NUTRITIVE VALUES OF FERMENTED AND DEFATTED 
SCRAP FISH MEALS FED TO 
RED SEA BREAM *CHRYSOPHRYS MAJOR*

M. A. HOSSAIN

Department of Fisheries Biology and Limnology, Bangladesh Agricultural University, 
Mymensingh, Bangladesh

ABSTRACT

Red sea bream *Chrysophrys major* were reared on highly oxidized scrap fish meal fermented by a 
group of micro-organisms and their growth and feed efficiency were compared to those fish reared on non-
fermented and defatted scrap meals and white fish meal. Fermentation by micro-organisms decreased 
POV and TBA but slightly increased VBN content in the scrap meal. The essential amino acids to total 
non-essential amino acids (EAA/NEAA) showed scarcely any difference between non-fermented, defatted 
or fermented scrap meals. The percentage of w3 HUFA in scrap meal significantly improved after fer­
mentation.

The growth and feed efficiency of fish fed on fermented scrap meal was significantly superior to those 
of the nonfermented scrap meal, and was comparable to those reared on defatted scrap meal or white fish 
meal.

INTRODUCTION

The non-edible and spoiled fishes or fish 
wastse are generally spread in the beaches or open field all over the world particularly 
in developing countries for sun drying and then used for scrap meal. However, the 
scrap meal could not be directly utilized as protein and lipid sources for fish feed 
because of the presence of high level of toxic 
lipid and protein degenerates. The 
chemical process to remove oxidized lipid from 
scrap meal is expensive. Efforts have been 
made to eradicate oxidized toxic substances 
from the lipid by micro-organisms (Tomii-
yama, 1925; Yamamoto, 1925; Yone et al, 

Recently micro-organisms with ability to 
remove oxidized lipids were selected (Kato 
et al, 1985) and it was found that *Aspergillus 
oryzae, A. sojae, Saccharomycescerevisiae* IFO 
2114 are comparatively more efficient than 
the others tested. In the present study, fer­
mentation by these molds and yeast together 
with a bacteria *Bacillus subtilis* on the pro­
ximate composition, POV, TBA, VBN, 
fatty acids and amino acids offish waste were 
determined and compared those with non­fermented ones. Furthermore, the effects of 
diet containing fermented scrap meal on 
growth and feed efficiency of red sea bream 
*C. major* were compared with those of the 
fish fed on diets containing non-fermented 
and defatted scrap meals and white fish 
meal.

MATERIALS AND METHODS

Scrap Fish Meal (NFM)

Fish waste mainly consisting of head, 
bones containing some muscles, tail,
internal organs etc. as well as damaged and spoiled fish were collected from a mackerel processing plant in Fukuoka city, Japan. The waste was minced in an electric meat chopper, steamed for 40 minutes wrapping by ordinary long cloths, and pressed by a specially designed press to remove water and oil as much as possible. The pressed waste was dried in a hot air oven at 65 °C for five hours. The dried waste was crushed in a mixer and sieved through a 1 mm mesh to remove hard bones. The sieved meal was then milled and sieved through 21 of mesh to produce a fine powder.

Preparation of Micro-organisms for Fermentation

Molds, A. oryzae, A. sojae, Yeast, S. cerevisae IFO 2114; and bacteria, B. subtilis were collected from Department of Agricultural Chemistry, Saga University, Japan. The molds, yeast and bacteria were separately inoculated into 10 ml liquid medium in a 50 ml test tube and cultured at 30°C for 48, 36 and 24 hours, respectively, in a water bath with shaking on reciprocal shaker. MY media was used for molds and yeast. Bacteria was cultured with Bouillon media. The cultured molds (filamentous stage) from the test tube was inoculated on 25 g sterilized wheat bran and cultured in a 500 ml flask at 30°C for 96 hours. The micro-organism to be inoculated for fermentation with pressed fish waste were prepared as follows: 10 g of each of the molds propagated on wheat bran and 10 ml of yeast and 10 ml of bacteria culture were mixed together with 50 g sterilized wheat bran. This mixture was considered as seed micro-organisms.

