魚類の成長･飼料効率,肝臓･筋肉成分と消化吸収率に及ぼす飼料デキストリンの影響

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Effect of Dietary Dextrin Levels on the Growth and Feed Efficiency, the Chemical Composition of Liver and Dorsal Muscle, and the Absorption of Dietary Protein and Dextrin in Fishes*[1]

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In order to investigate the utilization of carbohydrate by carp, *Cyprinus carpio*, red sea bream, *Chrysophrys major*, and yellow tail, *Seriola quinqueradiata*, the fishes were reared on diets containing 0%, 10%, 20%, 30% and 40% dextrin for 30 days. Growth retardation and low feed efficiency were noticed in carp fed on a 40% dextrin diet, red sea bream on 30% dextrin and yellow tail on 20% dextrin. The rates of the increase in liver glycogen and the decrease in liver and muscle lipid were lowest in carp. On the other hand, comparably high percent absorption of protein and dextrin was determined in all species regardless of dietary dextrin levels. From these findings, it is presumed that the low growth and feed efficiency resulting from feeding high dextrin diets might be caused by the poor capability of utilizing the absorbed dextrin, and that the capacity of carp is highest among the fish tested.

The aquaculture of fish is recently under development in various districts. However, the fishes are generally reared on high protein diets as compared to domestic animals. A considerable portion of dietary protein may possibly be utilized as the energy source. If the fishes could utilize a large amount of carbohydrate effectively, the expansion of its farming can be actualized. Many studies on the utilization of carbohydrate by fishes have separately been conducted by the use of different carbohydrate sources.[1–17] Accordingly, in the present paper, the capability of several kinds of fishes with different digestive systems for utilizing carbohydrate was simultaneously studied by investigating the effect of dietary dextrin levels on the growth and feed efficiency of the fishes, the chemical composition of liver and dorsal muscle, and the percent absorption of dietary protein and dextrin. The fishes studied were carp, an omnivorous fish, red sea bream, a semi-carnivorous one, and yellow tail, an extremely carnivorous one.

Materials and Methods

Fishes

Young carp and red sea bream were used, which grew at a comparable rate during a 3-month prefeeding period with a compounded feed, and young yellow tail with jack mackerel for 2 weeks. Fish were equally divided into five groups in each species, based on the average body weight and the number of fish with comparable weight.

Diets

Five test diets containing 0, 10, 20, 30, and 40% dextrin were used. Dextrin used (Matsutani Chemical Industry Co., Ltd.; Pinedex ♯2) was produced by hydrolyzing potato starch with acid. The composition of the diets is shown in Table 1. The dietary calories were maintained at a certain level by decreasing the amount of casein, gelatin, and amino acid mixture with the increase of dextrin in the diets. The preparation of diets was conducted as presented in the previous paper.[18]

Feeding Method

Each lot of 63 carp and 45 red sea bream were maintained in an aquarium (90×45×45 cm), and each lot of 50 yellow tail in a concrete, round tank of 3 ton capacity (Diameter 2 m×Depth 1 m), and fed test diets for 30 days, respectively. Water temperature was approximately 23°C for carp and red sea bream, and within the range of

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Table 1. Composition of test diets

Diet	for carp and (red sea bream)					for yellow tail				
Dextrin level (%)	0	10	20	30	40	0	10	20	30	40
Casein	61.7	54.0	46.3	38.6	30.9	64.2	57.0	49.0	41.0	32.9
Gelatin	13.7	12.0	10.3	8.6	6.9	13.5	12.0	10.3	8.6	6.9
Amino acids*1	3.6	3.0	2.4	1.8	1.2	2.3	2.0	1.7	1.4	1.2
Dextrin	0	10	20	30	40	0	10	20	30	40
Pollack liver oil	9	9	9	9	9	9	9	9	9	9
Vitamins*2	3	3	3	3	3	2	2	2	2	2
Minerals*3	4 (5)	4 (5)	4 (5)	4 (5)	4(5)	7	7	7	7	7
Elicitors*4	1	1	1	1	1	1	1	1	1	1
α-Cellulose	4 (3)	4 (3)	4 (3)	4 (3)	4 (3)	0	0	0	0	0
Total-N (%)	12.9	11.5	10.0	8.2	6.6	13.1	11.6	9.8	8.3	6.9

Number in the parentheses is one for red sea bream.

