Mem. Fac. Fish., Kagoshima Univ.
Vol. 31 pp. 201~204 (1982)

Essential Fatty Acids of *Tilapia nilotica*

Shin-ichi TESHIMA, Akio KANAZAWA, and Mineshi SAKAMOTO*[1]

Abstract

The essential fatty acid requirements of *Tilapia nilotica* were examined by the 4-week feeding trials using the defined, artificial diets at water temperatures of 20℃ and 28℃. The test diets contained 1.0% levels of 18:1 ω9, 18: 2ω6, 18: 3ω3, 20: 4ω6, or ω3-HUFA (60% 20: 5ω3 and 40% 22: 6ω3) in addition to 4.0% 18: 1ω9 as dietary lipids. The highest weight gains were observed on the diets supplemented with 1.0% levels of 18: 2ω6 or 20: 4ω6. These indicated that *T. nilotica* requires ω6-fatty acids such as 18: 2ω6 and 20: 4ω6 rather than ω3-fatty acids in contrast to other fishes. However, the effects of water temperatures on the EFA requirements of *T. nilotica* were not clarified in the present study due to the poor growth of this fish at 20℃.

Many papers have shown that fishes require ω3-fatty acids such as linolenic (18: 3ω3), eicosapentaenoic (20: 5ω3), and docosahexaenoic (22: 6ω3) acids for growth as essential fatty acids (EFA)[1,2]. These findings have indicated that EFA requirements of fishes are different with those of mammals which require ω6-fatty acids such as linoleic (18: 2ω6) and arachidonic (20: 4ω3) acids as EFA. Previously, we have revealed that *Tilapia zillii* requires 18: 2ω6 and 20: 4ω6 as EFA rather than ω3-fatty acids such as 18: 3ω3 and ω3-HUFA (highly unsaturated fatty acids such as 20: 5ω3 and 22: 6ω3), indicating that the EFA requirements of *T. zillii* are quite unique among the fishes[3]. We imagine that EFA requirements of fish may be variable with environmental factors such as water temperatures and salinities besides the genetic differences of fish. In the present study, the feeding experiments using *Tilapia nilotica* were conducted in order to confirm the unique aspect of EFA requirements in *Tilapia* species and also to examine the effect of water temperatures on the EFA requirements of this fish.

Materials and Methods

Specimens of *T. nilotica*, approximately 3.7-4.0 g in body weight, were obtained from the Ibusuki Branch of Fisheries Experimental Station of Kagoshima Prefecture. The *Tilapia* were fed the lipid-free diet for 10 days before the feeding trials, divided into 10 experimental groups of 10 fishes in an aquarium (30 liter-capacity), and reared with the test diets for 4 weeks. The composition of the basal ration was essentially the same as that used for *T. zillii* in the previous

*[1] Laboratory of Fisheries Chemistry, Faculty of Fisheries, University of Kagoshima, 4-50-20 Shimoarata, Kagoshima 890, Japan.

study[3] and contained the following ingredients (%); casein 40, dextrin 31, lipids 5, vitamins 3, minerals 4, cellulose powder 13, and agar 4. The test diets 1, 2, 3, 4, and 5 contained 1.0% levels of oleic acid (18: 1ω9), 18: 2ω6, 18: 3ω3, 20: 4ω6, and ω3-HUFA (a mixture of 60% 20: 5ω3 and 40% 22: 6ω3), respectively, in addition to 4.0% 18: 1ω9 as dietary lipids (Table 1). The *Tilapia* were fed the test diets at the 4.0% level of their body weight daily (feeding time; 9:00 a.m. and 6:00 p.m.). The feeding trials of experimental groups 1 to 5 and 6 to 10 were carried out at the water temperatures of 28℃, and 20℃, respectively.

Results and Disussion

Table 1 and Fig. 1 show the results of the feeding trials. When the *Tilapia* were reared at 28℃, the highest weight gain was attained on the diets 2 and 4 which were supplemented with 1.0% levels of 18: 2ω6 and 20: 4ω6, respectively. The *Tilapia* fed the diet containing 1.0% ω3-HUFA also showed a relatively high weight gain, but the weight gain on 1.0% ω3-HUFA was slightly inferior to those on 1.0% 18: 2ω6 and 1.0% 20: 4ω6. Whereas, growth of the *Tilapia* was markedly poor on the diets supplemented with 18: 3ω3 or 18: 1ω9. These results

Table 1. Effects of dietary fatty acids on the weight gain and hepatosomatic index of *T. nilotica* reared at water temperatures of 20°C and 28°C.