Fermented Scrap Fish Meal (FFM)

Identical wastes used for the NFM were minced, steamed and pressed in the same way mentioned above. The pressed waste was converted into a moist loose pellet of about 1 cm in length and 1 cm diameter with a meat chopper without using a cutter. The pellets were sterilized. One kg of the pellet was mixed with the seed micro-organisms and incubated at 30°C for 20 hours in steel container. Several containers were used for fermentation. The cover of the container was slightly opened during the incubation period and the pellet was stirred with a sterilized spoon at intervals of 4 hour to aerate. After fermentation the pellets were dried at 70°C for 5 hours, and then were ground and sieved by the same ways as those in the preparation of the NFM.

Defatted Scrap Meals (DF-1 and DF-2)

Two types of scrap meals were used. One was the same scrap meal (NFM) as described above (DF-1). The other (DF-2) was prepared from relatively fresh waste with lower POV, TBA and VBN than the NFM. The lipid was extracted from these scrap meals with petroleum ether using soxhlet extractor, and the defatted scrap meals were kept in a hot air oven at 75 °C for 3 hours to remove the petroleum ether.

Diets

Three test diets containing fermented (FFM) and defatted scrap meals (DF-1 and DF-2), one negative control diet containing nonfermented scrap meal (NFM), and one positive control diet containing white fish meal (WFM) were prepared (Table 1). The ingredients of each diet were mixed thoroughly, and an aliquot of water was added to the mixture. After pelleting, the diets were dried in a hot air oven at 60°C. Proximate compositions of the diets are shown in Table 2.

Fish

Red sea bream, which grew at a comparable rate during a 2 months pre-feeding trial with the positive control diet (WFM) containing white fish meal were used. Before grouping, fish were bathed in 2 ppm copper sulfate (CuSO₄, 5H₂O) and 0.5 ppm masoten solution (0.0-dimethyl, 1-hydroxy-2,2-trichloro-ethyl phosphonate) for 3 hours per day, 3 days in succession in order to remove any infection. During the bathing, water supply was totally stopped and aeration increased.
TABLE 1. *Composition of NFM, FFM, DF-1, DF-2 and WFM diets*

<table>
<thead>
<tr>
<th>Diets</th>
<th>NFM</th>
<th>FFM</th>
<th>DF-1</th>
<th>DF-2</th>
<th>WFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>White fish meal</td>
<td>83.3</td>
<td>85.6</td>
<td>74.2</td>
<td>75.2</td>
<td>68.5</td>
</tr>
<tr>
<td>Scrap fish meals</td>
<td>5.0</td>
<td>4.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>cc - starch</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Vitamin mixture*1</td>
<td>3.43</td>
<td>3.43</td>
<td>3.43</td>
<td>3.43</td>
<td>3.43</td>
</tr>
<tr>
<td>Na2P04, 2H2 O</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Fe-citrate</td>
<td>3.26</td>
<td>2.86</td>
<td>3.26</td>
<td>2.26</td>
<td>3.26</td>
</tr>
<tr>
<td>Pollack liver oil*2</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Carboxymethylcellulose</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>L-Aspartic acid Na</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>9.4</td>
</tr>
</tbody>
</table>

*1 Halver’s vitamin mixture (1957) cc-cellulose
*2 Feed oil, Riken vitamin Ltd.

TABLE 2. *Proximate compositions of diets used*

<table>
<thead>
<tr>
<th>Diets</th>
<th>NFM</th>
<th>FFM</th>
<th>DF-1</th>
<th>DF-2</th>
<th>WFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>9.2</td>
<td>11.9</td>
<td>12.5</td>
<td>10.7</td>
<td>9.8</td>
</tr>
<tr>
<td>Protein (%d.m.)</td>
<td>43.7</td>
<td>44.2</td>
<td>44.2</td>
<td>45.3</td>
<td>45.6</td>
</tr>
<tr>
<td>Lipid (%d.m.)</td>
<td>16.2</td>
<td>15.5</td>
<td>9.8</td>
<td>9.7</td>
<td>10.1</td>
</tr>
<tr>
<td>Carbohydrate* (% d.m.)</td>
<td>4.6</td>
<td>5.8</td>
<td>5.2</td>
<td>4.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Ash(%d.m.)</td>
<td>18.1</td>
<td>17.6</td>
<td>18.3</td>
<td>18.2</td>
<td>17.1</td>
</tr>
</tbody>
</table>

