トラフグ低魚粉飼料におけるムラサキイガイ粉末の添加効果

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Tsukuba Business-Academia Cooperation Support Center, Agriculture, Forestry and Fisheries Research Council Secretariat
Supplemental Effects of Dietary Blue Mussel Meat for Juvenile Tiger Puffer Takifugu rubripes When Fed Diets Containing Low Fishmeal Contents

Kyaw KYAW, Shunsuke KOSHIo, Manabu ISHIKAWA, Saichiro YOKOYAMA, Kotaro KUCHI and Yoshikazu MURAOKA

Abstract: A 50-day feeding trial was conducted to investigate supplemental effects of blue mussel (BM) when fed low fishmeal (FM) diets for juvenile tiger puffer. Isonitrogenous FM and soybean protein isolate (SPI) based diets containing five different levels of BM (0, 2.7, 5.3, 8.1, 10.5%) were formulated. A control diet contained 63% of FM without SPI. Nine juveniles (27.01 ± 0.05 g) were randomly stocked into 100 l tank and fed the test diet twice a day with satiation.

Results indicated that a diet containing 27% FM and 27% SPI together with 5.3% BM produced the highest weight gain, feed intake, specific growth rate and feed efficiency and the values of those parameters were not significantly different (P>0.05) from those of a control group and a diet containing 28.5% FM, 27% SPI together with 2.7% BM. No significant differences were detected in survival rate, hepatosomatic index, and chemical compositions of fish whole body among all treatments.

This study demonstrated that BM supplementation in low FM diet was very effective to improve the growth of tiger puffer, and level of 2.7 to 5.3% was optimum when 27% of SPI together with FM ranging from 27 to 28.5% were used.

Key words: Takifugu rubripes; Blue mussel; Soybean protein; Fish meal

The tiger puffer Takifugu rubripes (‘torafugu’ in Japanese) is one of the most popular marine finfish cultured in Japan because of its desirable taste and high market price. Although commercial pellet diets for the species have been available in Japanese market, little is still known about their nutritional requirements. Similar to other marine cultured finfish, tiger puffer requires high percentages of protein in the diet. Fishmeal (FM) is a major protein source in aquafeeds because of its high nutritional values and excellent palatability (Lovell 1984; Hardy 1999). Because of the limiting supply and high demand, resulting in the high cost of FM around the world, many studies have been conducted to replace it or reduce its inclusion in aquafeeds using less expensive alternative protein sources.

Among several protein feedstuffs, blue mussel meat (BM) is considered to be one of the most nutritious ingredients due to its favorable protein and amino acid contents (Kitamura et al. 1981; Berge and Austreng 1989). BM from Mytilus galloprovincialis has been used as a supplemental feed for crustaceans such as kuruma prawn Marsupenaeus japonicus and spiny lobster Panulirus japonicus in Japan. Kikuchi and Sakaguchi (1997) reported that the freeze-dried
meat of blue mussel could effectively replace FM in the diet of juvenile Japanese flounder *Paralichthys olivaceus*. In addition, dietary inclusion of the mussel meat improved the growth of this species with increased feed intake (Kikuchi and Sakaguchi 1997). Availability of the mussel meat in finfish feed was also demonstrated with rainbow trout *Oncorhynchus mykiss* (Grave et al. 1979; Berge and Austreng 1989) and red sea bream *Pagrus major* (Kitamura et al. 1981). Recently, it was reported that water-soluble fraction of blue mussel (Kikuchi and Furuta 2009a) and blue mussel meat (Kikuchi and Furuta 2009b) were effective feeding stimulants, and inclusion of those increased growth and feed utilization of tiger puffer. However, there is still limited information to assess the value of blue mussel meat under the lower contents of dietary fishmeal for tiger puffer. Therefore, we examined the growth performances of juvenile tiger puffer when fed test diets with supplemented blue mussel meat under the low fishmeal conditions.