*1 for carp and red sea bream: L-Arg·HCl 1.5, L-Try 0.2, L-Phe 0.6, L-Val 0.7 g/3 g amino acids, for yellow tail: L-Lys·HCl 0.2, L-His·HCl 1.5, L-Cys 0.3 g/2 g amino acids.

*2 HALVER's vitamin mix.(1957)+α-cellulose.

*3 for carp: UPS XII, No. 2+trace metals (HALVER, 1957), for red sea bream: KCl 8.32, $NaH_2PO_4 \cdot 2H_2O$ 49.28, Fe-citrate 2.40, $AlCl_3 \cdot 6H_2O$ 0.015, $ZnSO_4 \cdot 7H_2O$ 0.291, $MnSO_4 \cdot 4{\sim}6H_2O$ 0.065, CuCl 0.009, KI 0.014, $CoCl_2 \cdot 6H_2O$ 0.086, α-cellulose 39.52 g/100 g minerals, for yellow tail: KH_2PO_4 15, $CaH_4(PO_4)_2 \cdot H_2O$ 33, Ca-lactate 15, Fe-citrate 7, $MgSO_4 \cdot 7H_2O$ 10, $AlCl_3 \cdot 6H_2O$ 0.015, $ZnSO_4 \cdot 7H_2O$ 0.300, $MnSO_4 \cdot 4{\sim}6H_2O$ 0.080, CuCl 0.010, KI 0.015, $CoCl_2 \cdot 6H_2O$ 0.100, dextrin 15, α-cellulose 4.480 g/100 g minerals.

*4 for carp and red sea bream: L-Asp·Na, for yellow tail: L-Asp·Na 0.3, DL-Ala 0.3, L-Glu·Na 0.368, 5′-ribonucleotide·Na 0.032 g/g elicitors.

20°C to 24.5°C for yellow tail during the feeding trial period, respectively. Fish care and feeding were achieved as described previously.[18]

Weighing and Chemical Analysis of Fish

Fish were individually weighed after anesthetization with quinaldine (10 ppm) every 15 days. At the end of the feeding trial, 5 fish from each group were sampled at random. The homogenized liver and dorsal muscle which were taken from each fish in the same amount, were mixed separately for each group and subjected to the determination of the protein, lipid, and glycogen content. Protein and glycogen were quantified by the method of KJELDAHL and CARROLL *et al.*[19], respectively. Lipid was extracted with ethyl ether and the Soxhlet extractor.

Determination of Percent Absorption

After the feeding trial, the percent absorption of dietary protein and dextrin was estimated by the indirect method using Cr_2O_3 as an indicater. Namely, after a 3-day feeding period with the test diets containing 1% Cr_2O_3, the feces was collected by applying slight pressure on the ventral side of the fish at 7 hours after the final feeding. The contents of Cr_2O_3 and protein in the diet and feces were quantified by the method of FURUKAWA and TSUKAHARA[20] and of KJELDAHL, respectively. The carbohydrate contents of the diet and feces were determined by the phenol-sulfuric acid method[21] after hydrolysis with HCl.

Results and Discussion

Growth and Feed Efficiency

The carp exhibited growth retardation and remarkably low feed efficiency when the fish were fed the diet containing a 40% level of dextrin as shown in Table 2. However, no significant difference was detected between the 40% dextrin group and the dextrin-free diet group in the average body weight at the 30th day. In case of red sea bream and yellow tail, the growth and feed efficiency of the fishes decreased with the increase of dietary dextrin level, except in the 10% dextrin group of red sea bream (Tables 3 and 4). At the end of the feeding trial, the average body weight of red sea bream fed the diet with 30% or 40% dextrin and of yellow tail with dextrin at levels higher than 20% was significantly lower when compared to the control group without dextrin, respectively. The results indicate that the optimum level of dietary dextrin for the maximum growth and feed efficiency of the fishes differs between the species, and was lower than that of domestic animals.

