, Carbohydrate sources

Introduction

The snail *Semisulcospira gottschei* is widely distributed in Korea, Japan, Taiwan and China (Davis, 1969). As a healthy food, it has high demand in Korea. However, since its natural production is decreasing, it has become a candidate shellfish for aquaculture. Hence the development of the nutritionally balanced and cost-effective feed for the snail has become a necessity and is dependent on information on dietary nutrients converted into the body of the snail. Lee et al. (2002) reported the requirement of essential fatty acids to sustain normal growth of the snail.

Although carbohydrate is not an essential nutrient for fish, its growth is reduced, when fed carbohydrate-deficient diets. This is probably due to catabolism of protein to meet the metabolic energy demand, which reduces the protein retention and increases the nitrogenous waste released into the culture system. Carbohydrate may serve as precursor to dispense amino acids and nucleic acids, which are metabolic intermediates required for growth of fish, and it is also the least expensive nutrient in feed formulation but improves the physical properties of extruding and steam pelleting of feeds. Therefore, most studies have been focussed on formulation to contain the maximum level of carbohydrate in diet that fish can utilize efficiently. However, the ability to utilize carbohydrate varies among fishes (NRC, 1993). Generally, warmwater herbivorous or omnivorous fish utilize much higher levels of carbohydrate than carnivorous coldwater salmonids and marine fish (Wilson, 1994). Recently, Lee et al. (1998) suggested that carbohydrate may be more efficiently utilized than lipid as an energy source by abalone *Haliotis discus hannai*. However, no information on carbohydrate utilization of the snail is available. Hence this study was conducted to investigate the effects of different dietary carbohydrate sources on growth and body composition of the juvenile snail.

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Materials and Methods

Ingredients and proximate analyses of the experimental diets are presented in Table 1. Wheat flour, used as the carbohydrate source in the control diet, was replaced with 30% glucose, 30% maltose, 30% cellulose, or 30% α-starch. All experimental diets were formulated by laboratory pellet machine after 35-40 g water was mixed with 100 g mixture of ingredients, and dried at room temperature overnight. Experimental diets were stored at -30°C until used.

Juvenile snails were acclimated to a re-circulating system in the laboratory for 1 week by feeding a commercial abalone diet containing 30% protein and 5% lipid. They were then randomly re-distributed into 25 L tanks at a density of 70 snails (154 mg/snail) per tank. Three replicate groups of snails were fed *ad libitum* at interval of 2 days for a period of 8 weeks. Before feeding, uneaten pellets in each tank were cleaned by siphoning and replacing 20% water in the system

Table 1. Ingredients and nutrient content of the experimental diets

Diet	Con	G30	M30	C30	S30
Ingredients (%)					
White fish meal	20.0	25.0	25.0	25.0	25.0
Glucose		30.0			
Maltose			30.0		
α-Cellulose				30.0	
α-potato starch					30.0
Wheat flour	65.5	30.5	30.5	30.5	30.5
Squid liver oil	2.0	2.0	2.0	2.0	2.0
Soybean oil	2.0	2.0	2.0	2.0	2.0
Vitamin mix[1]	2.5	2.5	2.5	2.5	2.5
Mineral mix[1]	3.0	3.0	3.0	3.0	3.0
Carboxymethyl cellulose	5.0	5.0	5.0	5.0	5.0
Nutrients content (dry matter basis)					
Crude protein (%)	22.7	23.0	22.8	22.9	22.9
Crude lipid (%)	5.4	5.3	5.7	5.5	5.4
N-free extract (%)[2]	62.0	61.5	61.5	29.0	61.4
Crude fiber (%)	1.1	1.1	1.1	33.4	1.1
Ash (%)	8.8	9.1	8.9	9.2	9.2
Estimated energy (kcal/g diet)[3]	3.9	3.9	3.9	2.6	3.9
E/P ratio (kcal/g protein)	17.0	16.8	17.0	11.2	16.9

[1]Same as Lee et al. (2002).
[2]Calculated by the difference (=100-crude protein-crude lipid-crude fiber-ash).
[3]Calculated based on 4 kcal/g protein, 9 kcal/g lipid and 4 kcal/g NFE.

with freshwater every 2 days. Freshwater was supplied at a flow rate of approximately 0.3 L/min in the recirculating system. Photoperiod was left at the natural condition but water temperature was maintained 23.5±0.47°C during the feeding trial. The snails in each tank were collectively weighed on the day of initiation and on the day of termination of the experiment after fasting for 24 h.