* as glucose

Rearing and Feeding

Fish averaging 29.0 g in body weight were divided into 5 groups with 25 fish each in such a way that every group had comparable fishes by weight. Thus average weight as well as standard deviation (S.D. ±) of each group was identical. For this reason 125 healthy fishes were sorted out from about 400 fishes. Each and every fish was anesthetized with 100 ppm MS 222 (m-aminobenzoic acid ethylester methanesulfonate). The fishes were kept in 150 litre aquaria. The diet was fed to fish twice a day for 8 weeks slowly and continuously, as long as fish accepted the diet. The weight of diet fed to each group was recorded and was assumed to be the actual amount consumed by fish. Every day in the early morning and at noon the bottom and inner walls of the aquaria were carefully cleaned by a brush attached to a siphon tube to remove faeces and uneaten feed particles. The fish were individually weighed after anesthetization with MS 222 every 2 weeks. After weighing, the fish were bathed in 10 ppm sodium nifurstyrenate (sodium salt of 5-nitro-2 (P-carboxystyryl)-furam) for 1 hour, in order to prevent bacterial infections in

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wounds of skin which may have been caused during handling of fish.

**Analytical Methods**

The proximate compositions of fish waste, the NFM, FFM, DF-1, DF-2, WFM and the experimental diets were determined as follows: Moisture was estimated by a 16 hour drying in an electric oven at 100-110°C. Protein and carbohydrate were determined by the methods of Kjeldahl and of Hodge and Hofreiter (1962), respectively. Lipid was extracted with ethyl ether using soxhlet extractor. Ash was determined by a 6 hour burning in an electrical furnace at 625°C. The VBN (volatile basic nitrogen) was analysed by Tomiyama *et al.* (1951) method. POV (peroxide value) and TBA (thiobarbituric acid) were quantified by the modified methods of Lea (1931), and of Shinnhuber and Yu (1977), respectively. Amino acids and fatty acids in meals were also determined. Amino acids were analyzed by an amino acid analyzer (JCL-AH) after hydrolysis using 6N HCl. Total lipids were extracted from the meals by the methods of Folch *et al.* (1957), and transesterified by the method of Morison and Smith (1964). Methyl esters were stored at-20°C under nitrogen until analysed by gas-liquid chromatography (GLC). GLC operating conditions for the determination of fatty acids are summarized in Table 3. The components of methyl esters were identified by Ackman and Burgher method (1963), and equivalent chain length values of Hofsatter *et al.* (1965). The quantitative fatty acid data were calculated directly as area percent by triangulation method.

**TABLE 3. Operating conditions of gas-liquid chromatography**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>JOEL Model JGC-20 KFP (detector: Flame ionization detector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary phase</td>
<td>10% Diethylene glycol succinate polyester. Chromosorb W (AW, 100-mesh)</td>
</tr>
<tr>
<td>Column</td>
<td>3 mm 0 x 3 sus-colum (sus-27)</td>
</tr>
<tr>
<td>Carrier flow</td>
<td>N₂ 45ml/min</td>
</tr>
<tr>
<td>H₂ pressure</td>
<td>0.88 kg/cm²</td>
</tr>
<tr>
<td>Air pressure</td>
<td>2.5 kg/cm²</td>
</tr>
<tr>
<td>Injection port temp.</td>
<td>285°C</td>
</tr>
<tr>
<td>Colum temp.</td>
<td>185X</td>
</tr>
</tbody>
</table>

**TABLE 4. Proximate compositions, of POV, TBA, and VBN of fish waste and the NFM, EFM, DF-1, DF-2 and WFM meals**

<table>
<thead>
<tr>
<th>Meals</th>
<th>Fish waste</th>
<th>NFM</th>
<th>FFM</th>
<th>DF-1</th>
<th>DF-2</th>
<th>WFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>—</td>
<td>2.0</td>
<td>2.1</td>
<td><strong>8.0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lipid (% d.m.)</td>
<td>—</td>
<td>19.7</td>
<td>18.6</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (% d.m.)</td>
<td>—</td>
<td>53.4</td>
<td>52.5</td>
<td>59.3</td>
<td>58.5</td>
<td>69.8</td>
</tr>
<tr>
<td>Carbohydrate*1 (% d.m.)</td>
<td>—</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash (% d.m.)</td>
<td>—</td>
<td>17.9</td>
<td>17.7</td>
<td>20.8</td>
<td>21.0</td>
<td>18.4</td>
</tr>
<tr>
<td>POV (meq/kg)</td>
<td>248.3</td>
<td>202.3</td>
<td>27.0</td>
<td></td>
<td></td>
<td>17.1</td>
</tr>
<tr>
<td>TBA (number)</td>
<td>66.8</td>
<td>56.2</td>
<td>28.0</td>
<td></td>
<td></td>
<td><strong>18.7</strong></td>
</tr>
<tr>
<td>VBN (mg%)</td>
<td>86.3</td>
<td>36.7</td>
<td>72.0</td>
<td>37.2</td>
<td>35.0</td>
<td>42.6</td>
</tr>
</tbody>
</table>