Proximate Composition of Liver and Dorsal Muscle

As shown in Tables 5, 6, and 7, the liver glycogen increased, and the liver and muscle lipid de-

Table 2. Effect of dietary dextrin levels on growth and feed efficiency of carp

Dextrin level in diet (%)		0	10	20	30	40
No. of fish	At start	63	63	63	63	63
	After 30 days	63	63	63	63	63
Average body weight (g)	At start	22.8±5.5*1	22.9±5.5	22.9±5.8	22.9±5.7	22.9±5.4
	After 30 days	36.1±8.3	38.1±8.1	38.2±9.2	37.4±8.7	34.7±8.1
"t" test (5%)		—	NS*2	NS	NS	NS
Gain / fish (g)		13.3	15.2	15.3	14.5	11.8
Diet fed / fish (g)		16.0	17.3	18.0	19.6	17.2
Feed efficiency (%)		83.1	87.9	85.0	74.0	68.6

*1 Standard deviation. *2 Nosignificant.

Table 3. Effect of dietary dextrin levels on growth and feed efficiency of red sea bream

Dextrin level in diet (%)		0	10	20	30	40
No. of fish	At start	45	45	45	45	45
	After 30 days	41	45	43	43	43
Average body weight (g)	At start	33.4±2.9	33.5±2.8	33.4±2.8	33.4±2.7	33.5±2.7
	After 30 days	47.2±6.7	47.7±7.5	46.2±9.6	43.9±7.9	42.8±5.8
"t" test (5%)		—	NS	NS	S*1	S
Gain / fish (g)		13.8	14.2	12.8	10.5	9.3
Diet fed / fish (g)		18.8	18.0	21.3	21.3	20.6
Feed efficiency (%)		73.4	78.9	60.1	49.3	45.1

*1 Significant.

Table 4. Effect of dietary dextrin levels on growth and feed efficiency of yellow tail

Dextrin level in diet (%)		0	10	20	30	40
No. of fish	At start	50	50	50	50	50
	After 30 days	43	44	46	42	41
Average body weight (g)	At start	20.8±3.2	21.0±3.3	20.8±3.1	20.9±3.3	20.9±3.1
	After 30 days	87.6±17.6	81.0±16.9	76.7±19.6	62.3±15.9	44.3±14.1
"t" test (5%)		—	NS	S	S	S
Gain / fish (g)		66.8	60.0	55.9	41.4	23.4
Diet fed / fish (g)		55.8	55.2	58.7	60.5	60.6
Feed efficiency (%)		119.7	108.7	95.2	68.4	38.6

creased in all species fed the dextrin containing diets. The rates of the increase in glycogen and the decrease in lipid were lowest in carp.

Percent Absorption of Dietary Protein and Dextrin

The fishes fed diets with and without dextrin showed comparably high percent absorption of dietary protein and dextrin (Table 8 (a)). In order to confirm this result, the percent absorption was redetermined using other carp and red sea bream fed the same diets as listed in Table 1 for 7 days. Consequently, a high percent absorption of protein and dextrin similarly to the values in Table 8 (a) was recognized in both carp and red sea bream, as shown in Table 8 (b).

From these findings, it can be considered that the growth retardation and decreased feed efficiency resulting from the feeding of diets with a high level of dextrin were due to the low utilization of dextrin absorbed, and that carp can utilize dietary dextrin more effectively than red sea bream and yellow tail.

