

# LINSEED OIL AS AN ALTERNATIVE TO FISH OIL IN THE DIET OF NILE TILAPIA (*Oreochromis niloticus*)

Ioannis, T. Karapanagiotidis \*, Michael, V. Bell and David, C. Little

Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland - ikarapan@apae.uth.gr

## Abstract

A feeding trial was conducted to determine whether increasing linolenic acid (18:3n-3) in linseed oil based diets would lead to increased tissue deposition of 22:6n-3 in Nile tilapia (*Oreochromis niloticus*). The study suggests that Nile tilapia has a limited capacity to synthesize 20:5n-3 and 22:6n-3 from dietary 18:3n-3. The replacement of fish oil in the diet of farmed tilapia with vegetable oils could therefore lower tissue concentrations of 20:5n-3 and 22:6n-3, and consequently produce an aquaculture product of lower lipid nutritional value for the consumer.

**Keywords :** Aquaculture, Diet, Fishes.

## Introduction

Today industrialized societies are characterized by an increase in energy intake, saturated fat and n-6 polyunsaturated fatty acids (PUFA) and a decrease in n-3 PUFA intake [1]. This nutritional status has led to many modern human health disorders [2]. It is recommended to increase the intake of n-3 PUFA, and particularly 20:5n-3 and 22:6n-3, and decrease the dietary intake of n-6 PUFA in the human diet [3]. Fish and marine mammals are by far the richest source of long chain n-3 PUFA in nature. As the farming of fish is becoming a major contributor to world fish supplies, it is important for the aquaculture sector to maintain the high lipid nutritional quality of the product and continue to provide large amounts of the health-promoting n-3 PUFA for the consumer.

## Materials and Methods

Male sex-reversed tilapia fry (*Oreochromis niloticus*) of initial weight 0.5-2 g were grown on five isonitrogenous (32% crude protein) and isoenergetic (17 KJ/g diet) diets that were supplemented with 3% of either a blend of refined palm olein oil with linseed oil (PO-LO 3:2) or a blend of linseed oil with refined palm olein oil (LO-PO 2:1) or linseed oil (LO), fish oil (FO) and corn oil (CO). The fish were stocked into 6 replicate net cages (3 m x 1.8 m x 0.8 m, 3 mm mesh size) per dietary treatment that were suspended in an earthen pond (40 m x 40 m x 1 m). After 20 weeks of feeding, 30 fish from each treatment were taken, the dorsal muscle tissue of each was dissected and used for fatty acids analysis. The fatty acid analysis was performed by using gas liquid chromatography [4]. The fatty acid composition of the five treatments was subjected to one-way analysis of variance (ANOVA) and differences were considered significant at an alpha value of 0.01.

## Results and Discussion

The results suggest that LO and its blends with PO could totally replace fish oil without any negative effects ( $P>0.01$ ) on the growth, feed efficiency and survival of Nile tilapia. The muscle content of 18:2n-6 and 18:3n-3 strongly reflected dietary intake with the highest ( $P<0.01$ ) amounts of 18:2n-6 in fish fed the CO diet and 18:3n-3 in fish fed the LO diets, while fish fed the FO diet contained the highest ( $P<0.01$ ) amounts of long-chain n-3 PUFA (Table 1). The inclusion of increasing levels of LO in the diet, and thus graded amounts of dietary 18:3n-3, resulted in commensurate increases in tissue 18:3n-3 and all n-3 PUFA pathway anabolites. Therefore, the PUFA biosynthetic pathways are active in Nile tilapia. However, when comparing the FA compositions of the LO-based treatments with those of FO-fed fish, it is becoming clear that the conversion of 18:3n-3 to longer chain n-3 PUFA derivatives is not efficient, and particularly the synthesis of 20:5n-3 and 22:6n-3 is low ( $P>0.01$ ). These findings are in agreement with studies in other fish species [4, 5] fed on vegetable oil (VO) diets. This is a conclusion of great importance indicating that the replacement of FO with VO in diets for farmed fish lowers their content of the nutritionally important long-chain n-3 PUFA.

It is recommended that VO alternatives that are rich in 18:3n-3 and low in 18:2n-6, such as LO, are used if the replacement of FO in fish feeds become inevitable. The inclusion of LO can maximise the retention of desirable 20:5n-3 and 22:6n-3 and can minimise the deposition of undesirable long-chain n-6 PUFA in the edible muscle tissue of fish compared to a VO is rich in 18:2n-6.

Tab. 1. The fatty acid compositions (ug/mg of TL) of muscle TL of fish fed the five diets at the end of the 20-week feeding period. Values are the mean of 6 replicate groups of 6 fish ( $\pm$  S.D.). Values in the same row, which do not share the same superscript letter (i.e. a, b, c, d, e) are significantly different at  $\alpha=0.01$ ; n.d., not detected.