*1 as glucose, *2 value just after fermentation but before drying.
RESULTS AND DISCUSSION

Proximate Compositions, POV, TBA and VBN of Fish Waste, NFM, FFM, DFA, DF-2 and WFM

As shown in Table 4, there was scarcely any difference in crude protein and ash contents between the nonfermented (NFM) and the fermented (FFM) scrap fish meals. However, the lipid content decreased from initial 19.7% to 18.6% (on dry wt. basis) after fermentation. On the other hand, the decrease of POV and TBA was remarkable in the FFM, compared to the NFM. The POV decreased approximately 87% from 202.3 to 27.0 meq/kg after fermentation. The TBA decreased approximately 50% from 56.2 number before fermentation to 28.0 number after fermentation.

In contrast, the VBN increased after fermentation (128.2 mg %), but decreased to 72.0 mg% after drying, though the value was still higher than the NFM but slightly lower than the fish waste. The decrease of POV, TBA and VBN in the FFM compared to the fish waste (Table 3), simply indicates the partial removal of oxidized lipid due to pressing and evaporation of VBN due to steaming.

Fermentation by \textit{B. subtilis} is said to be an effective process to consume the protein degenerates which is widely used in the processing of a soybean product (malted bean, Natto) in Japan. However, the findings suggest that the protein degenerates were produced during fermentation and \textit{B. subtilis} could not consume them.

On the other hand, VBN in the DF-1 and DF-2 were similar to those of the NFM and WFM. The protein and ash contents of the DF-1 and DF-2 became higher than

<table>
<thead>
<tr>
<th>Amino acids</th>
<th>NFM g/100g</th>
<th>FFM g/100g</th>
<th>DF-1 g/100g</th>
<th>DF-2 g/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lys.</td>
<td>4.19</td>
<td>3.94</td>
<td>4.52</td>
<td>5.03</td>
</tr>
<tr>
<td>His.</td>
<td>1.43</td>
<td>1.48</td>
<td>1.62</td>
<td>1.51</td>
</tr>
<tr>
<td>Arg.</td>
<td>2.84</td>
<td>2.91</td>
<td>3.02</td>
<td>2.84</td>
</tr>
<tr>
<td>Asp.</td>
<td>5.00</td>
<td>5.11</td>
<td>4.31</td>
<td>5.38</td>
</tr>
<tr>
<td>Thr.</td>
<td>2.41</td>
<td>2.27</td>
<td>2.58</td>
<td>2.59</td>
</tr>
<tr>
<td>Ser.</td>
<td>2.48</td>
<td>2.35</td>
<td>2.81</td>
<td>2.81</td>
</tr>
<tr>
<td>Glu.</td>
<td>6.75</td>
<td>6.59</td>
<td>7.03</td>
<td>7.92</td>
</tr>
<tr>
<td>Pro.</td>
<td>1.60</td>
<td>1.78</td>
<td>2.01</td>
<td>1.89</td>
</tr>
<tr>
<td>Gly.</td>
<td>4.71</td>
<td>4.70</td>
<td>5.13</td>
<td>5.16</td>
</tr>
<tr>
<td>Ala.</td>
<td>3.81</td>
<td>3.56</td>
<td>4.08</td>
<td>4.22</td>
</tr>
<tr>
<td>Val.</td>
<td>3.00</td>
<td>2.87</td>
<td>3.19</td>
<td>3.29</td>
</tr>
<tr>
<td>Met.</td>
<td>1.70</td>
<td>1.62</td>
<td>2.11</td>
<td>2.26</td>
</tr>
<tr>
<td>Ileu.</td>
<td>2.19</td>
<td>2.24</td>
<td>2.29</td>
<td>2.05</td>
</tr>
<tr>
<td>Leu.</td>
<td>4.08</td>
<td>3.91</td>
<td>3.98</td>
<td>4.56</td>
</tr>
<tr>
<td>Tyr.</td>
<td>1.52</td>
<td>1.39</td>
<td>1.84</td>
<td>1.92</td>
</tr>
<tr>
<td>Thr.</td>
<td>2.31</td>
<td>2.00</td>
<td>2.48</td>
<td>2.71</td>
</tr>
</tbody>
</table>