Exptl. group	Water temp. (°C)	Dietary lipid	Body weight(g) Initial	Body weight(g) Final	Body weight gain (%)*1	Hepato-somatic index*2
1	28	1% 18 : 1ω9 + 4% 18 : 1ω9	3.86	6.94	79.8	3.28
2	28	1% 18 : 2ω6 + 4% 18 : 1ω9	3.75	8.06	114.9	3.56
3	28	1% 18 : 3ω3 + 4% 18 : 1ω9	3.96	6.61	66.9	4.20
4	28	1% 20 : 4ω3 + 4% 18 : 1ω9	4.02	8.60	113.9	2.54
5	28	1%ω3-HUHA + 4% 18 : 1ω9	3.65	7.41	103.0	3.61
6	20	1% 18 : 1ω9 + 4% 18 : 1ω9	3.71	4.81	29.7	2.26
7	20	1% 18 : 2ω6 + 4% 18 : 1ω9	3.88	5.08	30.9	1.75
8	20	1% 18 : 3ω3 + 4% 18 : 1ω9	3.94	5.04	27.9	1.96
9	20	1% 20 : 4ω6 + 4% 18 : 1ω9	3.69	4.61	24.9	1.52
10	20	1%ω3-HUFA + 4% 18 : 1ω9	3.71	4.75	28.0	1.56

*1 (Final body wt. − Initial body wt.) x 100/Initial body wt.
*2 Liver wt. x 100/Body wt.

indicated that *T. nilotica* requires ω6-fatty acids such as 18: 2ω6 and 20: 4ω6 as EFA rather than ω3-fatty acids as also observed on *T. zillii* in the preceding study. Recently, TAKEUCHI *et al*[4]. have also presented that *T. nilotica* showed better growth when fed the diets suppelemented with 18: 2ω6 rather than 18: 3ω3 or ω3-HUFA. Furthermore, they have demonstrated that corn oil and soybean oil containing large amounts of 18: 2ω6 had a higher dietary value for *T. nilotica* than several lipids such as middle carbon triglycerides, beef tallow, pollack liver oil, etc[5].

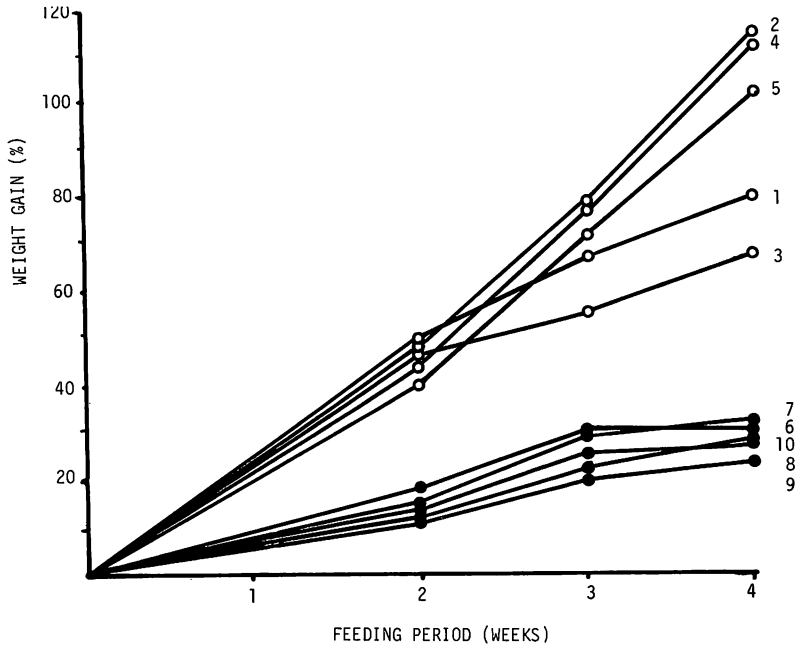

Fig. 1. Growth of *T. nilotica* fed the test diets. Letters indicate the exprimental groups. ○, reared at 28°C; ●, reared at 20°C.

Differing from the present study (water temp., 28℃), TAKEUCHI *et al*[4,5]. have conducted the feeding trials of *T. nilotica* at 25℃, however their results of the EFA requirements[4] were essentially similar to those obtained in the present study, except for the growth-promoting effect of 20: 4 ω6. They have pointed out that 20: 4ω6 did not improve the weight gain as effectively as 18: 3 ω3 in contrast to the present study. We assume that *T. nilotica* is possibly able to convert 18: 2 ω6 to 20: 4ω6 as found in mammals and several fishes[6-8], because the growth-promoting effect of 18: 2ω6 was almost equal to that of 20: 4ω6. However, the above assumption should be confirmed by further studies using radioactive tracer experiments.