In the previous study with red sea bream by the

Table 5. Effect of dietary dextrin levels on proximate composition of liver and dorsal muscle of carp

Dextrin level in diet (%)	0	10	20	30	40
Liver					
Hepatosomatic index*[1]	2.28±0.55	2.48±0.22	2.20±0.35	2.32±0.44	2.37±0.38
"t" test (5%)	—	NS	NS	NS	NS
Moisture (%)	64.5	69.7	71.5	70.5	66.8
Protein (% d.m.)*[2]	50.4	49.4	50.0	50.2	47.3
Lipid (% d.m.)	40.8	34.5	35.4	35.1	38.4
Glycogen (% d.m.)	5.2	7.6	9.9	8.3	8.7
Muscle					
Moisture (%)	77.6	77.2	77.5	77.6	77.6
Protein (% d.m.)	88.4	88.6	90.2	88.4	87.5
Lipid (% d.m.)	8.3	6.6	5.4	7.5	7.2
Glycogen (% d.m.)	0.001	0.001	0.001	0.001	0.001

*1 Liver weight (g) × 100/Body weight (g).
*2 % dry matter.

Table 6. Effect of dietary dextrin levels on proximate composition of liver and dorsal muscle of red sea bream

Dextrin level in diet (%)	0	10	20	30	40
Liver					
Hepatosomatic index	1.66±0.30	1.82±0.48	1.99±0.47	1.90±0.41	1.76±0.35
"t" test (5%)	—	NS	NS	NS	NS
Moisture (%)	65.4	67.8	68.0	69.4	66.2
Protein (% d.m.)	50.5	56.6	41.7	45.9	43.4
Lipid (% d.m.)	36.7	28.6	29.4	21.2	28.7
Glycogen (% d.m.)	8.4	11.1	27.3	26.6	23.9
Muscle					
Moisture (%)	76.4	76.8	76.4	76.7	77.2
Protein (% d.m.)	88.2	90.1	90.7	89.4	89.8
Lipid (% d.m.)	6.8	5.2	5.4	4.8	3.9
Glycogen (% d.m.)	0.002	0.001	0.002	0.001	0.002

Table 7. Effect of dietary dextrin levels on proximate composition of liver and dorsal muscle of yellow tail

Dextrin level in diet (%)	0	10	20	30	40
Liver					
Hepatosomatic index	1.51±0.28	1.55±0.21	1.45±0.32	1.33±0.28	1.33±0.41
"t" test (5%)	—	NS	NS	NS	NS
Moisture (%)	76.5	76.2	76.4	76.3	77.8
Protein (% d.m.)	76.2	76.1	74.6	70.9	72.5
Lipid (% d.m.)	20.4	17.6	16.9	16.5	13.5
Glycogen (% d.m.)	0.9	2.2	3.5	7.0	8.6
Muscle					
Moisture (%)	76.4	75.7	76.9	76.8	77.4
Protein (% d.m.)	88.6	88.1	93.5	94.0	93.4
Lipid (% d.m.)	8.9	4.9	4.8	4.7	4.4
Glycogen (% d.m.)	0.018	0.028	0.020	0.016	0.019

Table 8. Effect of dietary dextrin levels on percent absorption of protein and dextrin by fishes

(a) After 30 days feeding

Dextrin level in diet (%)		0	10	20	30	40
Carp	Protein	92.7	93.6	90.3	91.0	90.6
	Dextrin	—	98.7	98.5	97.3	97.6
Red sea bream	Protein	98.1	98.3	98.6	95.8	96.4
	Dextrin	—	96.8	92.4	92.6	92.3
Yellow tail	Protein	98.5	98.9	98.8	98.1	98.4
	Dextrin	—	97.4	95.9	95.3	93.1

(b) After 7 days feeding

Dextrin level in diet (%)		0	10	20	30	40
Carp	Protein	93.0	93.8	94.7	94.1	92.4
	Dextrin	—	99.7	99.4	99.5	99.4
Red sea bream	Protein	99.2	99.2	99.0	99.1	98.6
	Dextrin	—	98.9	95.9	96.0	94.6

use of crude diets containing white fish meal and glucose *etc.*, the percent absorption of protein and glucose declined with the increase of dietary glucose level.[17] Therefore, we supposed that the decreased absorption is a cause for the low growth and feed efficiency which resulted from feeding a high glucose diet. In the present study, however, a decrease in absorption was not recognized in the duplicate tests. The reason of this discrepancy is unknown.

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