200 snail samples at the beginning and all snail at the end of the feeding trial were sacrificed and storaged at -70°C for chemical analyses. After measuring of body weight, edible fraction of the snail was separated. Proximate composition of experimental diets and snail were analyzed. The data were subjected to one-way analysis of variance (ANOVA) using the SPSS (SPSS Inc., Michigan Avenue, Chicago, Illinois, USA).

Results and Discussion

Data obtained for survival and weight gain of the juvenile snail fed on diets containing different carbohydrate sources for a period of 8 weeks are presented in Table 2. Among all the tested groups, survival and weight gain of the snail were not significantly different (P>0.05). No significant differences (P>0.05) were also found in moisture, crude protein and lipid contents of edible portion in snail fed the diets containing different carbohydrate sources (Table 3).

Table 2. Survival and weight gain of the snail fed diets containing different carbohydrate sources for 8 weeks[1]

Diet	Survival (%)	Weight gain (%)
Con	70 ± 2.5[ns]	25 ± 3.4[ns]
G30	66 ± 4.1	45 ± 19.4
M30	70 ± 5.3	29 ± 12.3
C30	69 ± 2.2	57 ± 9.8
S30	65 ± 7.9	45 ± 5.8

[1]Values are mean±SE of 3 replicates.
[ns]Not significant (P>0.05).

Growth and body composition of the juvenile snail were not affected by dietary carbohydrate sources. Similar observation was also made in abalone (Lee et al., 1998). However, tilapia gained the maximum body weight on diet supplemented with starch, followed in descending order by maltose, sucrose, lactose and glucose (Shiau and Chuang, 1995). Hung et al. (1989) reported that white sturgeon fed glucose or maltose supplemented diet showed better growth than the fish fed on diet supplemented with dextrin or starch. The utilization of dietary carbohydrate by fish is related to their digestive and metabolic systems, as adaptation to different

Table 3. Proximate analysis of edible fraction of the snail fed diets containing different carbohydrate sources for 8 weeks[1]

Diet	Moisture (%)	Crude protein (%)	Crude lipid (%)
Con	64.8 ± 1.06[ns]	11.3 ± 0.50[ns]	0.5 ± 0.23[ns]
G30	69.8 ± 1.38	10.8 ± 0.69	0.7 ± 0.35
M30	67.1 ± 1.63	11.3 ± 0.07	0.7 ± 0.21
C30	63.8 ± 4.18	11.3 ± 0.36	0.5 ± 0.26
S30	65.1 ± 3.41	10.0 ± 0.42	0.8 ± 0.33

[1]Values are mean±SE of 3 replicates.
[ns]Not significant (P>0.05).

aquatic environments (Walton and Cowey, 1982), and the dietary carbohydrate source and level (Bergot, 1979; Hutchins et al., 1998).

Generally, dietary fiber is not hydrolyzed by fish (Hung et al., 1989) and high fiber levels may reduce the utilization of other nutrients (Anderson et al., 1984). Many studies have shown a negative correlation between dietary cellulose levels and growth or nutrient digestibility in fish (Hiton et al., 1983; Fynn-Aikins et al., 1992). However, the snail fed diet containing 30% cellulose showed equal growth, compared with the other diets in the present study. This result suggests that snail may have considerable cellulase activity or cellulolytic microflora. Besides, good growth of the snail fed cellulose diet could also be related to its characteristics of feeding behavior; the snail scrapes particles in diet using its radula. Considering the leachability of the diet with high cellulose content, the snail could eat cellulose diet more easily than the other diets. Another possible explanation to the observed growth of the snail fed on cellulose diet is that the dietary metabolizable energy to protein could be lower than the expected one. The E/P ratio of 11.2 kcal/g protein in the diet supplemented with 30% cellulose (2.6 kcal/g diet) was lower than the value of about 17.0 kcal/g protein in the other experimental diets (3.9 kcal/g diet). Therefore, the high energy (3.9 kcal/g diet) diet may not be necessary to sustain normal growth of the snail. While further study is required to determine the optimum energy level in the diet to promote normal growth of the snail, all the tested carbohydrates are good dietary carbohydrate sources.

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