### Materials and Methods

#### Test diets and experimental design

Major protein sources were brown fishmeal (FM, 74.95% proteins, 10.7% lipid, and 9% ash) and soybean protein isolate (SPI, 84% protein, 5% lipid and 8% ash). Blue mussel meat (BM, 41% protein, 10% lipid and 11% ash) was provided from Kansai Electric Power Industry. Total six isocaloric and isolipidic test diets containing 30% FM with 0% BM (Diet 2, D2), 28.5% FM with 2.7% BM (D3), 27% FM with 5.3% BM (D4), 25.5% FM with 8.1% BM (D5), 24% FM with 10.5% BM (D6) respectively, under respective SPI and 63% FM without BM and SPI (D1 as a positive control) were formulated for the trial. Pollack liver oil was served as major lipid source, and carbohydrate sources were starch and dextrin, respectively.

BM was freeze-dried and ground to desired particle size prior to preparing the diet. To prepare diets, all dry ingredients were well mixed for 30 min in a food mixer, and then pollack liver oil was added and mixed for 15 min. Finally, water (35% of the dry weight of ingredients) was added, and mixing lasted for 15 min. The pH of the diets was adjusted to 7.0–7.5 with 4N sodium hydroxide. The pellets (1.2 to 2.2 mm in diameter) were made with a meat grinder, and dried in a dry-air mechanical convention oven (DK 400, Yamato Scientific, Japan) at 60°C for 2 to 3 h to obtain approximately 10% moisture level. The test diets were then stored at –30°C until use. The formulation, analytical data of protein, lipid, and ash for test diets are shown in Table 1.

<table>
<thead>
<tr>
<th>Ingredients (g/kg as fed diet)</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td>Brown fishmeal</td>
<td>630</td>
</tr>
<tr>
<td>Blue mussel meat</td>
<td>0</td>
</tr>
<tr>
<td>Soybean protein isolate</td>
<td>0</td>
</tr>
<tr>
<td>Other ingredients</td>
<td>304</td>
</tr>
<tr>
<td>α-cellulose</td>
<td>66</td>
</tr>
</tbody>
</table>

**Contents of protein, lipid, and ash (% dry diet)**

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>47.3</td>
<td>47.1</td>
<td>47.3</td>
<td>47.6</td>
<td>47.6</td>
<td>47.2</td>
</tr>
<tr>
<td>Crude lipid</td>
<td>14.5</td>
<td>12.1</td>
<td>12.1</td>
<td>12.8</td>
<td>12.8</td>
<td>12.5</td>
</tr>
<tr>
<td>Crude ash</td>
<td>11.1</td>
<td>10.5</td>
<td>10.6</td>
<td>10.8</td>
<td>10.8</td>
<td>10.8</td>
</tr>
</tbody>
</table>

1 Kansai Electric Power Co. Ltd., Osaka, Japan.
2 Fuji Seiyu Co., Ltd., Japan.
3 Other ingredients (g/kg): Activated gluten, 50; α-starch, 50; Dextrin, 70; Pollack liver oil, 50; 3-HUFA, 10; Vitamin mixture 6, 30; Mineral mixture 4, 40; Stay-C 1; Betaine, 2; Inosine-5-monophosphate, 1.
4 Vitamin mixture (g/kg diet): α-amino-benzoic acid, 0.80; biotin, 0.01; inositol, 8.02; nicotinic acid, 1.56; Ca-pantothenate, 0.56; pyridoxine·HCl, 0.10; riboflavin, 0.40; thiamine nitrate, 0.12; menadione, 0.10; β-carotene, 0.38; α-tocopherol, 0.80; cyanocobalamin, 0.55; Calciferol, 0.02; folic acid, 0.04 and choline chloride, 16.38.
5 Mineral mixture (g/kg diet): NaCl, 1.553; MgSO₄·7H₂O, 5.475; NaHPO₄·2H₂O, 3.485; KH₂PO₄, 9.583; Ca(H₂PO₄)₂·2H₂O, 5.427; Fe·citrate, 1.187; Ca·lactate, 13.068; Al(OH)₃, 0.007; ZnSO₄·7H₂O, 0.143; CuSO₄, 0.004; MnSO₄·5H₂O, 0.032; Ca(IO₃)₂, 0.006 and CaSO₄·7H₂O, 0.04.
6 Ascorbyl-3-Monophosphate Ca/Na from DSM Co. Ltd., Japan.
Several parameters on fish performances such as weight gain, feed intake, specific growth rate, feed efficiency ratio, hepatosomatic index, and survival rate were compared when fed those diets to fish. Moreover, moisture, crude protein, crude lipid, and ash of whole body were also analyzed at the end of the trial.