When *T. nilotica* were reared at 20℃, the weight gains and hepatosomatic indices were low as compared with the *Tilapia* reared at 28℃. The weight gains of *Tilapia* were not significantly different among the groups fed the diets supplemented with 1.0% levels of 18: 1 ω9, 18: 2ω6, 18: 3 ω3, and ω3-HUFA, although the *Tilapia* gave a slightly low weight gain on the diet with 1.0% 20: 4ω6. Therefore, we could not withdraw any conclusion on the effects of water temperature on the EFA requirements of *T. nilotica*. The rearing of *T. nilotica* at low water temperature such as 20℃ may result in a marked depression of metabolism of lipids and other nutrients.

Considering the above data and information, *T. nilotica* was concluded to require ω6-fatty acid as 18: 2ω6 and 20: 4ω6 for growth in contrast to other fishes such as the rainbow trout[9,10], carp[11,12], turbot[13], red sea bream[14], Ayu (*Plecoglossus altivelis*)[15-17], eel[18], and chum salmon[19].

Finally, we assume that the EFA requirements of some fishes habiting in tropical environments may differ from those of fishes living in temperate and cold water zones.

References

1) T. TAKEUCHI: in "Fish Culture and Dietary Lipids (in Japanese)" (ed. by Japan. Soc. Sci. Fish.,), Suisangaku Series No. 22, Koseisha-Koseikaku, Tokyo, 1978, pp. 60-77.
2) Y. YONE: in "Fish Culture and Dietary Lipids (in Japanese)" (ed. by Japan. Soc. Sci. Fish.), Suisangaku Series No. 22, Koseisha-Koseikaku, Tokyo, 1978, pp. 43-59.
3) A. KANAZAWA, S. TESHIMA, M. SAKAMOTO, and Md. A. AWAL: *Bull. Japan. Soc. Sci. Fish.*, **46**, 1353-1356 (1980).
4) T. TAKEUCHI, H. SATO, and T. WATANABE: On the essential fatty acid requirements of *Tilapia nilotica*. The Autumn Meeting of Japan. Soc. Sci. Fish. p. 93 (1981).
5) T. TAKEUCHI, H. SATO, and T. WATANABE: Nutritional values of several lipids for *Tilapia nilotica*. The Spring Meeting of Japan. Soc. Sci. Fish. p. 95 (1982).
6) M. KAYAMA, Y. TSUCHIYA, J.C. NEVENZEL, A. FULCO, and J.F. MEAD: *J. Am. Oil Chem. Soc.*, **40**, 477-502 (1963).
7) J.M. OWEN, J.M. ADRON, C. MIDDLETON, and C.B. COWEY: *Lipids*, **10**, 528-531 (1975).
8) A. KANAZAWA, S. TESHIMA, and K. ONO: *Comp. Biochem. Physiol.*, **63B**, 295-298 (1979).
9) J.D. CASTELL, R.O. SINNHUBER, D.R. LEE, and J.H. WALES: *J. Nutr.*, **102**, 87-92 (1972).
10) T. WATANABE, C. OGINO, Y. KOSHIISHI, and T. MATSUNAGA: *Bull. Japan. Soc. Sci. Fish.*, **40**, 493-499 (1974).
11) T. WATANABE, T. TAKEUCHI, and C. OGINO: *Bull Japaan. Soc. Sci. Fish.*, **41**, 263-269 (1975).
12) T. WATANABE, O. UTSUE, I. OGINO: *Bull. Japan. Soc. Sci. Fish.*, **41**, 257-262 (1975).
13) C.B. COWEY, J.M. OWEN, J.W. ADRON, and C. MIDDLETON: *Brit. J. Nutr.*, **36**, 479-486 (1976).
14) M. FUJII and Y. YONE: *Bull. Japan. Soc. Sci. Fish.*, **42**, 583-588 (1976).
15) A. OKA: *The Aquiculture*, **27**, 202-208 (1980).
16) C. KITAJIMA, M. YOSHIDA, and T. WATANABE: *Bull. Japan. Soc. Sci. Fish.*, **46**, 47-50 (1980).
17) A. OKA, N. SUZUKI, and T. WATANABE: *Bull. Japan. Soc. Sci. Fish.*,**45**, 1413-1418 (1980).
18) T. TAKEUCHI, S. ARAI, T. WATANABE, and Y. SIMMA: *Bull. Japan. Soc. Sci. Fish.*, **46**, 345-353 (1980).
19) T. TAKEUCHI, T. WATANABE, and T. NOSE: *Bull. Japan. Soc. Sci. Fish.*, **45**, 1319-1323 (1979).