カビ処理したサバ廃棄油を摂ったマダイの成長および飼料効率

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著者	Hossain, Md.A. 古市, 政幸 米, 康夫
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Growth and Feed Efficiency in Red Sea Bream Fed on Waste Lipid Treated with Mold

Md. Abul Hossain,[*2] Masayuki Furuichi,[*2]
and Yasuo Yone[*2]

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An attempt was made to know whether fish waste lipid treated with mold can be utilized as a feed oil or not. The lipid from mackerel waste juice was treated with *Aspergillus terreus* for 18 h and the treated lipid was added into a diet containing white fish meal, and the effect of treated lipid on growth of red sea bream *Chrysophrys major* and feed efficiency was compared with that of nontreated lipid and pollack liver oil. Treatment with the mold decreased POV and TBA value of lipid (NTL) from waste juice and increased ω3 HUFA content. The growth and feed efficiency in red sea bream fed on the treated lipid (TL) were significantly high as compared with those of fish fed on the nontreated lipid (NTL), and were similar to the fish fed on pollack liver oil (PLO).

In the previous study,[1] when the lipid from mackerel waste juice was treated with *Aspergillus terreus*, the peroxide value (POV) and thiobarbituric acid (TBA) value of the lipid decreased remarkably and the ω3 highly unsaturated fatty acids (ω3 HUFA) content increased. These findings suggest that the nutritive value of waste lipid may be improved by the microbial treatment. Therefore, in the present study, the effect of waste lipid treated with *Asp. terreus* on the growth of red sea bream and feed efficiency was compared with those of nontreated waste lipid and pollack liver oil.

Materials and Methods

Lipid and Liquid

The lipid and liquid (water soluble fraction) of juice from pressed mackerel waste were separated by the method described in the previous paper.[2]

Mold Seed

Aspergillus terreus was cultured in a medium containing 2.5 m*l* of liquid and 1 g of molasses and 96.5 m*l* of tap water at 28–30°C for 48 h by the method described previously.[1]

Microbial Treatment

Fifty grams of sterilized waste lipid was stirred in 50 m*l* of mold seed with a mixer and the mixture was incubated for 18 h under the same conditions as those for the preparation of mold seed.

Separation of Treated Lipid

The treated lipid was separated from the medium by centrifuging at 3,000 rpm for 15 min and stored at −20°C under nitrogen gas until it was used.

Diets

A test diet containing the treated lipid (TL) and two control diets with nontreated lipid (NTL) or pollack liver oil (PLO) were prepared by the same method as in the previous study.[3] Compositions and proximate compositions of the diets are shown in Table 1. Fatty acid compositions of the dietary lipids are also shown in Table 2. Every diet has similar protein, lipid, carbohydrate and ash contents.

Fish

Red sea bream were fed on the control diet containing pollack liver oil (PLO) for 2 weeks, and fish with a comparable size were selected. The fish were used after bathing in solution containing 2 ppm copper sulfate and 0.5 ppm Masoten (0, 0-dimethyl-1-hydroxy-2, 2, 2-trichlorethylphosphonate) for 3 h per day, 3 days in succession.

[*1] Contribution from Fish. Res. Lab., Kyushu University, No. 177. Studies on Utilization of Fish Waste-11.

[*2] Fishery Research Laboratory, Kyushu University, Tsuyazaki, Fukuoka 811–33, Japan (Md. Abul. Hossain, 古市政幸, 米　康夫: 九州大学農学部附属水産実験所).

Table 1. Compositions and proximate compositions of diets containing nontreated (NTL) and treated (TL) lipids, and pollack liver oil (PLO)

Diets		NTL	TL	PLO
White fish meal		69.7	69.7	69.7
α-Starch		5.0	5.0	5.0
Vitamin mixture*1		3.0	3.0	3.0
$NaH_2PO_4 \cdot 2H_2O$		3.43	3.43	3.43
Fe-citrate		0.11	0.11	0.11
Nontreated lipid		11.8	—	—
Treated lipid		—	11.8	—
Pollack liver oil		—	—	11.8
L-Aspartic acid Na		1.0	1.0	1.0
Carboxymethylcellulose		1.96	1.96	1.96
α-Cellulose		4.0	4.0	4.0
Moisture	(%)	17.4	12.0	12.5
Protein	(% d.m.)	44.6	43.3	43.7
Lipid	(% d.m.)	15.6	15.2	15.7
Carbohydrate*2	(% d.m.)	4.9	4.4	4.6
Ash	(% d.m.)	15.4	15.3	15.3

*1 Halver's mixture (1957)+α-cellulose. *2 as glucose.

Table 2. Fatty acid compositions of lipids from diets containing NTL, TL, and PLO, and ω3 HUFA contents in diets

Fatty acids (%)	NTL	TL	PLO
12: 0	0.6	0.4	0.1
13: 0	0.2	0.2	0.1
14: 0	7.0	6.2	5.3
15: 0	0.6	0.5	0.2
16: 0	17.3	14.9	8.2
16: 1ω7	7.0	4.7	5.3
18: 0	3.4	3.6	2.6
18: 1ω9	21.4	17.5	17.4
18: 2ω9	2.3	3.0	3.9
18: 2ω6	0.4	1.0	0.5
18: 3ω3	0.9	1.6	1.0
20: 1ω9	9.4	13.5	15.0
20: 1ω7	1.3	1.5	2.4
20: 2ω9	0.3	1.0	0.3
20: 2ω6	—	—	tr
20: 4ω6	0.3	0.8	0.5
20: 5ω3	6.6	6.9	11.0
22: 1	7.1	9.6	11.0
22: 4ω6	0.7	0.4	0.5
22: 5ω6	0.9	1.8	1.6
22: 5ω3	0.9	0.9	0.8
22: 6ω3	4.8	6.4	8.2
Σω3 HUFA	12.3	14.2	20.0
ω3 HUFA content (%) in diet*	1.9	2.1	3.1

* Lipid content (Table 1) × Σω3 HUFA.