**Feeding trial**

Juvenile tiger puffer (mean initial weight ± SE=27.0±0.05 g) were obtained from commercial marine fish hatchery (Fukuoka, Japan), and transferred to Kamoike Marine Production Laboratory, Faculty of Fisheries, Kagoshima University. Juveniles were stocked in 500 liter tank with feeding commercial tiger puffer diet (Sakamoto Feeds Co.,Ltd., Chiba, Japan) for 10 days prior to the experiment. Juveniles were then randomly allocated to 18 polycarbonate circular tanks (size of tank: 100 l) with triplicate groups (9 fish/tank), and were fed the respective test diets with satiation. Feeding was divided into two times at 8:30 and 16:30h, and every 10 days, all fish were weighed in bulk while all tanks were cleaned. The feeding trial was conducted for 50 days. All rearing tanks were provided with continuous aeration and the photoperiod was maintained under natural light/dark regime (12:12h). Filtered seawater was continuously provided at a flow rate of 1.5 l/min under the flow-through system. Water temperature, pH and salinity (mean ± S.E.) during the trial were 26.0 ± 2°C, 8.0 ± 0.2 and 32.0 ± 0.5ppt, respectively.

**Chemical analysis**

Crude protein was determined by the Kjeldahl method with a Tecator Kjeltec System (1007 Digestion system, 1002 Distilling and Titration units). Total lipid was determined using the Bligh and Dyer (1959) method. Ash and moisture contents were analyzed by standard methods (AOAC, 1990). Amino acid content including both protein linked (PLA) and free amino acids (FAA) in test diets were determined by the method of Teshima et al. (1986) with using high performance liquid chromatography (HPLC, Shimadzu Corp. Tokyo, Japan). For PLA, approximately 1mg of dry sample was weighed and hydrolyzed with 4N methanesulfonic acid for 22h at 110°C. The pH of hydrolysate was adjusted to 2.2 and injected into the HPLC unit with an ion exchange resin column. Norleucine was used as an internal standard for quantitative determination. FAA concentration of the samples was determined as follows: samples weighing approximately 100 mg were homogenized using a polytron homogenizer (Kinematica, Gmbh LITTAU, Switzerland) with 0.9 ml cold pure water, 0.1 ml internal standard (norleucine, 0.6 mg DL-norleucine/0.1 ml pure water) and 5 ml 8% trichloroacetic acid (TCA) solution. After centrifuging (4°C, 3000xg, 15 min), supernatant was collected and repeatedly washed with diethyl ether to remove TCA from homogenate. Then, the pH was adjusted to 2.2 and filtered samples were injected into the HPLC as described by Teshima et al. (1986).

**Statistical analysis**

All data from the feeding trial and chemical analysis were tested using one-way analysis of variance (Package super-ANOVA, ver. 1.11, Abacus Concepts, Berkeley, CA, USA). Significant differences between individual treatments (P<0.05) were evaluated by Turkey Kramer test when ANOVA detected the significance on dietary treatment.

**Results**

Table 2 indicates analytical results of PLA of all test diets. There was a trend that dietary methionine contents were lowered by increasing BM level. D1 contained the highest methionine content, and D6 did the lowest. Lysine contents were similar among D1, D2 and D3. D5 and D6 contained slightly lower lysine levels compared to D1, D2 and D3. Other amino acid levels were similar in all test diets.

