Effect of Carboxymethylcellulose Supplement on the Absorption of Dietary Nutrients, and on the Levels of Blood Sugar and Plasma Amino Nitrogen*1

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In order to clarify a reason for which carboxymethylcellulose (CMC) increases the growth of red sea bream *Chrysophrys major* and feed efficiency, the effects of CMC supplement on the absorptions of dietary dextrin and protein, and on the levels of blood sugar and plasma amino nitrogen were studied. CMC supplement into diets delayed the absorptions of dextrin and protein, and suppressed the elevation of blood sugar and plasma amino nitrogen levels within 2 hours after the feeding. From these results, it is presumed that the dietary dextrin and protein are effectively utilized by the supplementation of CMC as the energy source and for the biosynthesis of body components, consequently the growth of red sea bream and feed efficiency are improved.

The previous papers1,2) showed that the availability of dextrin, which was absorbed at a rapid rate before the rising of the activities of carbohydrate metabolic enzymes, in the nutrition of carp and red sea bream was lower than that of α-starch which was slowly absorbed, and that the optimum level of carboxymethylcellulose (CMC) supplemented to dextrin-containing diets increased the growth of red sea bream and feed efficiency.

Accordingly, in order to clarify a mechanism of the action of CMC, the effects of CMC supplement on the absorptions of dietary dextrin and protein, and on the levels of blood sugar and plasma amino nitrogen were investigated with red sea bream in this paper.

Materials and Methods

Fish and Diets

Red sea bream weighing 27 g to 52 g or 55 g to 100 g were divided into six groups and reared on the test diets for 5 days in each of 150 liter aquarium (90×45×45 cm). Feeding and fish care were conducted by the same methods as described in the previous paper.1) The test diets used were the control diets without CMC and the CMC-supplemented diets which gave the maximum growth and feed efficiency described in the previous study2): 6% CMC diet with 10% dextrin, 9% CMC diet with 20% dextrin, and 12% CMC diet with 30% dextrin (Table 1).

Determination of Percent Absorptions of Dietary Dextrin and Protein, and of Blood Sugar and Plasma Amino Nitrogen Levels

The fish were starved for a day, and were orally administered each diet at a level of 1 g per 100 g body weight, with the help of a plastic syringe with a vinyl tube instead of a needle. Five fish from each group were sampled at random before and 1, 2, 3, 5, 7, and 10 hours after the administration of diets. Blood was taken from the Cuvierian duct for the determination of blood sugar and plasma amino nitrogen, and the contents of the digestive tracts were sampled. Residual sugar and protein in the contents were determined by the phenol-sulfuric acid method4) after drying followed by hydrolysis with HCl and by the method of KJELDAHL, respectively. The percent absorptions of dextrin and protein at each sampling time were calculated by the same method as described in the previous paper.1) Blood sugar and plasma amino nitrogen were analyzed by the methods of MOMOSE et al.5) and of GOODWIN,6) respectively.

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Results and Discussion

At every level of dietary dextrin, the percent absorption of dietary dextrin in the CMC diet group was always lower than that in the CMC-free diet group, as shown in Fig. 1. Also, the absorption of dextrin within 2 hours before the appearance of the maximum plasma insulin level was remarkably lower in the CMC diet group than in the CMC-free diet group. On the contrary, the absorption of dextrin after 2 hours in the former was higher than or similar to that in the latter.

The CMC in diets affected also the absorption of protein as well as dextrin (Fig. 2). Namely, the changes in percent absorptions of protein at each time and within or after 2 hours were similar to those of dextrin. However, it is of interest that the absorption of protein after 2 hours by fish fed the 12% CMC diet with 30% dextrin was higher than that of the CMC-free diet group, in relation to the maximum growth and feed efficiency which were recognized in the 12% CMC diet group, in spite of no difference in the absorption of dextrin between the both groups.

The changes in blood sugar levels are shown in Fig. 3. In fish fed the 10% dextrin diets, the CMC diet and the CMC-free diet groups exhibited a similar pattern of changes in blood sugar levels and the maximum levels of blood sugar were similarly low. From this fact, it is supposed that dextrin entered the body within 2 hours was a little and was rapidly metabolized. However, in the case of 20% and 30% dextrin diets, the changes in blood sugar levels were clearly different between the groups with and without CMC. Namely, the blood sugar levels of the CMC diet group within 2 hours was low, whereas that of the CMC-free diet group was high.

As shown in Fig. 4, the plasma amino nitrogen

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Table 1. Composition of test diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>D10-C0</th>
<th>D10-C6</th>
<th>D20-C0</th>
<th>D20-C9</th>
<th>D30-C0</th>
<th>D30-C12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casein</td>
<td>47.8</td>
<td>47.8</td>
<td>39.9</td>
<td>39.9</td>
<td>32.1</td>
<td>32.1</td>
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<tr>
<td>Gelatin</td>
<td>10.6</td>
<td>10.6</td>
<td>8.9</td>
<td>8.9</td>
<td>7.1</td>
<td>7.1</td>
</tr>
<tr>
<td>Amino acids</td>
<td>2.6</td>
<td>2.6</td>
<td>2.2</td>
<td>2.2</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Dextrin</td>
<td>10.0</td>
<td>10.0</td>
<td>20.0</td>
<td>20.0</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Pollack liver oil</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Vitamins</td>
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<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Minerals</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
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<td>4.0</td>
</tr>
<tr>
<td>Attractant</td>
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<td>1.0</td>
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<td>α-Cellulose</td>
<td>12.0</td>
<td>6.0</td>
<td>12.0</td>
<td>3.0</td>
<td>12.0</td>
<td>0</td>
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<tr>
<td>CMC</td>
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<td>6.0</td>
<td>0</td>
<td>9.0</td>
<td>0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

*1 Amino acids (g/3 g): L-Phe 0.6, L-Try 0.2, L-Arg·HCl 1.5, L-Val 0.7.
*2 HALVER's vitamin mix (1957) + α-cellulose.
*3 Minerals (g/4 g): NaH₂PO₄·2H₂O 3.85, Fe-citrate 0.15.
*4 L-Asp·Na.
*5 Carboxymethylcellulose.
increased rapidly within 3 hours. The plasma amino nitrogen levels of the CMC diet group within 3 hours were very lower than those of the CMC-free diet group, but the changes in the plasma amino nitrogen levels after 3 hours were not different between the groups with and without CMC. It is presumed that insulin also plays a major role in the regulation of protein metabolism, because insulin injected decreases the levels of plasma amino acids and accelerates $^{14}$C-glycine incorporation into skeletal muscle protein.8-12

In the present study, protein in the CMC diets
was absorbed in a large quantity after 3 hours, but no difference in the levels of plasma amino nitrogen was recognized between the CMC diet and the CMC-free diet groups. This result suggests that protein in the CMC diet entered the body in a large quantity after insulin secretion was effectively utilized as sources of body protein and energy.

From these findings, it can be concluded that the CMC supplement delays the absorptions of dietary nutrients; the dietary dextrin and protein are effectively utilized as the energy source and for the biosynthesis of body components; hence the growth and feed efficiency in red sea bream are consequently improved.

References