EAA(%)**
NEAA(%)**
EAA/NEAA
EAA Index**

** Sample. *% of crude protein. *' calculated taking NFM as standard.
those of the NFM due to the removal of lipid content from scrap fish meal (NFM).

Changes in Amino Acid and Fatty Acid Compositions

Though there is minor variations among amino acids, total essential amino acid composition and total non-essential amino acid shows no significant differences between the NFM and FFM. The ratio of total essential amino acids to total non-essential amino acids (EAA/NEAA) also shows similar values between the NFM and FFM as shown in Table 5. Moreover, the EAA index calculated, taking the NFM as standard showed 86.7 in the FFM, which indicates that the fermentation by these microbes do not change the nutritive value of the proteins. The DF-1 and DF-2 meals also show similar EAA, NEAA and EAA/NEAA values compared to those of the NFM and FFM. However, apparently higher EAA index in DF-1 and DF-2 simply indicates the high protein levels in these meals due to the removal of lipids.

The fatty acid compositions of nonfermented (NFM) and fermented (FFM) meals are shown in Table 6. In spite of the similar lipid contents (Table 4), the percent of w3 highly unsaturated fatty acids with more than 20 carbons (HUFA) in total fatty acids was considerably higher in the FFM than the NFM. Fermentation by different molds reported to increase w3 HUFA content in fermented-steamed scrap meals (Hossain et al., 1987a). On the other hand, the POV and TBA decreased by the fermentation. Therefore, the increase of w3 HUFA by the fermentation appears to be related to the decrease of oxidized products of the lipid.

### Table 6. Fatty acid compositions of NFM, FFM, WFM and Pollack liver oil (PLO)

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>NFM</th>
<th>FFM</th>
<th>WFM</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:0</td>
<td>1.4</td>
<td>1.2</td>
<td>tr.</td>
<td>0.1</td>
</tr>
<tr>
<td>13:0</td>
<td>0.8</td>
<td>1.1</td>
<td>tr.</td>
<td>0.1</td>
</tr>
<tr>
<td>14:0</td>
<td>6.3</td>
<td>6.5</td>
<td>5.2</td>
<td>5.3</td>
</tr>
<tr>
<td>15:0</td>
<td>1.0</td>
<td>1.8</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>16:0</td>
<td>15.2</td>
<td>14.4</td>
<td>10.3</td>
<td>8.2</td>
</tr>
<tr>
<td>16:1 w7</td>
<td>6.8</td>
<td>5.6</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>18:0</td>
<td>5.9</td>
<td>5.8</td>
<td>3.0</td>
<td>2.6</td>
</tr>
<tr>
<td>18:1 u9</td>
<td>22.8</td>
<td>21.9</td>
<td>15.4</td>
<td>17.4</td>
</tr>
<tr>
<td>18:2 u9</td>
<td>2.4</td>
<td>2.6</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>18:2 o6</td>
<td>1.3</td>
<td>1.0</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>18:3 w3</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>20:1 w9</td>
<td>7.5</td>
<td>7.4</td>
<td>15.0</td>
<td>15.1</td>
</tr>
<tr>
<td>20:1 a7</td>
<td>2.1</td>
<td>2.2</td>
<td>1.7</td>
<td>2.4</td>
</tr>
<tr>
<td>20:2 w9</td>
<td>1.8</td>
<td>1.6</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>20:4 w6</td>
<td>0.9</td>
<td>0.8</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>20:5 u3</td>
<td>3.5</td>
<td>4.3</td>
<td>10.1</td>
<td>11.0</td>
</tr>
<tr>
<td>22:1</td>
<td>3.5</td>
<td>4.3</td>
<td>11.3</td>
<td>11.0</td>
</tr>
<tr>
<td>22:4 u6</td>
<td>tr.</td>
<td>tr.</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>22:5 w6</td>
<td>1.6</td>
<td>1.8</td>
<td>2.2</td>
<td>1.6</td>
</tr>
<tr>
<td>22:5 w3</td>
<td>0.4</td>
<td>1.4</td>
<td>12</td>
<td>0.8</td>
</tr>
<tr>
<td>22:6 w3</td>
<td>4.5</td>
<td>5.5</td>
<td>9.2</td>
<td>8.2</td>
</tr>
</tbody>
</table>

w3 HUFA | 8.4 | 11.2 | 20.5 | 20.0
### TABLE 7. Growth and feed efficiency of red sea bream fed on diets prepared by NFM, FFM, DF-1, DF-2 and WFM meals