FAA contents of FM, BM, and test diets are shown in Table 3. Total content of FAA in BM was markedly higher than that of FM, and FAA in SPI was below detectable level. Total FAA content increased with increased BM level but those were lower than fishmeal based (control) diet. There was increased trend on threonine,
glutamic acid, taurine, glycine, and alanine with increased BM. On the other hand, there was decreased trend on histidine.

Results of a feeding trial such as survival rate, growth performances and nutrient utilization are presented in Table 4. There was no mortality during the trial. At the end of the 50-day feeding trial, juveniles attained weight gain (WG) of 200–244%. No significant differences were detected in hematosomatic index (HIS) among all treatment groups. The WG and SGR of the fish fed D3 and D4 did not significantly differ from those of fish fed D1. However, fish fed D2, D5 and D6 showed significantly (P<0.05) lower growth in terms of WG and SGR than those fed D1. No significant differences were found in WG and SGR among D2, D3, D5 and D2, D5, D6, respectively.

The feed intake (FI) of fish fed D3 and D4 did not show any significant difference from that of fish fed D1. However, fish fed D2, D5 and D6 showed significantly (P<0.05) lower FI than those fed D1 and D4. No significant differences were found in FI among fish fed D2, D3, D5 and D2, D5, D6, respectively. Furthermore, feed efficiency ratio (FER) significantly lower in fish fed D2, D5 and D6 compared to those of fish fed D1 and D4. The best FER was obtained from fish fed D4.

Whole body compositions of juvenile tiger puffer at the end of feeding trial are shown in Table 5. No significant differences were detected in moisture, crude protein, crude lipid and ash among all treatment groups.

### Table 2. Protein linked amino acid (PLA) contents of the test diets (AA g/100g dry sample)

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>Indispensable</th>
<th>Dispensable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D2</td>
</tr>
<tr>
<td>Arginine</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Histidine</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>1.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Leucine</td>
<td>3.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Lysine</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Threonine</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Valine</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>3.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>8.1</td>
<td>10.6</td>
</tr>
<tr>
<td>Taurine</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Serine</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Proline</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Glycine</td>
<td>3.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Alanine</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Total AA</td>
<td>43.5</td>
<td>47.9</td>
</tr>
</tbody>
</table>

1. Values are means of duplicate measurements.

### Table 3. Detected contents of free amino acid (FAA) fraction of fish meal (FM), blue mussel meat (BM), and the test diets (AA g/100g dry sample)

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>FM</th>
<th>BM</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
<td>D2</td>
<td>D3</td>
</tr>
<tr>
<td>Indispensable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arginine</td>
<td>0.10</td>
<td>0.35</td>
<td>0.05</td>
</tr>
<tr>
<td>Histidine</td>
<td>0.76</td>
<td>0.13</td>
<td>0.30</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>0.06</td>
<td>0.07</td>
<td>0.04</td>
</tr>
<tr>
<td>Leucine</td>
<td>0.12</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.12</td>
<td>0.32</td>
<td>0.09</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.05</td>
<td>0.41</td>
<td>0.03</td>
</tr>
<tr>
<td>Valine</td>
<td>0.09</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>Dispensable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>0.03</td>
<td>0.50</td>
<td>0.01</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>0.13</td>
<td>0.51</td>
<td>0.07</td>
</tr>
<tr>
<td>Taurine</td>
<td>0.70</td>
<td>2.06</td>
<td>0.49</td>
</tr>
<tr>
<td>Serine</td>
<td>0.03</td>
<td>0.40</td>
<td>0.01</td>
</tr>
<tr>
<td>Proline</td>
<td>0.05</td>
<td>0.14</td>
<td>0.02</td>
</tr>
<tr>
<td>Glycine</td>
<td>0.06</td>
<td>0.47</td>
<td>0.05</td>
</tr>
<tr>
<td>Alanine</td>
<td>0.22</td>
<td>0.44</td>
<td>0.12</td>
</tr>
<tr>
<td>Total FAA</td>
<td>2.57</td>
<td>6.00</td>
<td>1.40</td>
</tr>
</tbody>
</table>