Table 3. POV, TBA value, and fatty acid compositions of lipids (NTL, TL, PLO) used and lipid from white fish meal (W)

Fatty acids (%)	NTL	TL	PLO	W
12: 0	0.8	0.5	tr	0.2
13: 0	0.9	0.3	0.1	0.3
14: 0	8.1	5.9	4.9	5.0
15: 0	1.2	1.0	0.3	0.1
16: 0	21.7	20.1	7.5	15.3
16: 1ω7	5.0	4.9	8.1	4.9
18: 0	5.1	4.0	2.6	2.7
18: 1ω9	22.1	21.0	14.1	12.8
18: 2ω9	0.5	0.9	0.7	1.2
18: 3ω6	tr	tr	0.3	0.9
18: 3ω3	1.0	1.1	tr	0.3
18: 4ω3	tr	tr	0.4	0.2
20: 1ω9	7.8	8.2	19.0	15.8
20: 1ω7	0.9	1.6	2.7	3.0
20: 2ω9	1.5	1.2	0.3	0.6
20: 2ω6			0.1	0.1
20: 3ω3			0.2	0.2
20: 4ω6	0.6	0.8	0.3	0.8
20: 5ω3	2.9	5.0	10.8	12.2
22: 1	7.0	7.8	14.3	10.3
22: 4ω6	0.9	0.6	0.9	0.2
22: 5ω6	1.0	1.9	1.1	1.0
22: 5ω3	0.5	1.5	1.2	1.0
22: 6ω3	4.9	6.4	8.3	8.5
$\Sigma\omega$3 HUFA	8.3	12.9	20.3	21.7
POV (meq/kg)	235.6	59.3	26.8	29.8
TBA (mg/kg)	83.8	40.2	34.6	21.6

Rearing and Feeding

Ninety fish with average body weight of 39.0 g were divided into 3 groups and each group was kept in a 150 *l* aquarium. An aquarium was continuously supplied with sand filtered sea water at a rate of 150 *l*/h. Water temperature was maintained within the range of 24.5°C to 25°C. The feeding and rearing were conducted for 14 weeks by the methods described previously.[4]

Analytical Methods

The moisture, protein, lipid, and ash contents in the diets and white fish meal, and carbohydrate in the diets were quantified by the same methods as those in the previous paper.[3] and the POV and TBA value of nontreated and treated lipids were also determined by the methods described in the previous study.[3] Fatty acid compositions of the diets, nontreated and treated lipids, pollack liver oil, and white fish meal were analyzed by the identical methods to those mentioned previously.[4]

Results and Discussion

Changes in POV, TBA Value and Fatty Acid Composition of Waste Lipid

As shown in Table 3, both the POV and TBA value of waste lipid (NTL) decreased remarkably by the treatment with *Asp. terreus* and its ω3 HUFA increased. These results agreed with the findings in the previous studies.[1,4] On the other hand, treated lipid (TL) was higher in POV and TBA value and lower in ω3 HUFA content than those of pollack liver oil (PLO) and lipid from white fish meal (W).

Growth of Fish and Feed Efficiency

The growth and feed efficiency of fish fed on the diet containing the treated lipid (TL) were significantly superior to those of the nontreated lipid (NTL) diet group, and similar to pollack liver oil (PLO) diet group (Table 4).

The ω3 HUFA contents (%) in the NTL, TL and PLO diets calculated with the ω3 HUFA (%) in total fatty acids (Table 2) and the contents (%,

Table 4. Effects of NTL, TL, and PLO on growth of red sea bream and feed efficiency

Diets		NTL	TL	PLO
No. of fish	at start	30	30	30
	after 14 weeks	30	30	30
Av. body	at start	39.0± 2.6	39.0± 2.6	39.0± 2.6
wt. (g)	after 14 weeks	91.2±21.6	118.1±28.3	126.3±30.6
"t" test	(5%)*1	S	NS	—
		S	—	
Gain/fish	(g)	52.2	79.1	87.3
Feed efficiency (%)		35.6	51.3	52.1
Feed intake/fish/day (g)*2		1.5	1.6	1.7

*1 S: significant, NS: insignificant. *2 dry weight basis.

Table 1) of the dietary lipids were about 1.9, 2.1 and 3.1, respectively, which are satisfactory for the requirement of red sea bream.[5] The similar ω3 HUFA contents of NTL and TL diets appear to be caused by the high ω3 HUFA content in the lipid of white fish meal. On the other hand, the POV and TBA value of nontreated waste lipid (NTL) used were remarkably higher than the treated lipid (TL) and pollack liver oil (PLO), as shown in Table 3. Therefore, it is clear that the significantly low growth and feed efficiency in NTL diet group were caused by the feeding of peroxidized product in the waste lipid and that the treatment with *Asp. terreus* removed the toxic peroxidized products and improved the nutritive value of mackerel waste lipid.

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