<table>
<thead>
<tr>
<th>Diets</th>
<th>NFM</th>
<th>FFM</th>
<th>DF-1</th>
<th>DF-2</th>
<th>WFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of fish at start</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>after 8 weeks</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Av.bodywt.(g) at start</td>
<td>29.0 ± 2.5*</td>
<td>29.1 + 2.6</td>
<td>29.0 + 2.4</td>
<td>29.0+ 2.6</td>
<td>29.1+ 2.5</td>
</tr>
<tr>
<td>after 8 weeks*</td>
<td>46.1 ± 7.3</td>
<td>64.9 + 11.3</td>
<td>65.9±12.1</td>
<td>66.4=12.4</td>
<td>72.8+11.8</td>
</tr>
<tr>
<td><em>t-test(5%)</em></td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>—</td>
</tr>
<tr>
<td>Gain/fish (g)</td>
<td>17.1</td>
<td>35.6</td>
<td>36.9</td>
<td>37.4</td>
<td>43.8</td>
</tr>
</tbody>
</table>

Feed intake/fish/day (dry) (g) 1.41 1.36 1.46 1.37 1.61 Feed efficiency 21.7 46.8 45.2 48.7 48.5

*± = S.D., *: S = Significant, IS = Insignificant

### Growth and Feed Efficiency

The growth of red sea bream fed on the fermented scrap meal diet (FFM) and the defatted scrap meal diets (DF-1 and DF-2) were significantly superior to those of the nonfermented scrap meal diet group (NFM) at a 5 % level as shown in Table 7. Furthermore, the differences in average body weight at the end of feeding experiment between white fish meal diet group (WFM) and the NFM diet group was significant, but that between the WFM and the FFM or the DF-1 or the DF-2 were insignificant. Apparently the higher gain in body weight of the WFM group compared to those of the FFM or the defatted groups was caused due to the higher intake of diet rather than the nutritive quality of the WFM diet, which is evident from the fact that all these four groups show relatively similar feed efficiency. On the other hand the group fed on the NFM diet shows very poor feed efficiency compared to rest of the diet groups.

The improvements of the growth and feed efficiency of the FFM, DF-1 or DF-2 compared to the NFM seem to be mainly caused by the removal of oxidized lipids by fermentation or defatting. Fermented-resteamed scrap meals (Yone et al., 1986) by identical microbes employed in this experiment or by molds isolated from smoked semi-dried skipjack (Hossain et al., 1987b) reported to improve growth and feed efficiency of red sea bream.

In the present study, fermented scrap meal, whose POV and TBA decreased but highly unsaturated fatty acids (ω3 HUFA) increased, improved the growth and feed efficiency of red sea bream juveniles. This seems to be caused by the decrease of toxic oxidative products from lipid. The improvement of lipid quality in fermented meals also appears to be related with removal of oxidative products. However, protein degenerates produced during the fermenting period, which is found with the increased VBN, appears to suppress the feed intake by fish if not suppress the growth and feed efficiency. Yone et al., 1986 suggested to steam the meals after fermentation for 30-40 minutes to remove the VBN. However, it is essential to find out ways to arrest VBN increment during fermentation. Furthermore, the findings confirm that removal of oxidized lipid and protein degenerates is essential in the utilization of fish waste as a dietary protein and lipid sources, and fermentation is an effective way for the removal of oxidized products from lipid. Defatting of scrap meal by chemical methods effectively remove oxidized lipid completely. However, the process is costly and time consuming, and defatted meals must be
supplemented with fresh lipid to prepare fish diet. Therefore, microbial treatment of oxidized fish waste appears suitable and opens a new cheap way to eradicate toxic materials from the waste.

REFERENCES