1. Values are means of duplicate measurements. Free amino acids in soybean protein isolate, and methionine in FM and BM were below detectable level.
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Table 4. Survival rate, growth performances and nutrient utilization of juvenile tiger puffer fed diets containing different levels of fishmeal and blue mussel meat for 50 days

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight gain (WG, %)</td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>241.2 ± 5.9a</td>
</tr>
<tr>
<td>Feed intake (g/fish/50days)</td>
<td>80.8 ± 0.9a</td>
</tr>
<tr>
<td>Specific growth rate (SGR, %/day)</td>
<td>2.45 ± 0.03a</td>
</tr>
<tr>
<td>Feed efficiency ratio (FER)</td>
<td>0.80 ± 0.01b</td>
</tr>
<tr>
<td>Hepatosomatic index (HSI)</td>
<td>9.1 ± 0.9</td>
</tr>
<tr>
<td>Survival rate (SR, %)</td>
<td>100 ± 0.0</td>
</tr>
</tbody>
</table>

1 Values are means of triplicate groups ± S.E. Within a row, means with the same letters are not significantly different (P<0.05). Absence of letters indicates no significant difference between treatments. Average initial body weight (means ± S.E.), 27.10 ± 0.09g.
2 WG, (final mean body weight-initial mean body weight) x 100/ initial mean body weight.
3 SGR, ln(final body weight-ln(initial body weight)/50days).
4 FER, weight gain (g)/dry feed intake (g).
5 HSI, liver weight (g)/final body weight (g) x 100.

Table 5. Whole body composition (%) of fish fed diets containing different levels of fishmeal and blue mussel meat for 50 days

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Diets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D1</td>
</tr>
<tr>
<td>Moisture</td>
<td>78.6 ± 0.5</td>
</tr>
<tr>
<td>Crude protein</td>
<td>57.2 ± 0.1</td>
</tr>
<tr>
<td>Crude lipid</td>
<td>29.6 ± 0.7</td>
</tr>
<tr>
<td>Crude ash</td>
<td>9.5 ± 0.1</td>
</tr>
</tbody>
</table>

1 All values are not significantly different among treatments.

Discussion

A constant supply of inexpensive ingredients is much desired for the development of practical diet in aquafeed industry. For the time being, one of the marine sessile organisms, such as blue mussels, is given high attention from this viewpoint. According to a document released by the Environmental Technique Investigation Committee of the Thermal and Nuclear Power Engineering Society, around 20,000 tons of sessile organisms were collected from cooling water conduits at 108 electric power stations throughout Japan annually. Because of its nutritional value such as relatively favorable protein (Kitamura et al. 1981) and amino acid contents (Berge and Austreng 1989) as well as its relatively higher availability, BM can be considered as a potential protein source or effective supplement when the aquafeeds contained low levels of FM.

The present study demonstrated that BM could be an effective supplement in puffer fish feeds containing low FM together with a high level of SPI although there is a limited inclusion level (about 5.3%) under the conditions applied in this study. Previous study on Japanese flounders (Kikuchi and Sakaguchi 1997) found that the growth of fish fed the diets containing 5% of freeze-dried BM was significantly higher than those in other dietary groups. Recently, the studies on the utilization of BM and/or BM extracts for tiger puffer (Kikuchi and Furuta 2009a, 2009b) showed that the diets supplemented with 10% or 20% of BM extracts with FM 50% and 43% produced similar growth and feed performance similar to those of FM based control diet. Furthermore, 20% supplement of BM with FM 43% gave similar growth and feed utilization to those of FM based control diet, and more than 15% supplement BM with FM 28.5% and 27 to 40% of defatted soybean meal produced the similar performances to those of control diet. On the other hand, those meal values above were still lower than those of FM based diet although there were no statistical significances. The present study demonstrated that comparing to FM based control diet, mean values of all growth parameters were rather higher when fish
fed the diet containing 5.3% BM together with 27% of SPI and FM.

Reduced feed intake which was found in fish fed Diets 2 and 3 in this study could be one of the reasons for lowered weight gain of those groups, since it has been cleared that lower feed intake reduces the amount of nutrients available for growth (Kissil et al. 2000). It is well known that feed intake of fish will be affected by the amount as well as kind of dietary FAA. Gustatory system of fish is highly sensitive to FAA, which have stimulant properties or highly efficient incitants for various aquatic species (Mackie and Mitchell 1985; Marui and Caprio 1992; Kasumyan and Doving 2003). In the present study, the diets containing lower level of BM contained lower individual FAA compared to D1 and D4, which might reflect the lower palatability of the diets. We assumed that lower individual FAA by low inclusion level of dietary BM could be the reason for the lower feed intake of fish even though there was relatively high content of indispensable PLA among dietary groups especially lysine and methionine contents in the test diets. In addition, reduced feed intake, which was also found in fish fed the D5 and D6 with high amount of BM and even including high level of individual FAA, might be one of the reasons for lower weight gain of the fish since the diets containing high concentration of FAA were unsatisfactory for reaching the maximum growth of fish.

Although the reason for decreased feed intake in fish fed the diets containing higher contents of BM is not conclusive, reduced growth found in those groups of fish might come from lowered methionine contents of the diets. Many studies have indicated the optimal dietary methionine levels for commonly cultured fish species ranged from 1.8% and 3.2% as the percentage of protein (Wilson 2002). Since the test diets with higher BM in the present study contained less levels than above, it may not meet the requirement for tiger puffer. Furthermore, there are some studies of improved growth performances on the supplementations of diets with lysine in rainbow trout (Davies et al. 1997; Rodehutscord et al. 2000). Atlantic salmon fed diets containing low levels of lysine showed reduced growth and feed utilization, and increasing dietary lysine levels improved the protein utilization ratio (Berge et al. 1998). It is likely that lower dietary lysine contents in test diets with higher BM in the present study may not be enough to obtain the optimal growth although there were high concentrations of individual FAA in those diets. Therefore, further study is necessary to determine the amino acids requirement and to evaluate the supplementation levels of amino acids in low fishmeal diets on this species.

In conclusion, it was found in this study that fish fed diets containing 5% BM performed better or at least similar growth performances compared to those fed with FM base diet. Therefore, the present study demonstrated that dietary FM contents could be reduced by supplementing BM in juvenile tiger puffer feeds without adverse effects of growth, feed efficiency, and body composition. It is likely that the dietary concentrations of PLA and/or FAA for growth and diet palatability seem to be limiting factors for using low or high levels of BM in the diets for juvenile tiger puffer.

Acknowledgements

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References


Supplementation of Blue Mussel for Tiger Puffer


トラフグ低魚粉飼料におけるムラサキイガイ粉末の添加効果

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トラフグ低魚粉飼料におけるムラサキイガイ粉末の添加効果を明らかにするために、沿岸魚粉および分離大豆タンパク (SPI) 主体の試験飼料にムラサキイガイ粉末 (BM) を0～10%添加した飼料を作成し、トラフグ稚魚（平均体重27.0g）に50日間給餌した。魚粉単独飼料（魚粉添加量63%）を対照飼料として用い、その他の飼料には魚粉添加量を減らしてSPIを27%添加した。タンパク質含量を同じにするため、BM添加量に応じて魚粉含量を調整した。飼育試験の結果、BM5.3%飼料区はBM無添加区より有意に高い増重率、飼料変換効率、日間成長率および飼料変換効率を示し、また、有意差は検出されなかったものの対照飼料区より高くなる傾向を示した。以上の結果から魚粉含量を低減した際のトラフグ稚魚の成長や飼料変換効率の低下をBM添加により改善できることが示唆された。