Fatty acid	FO-LO	LO-PO	LO	FO	CO
18:2n-6	59.67 $\pm$ 6.35 <sup>a</sup>	58.84 $\pm$ 5.20 <sup>a</sup>	61.78 $\pm$ 2.54 <sup>a</sup>	38.83 $\pm$ 2.70 <sup>b</sup>	108.95 $\pm$ 16.20 <sup>c</sup>
18:3n-6	1.46 $\pm$ 0.18 <sup>a</sup>	1.45 $\pm$ 0.15 <sup>a</sup>	1.17 $\pm$ 0.09 <sup>ab</sup>	0.92 $\pm$ 0.11 <sup>b</sup>	2.59 $\pm$ 0.38 <sup>c</sup>
20:2n-6	4.61 $\pm$ 0.43 <sup>a</sup>	4.06 $\pm$ 0.30 <sup>ab</sup>	3.85 $\pm$ 0.21 <sup>b</sup>	2.79 $\pm$ 0.15 <sup>c</sup>	9.08 $\pm$ 1.12 <sup>d</sup>
20:3n-6	5.23 $\pm$ 0.63 <sup>a</sup>	4.61 $\pm$ 0.18 <sup>ab</sup>	3.91 $\pm$ 0.43 <sup>b</sup>	3.09 $\pm$ 0.22 <sup>c</sup>	9.10 $\pm$ 1.42 <sup>d</sup>
20:4n-6	11.14 $\pm$ 1.65 <sup>a</sup>	9.65 $\pm$ 0.85 <sup>a</sup>	8.96 $\pm$ 1.12 <sup>a</sup>	9.59 $\pm$ 0.70 <sup>a</sup>	19.23 $\pm$ 3.19 <sup>b</sup>
22:4n-6	3.40 $\pm$ 0.38 <sup>b</sup>	2.78 $\pm$ 0.24 <sup>ab</sup>	2.31 $\pm$ 0.29 <sup>b</sup>	2.63 $\pm$ 0.30 <sup>a</sup>	6.80 $\pm$ 0.78 <sup>d</sup>
22:5n-6	5.95 $\pm$ 0.90 <sup>b</sup>	4.85 $\pm$ 0.43 <sup>ab</sup>	4.18 $\pm$ 0.84 <sup>a</sup>	4.18 $\pm$ 0.37 <sup>a</sup>	15.56 $\pm$ 2.39 <sup>c</sup>
Total n-6 PUFA	91.46 $\pm$ 9.22 <sup>a</sup>	86.24 $\pm$ 6.72 <sup>a</sup>	86.17 $\pm$ 4.26 <sup>a</sup>	62.04 $\pm$ 4.04 <sup>b</sup>	171.30 $\pm$ 21.92 <sup>c</sup>
18:3n-3	25.25 $\pm$ 3.68 <sup>a</sup>	36.98 $\pm$ 5.73 <sup>b</sup>	54.57 $\pm$ 5.89 <sup>c</sup>	5.96 $\pm$ 1.16 <sup>d</sup>	4.85 $\pm$ 1.12 <sup>d</sup>
18:4n-3	0.63 $\pm$ 0.07 <sup>a</sup>	0.85 $\pm$ 0.24 <sup>a</sup>	0.89 $\pm$ 0.18 <sup>a</sup>	0.81 $\pm$ 0.14 <sup>a</sup>	0.08 $\pm$ 0.11 <sup>b</sup>
20:3n-3	5.47 $\pm$ 0.85 <sup>a</sup>	7.47 $\pm$ 0.86 <sup>b</sup>	11.14 $\pm$ 0.63 <sup>c</sup>	1.06 $\pm$ 0.21 <sup>d</sup>	1.31 $\pm$ 0.23 <sup>d</sup>
20:4n-3	1.40 $\pm$ 0.18 <sup>a</sup>	1.82 $\pm$ 0.18 <sup>b</sup>	2.26 $\pm$ 0.18 <sup>b</sup>	1.73 $\pm$ 0.17 <sup>ab</sup>	0.23 $\pm$ 0.15 <sup>d</sup>
20:5n-3	2.76 $\pm$ 0.39 <sup>b</sup>	3.18 $\pm$ 0.39 <sup>ab</sup>	4.00 $\pm$ 0.41 <sup>b</sup>	8.47 $\pm$ 0.53 <sup>c</sup>	1.09 $\pm$ 0.26 <sup>d</sup>
22:4n-3	0.54 $\pm$ 0.16 <sup>a</sup>	0.68 $\pm$ 0.15 <sup>ab</sup>	0.90 $\pm$ 0.13 <sup>b</sup>	0.11 $\pm$ 0.13 <sup>c</sup>	n.d.
22:5n-3	7.42 $\pm$ 0.76 <sup>b</sup>	8.24 $\pm$ 0.81 <sup>a</sup>	8.98 $\pm$ 0.76 <sup>a</sup>	20.37 $\pm$ 1.93 <sup>b</sup>	4.53 $\pm$ 1.05 <sup>c</sup>
22:6n-3	40.95 $\pm$ 5.51 <sup>ab</sup>	42.05 $\pm$ 2.96 <sup>b</sup>	44.99 $\pm$ 6.48 <sup>b</sup>	86.98 $\pm$ 8.74 <sup>c</sup>	29.23 $\pm$ 4.43 <sup>b</sup>
Total n-3 PUFA	84.42 $\pm$ 9.93 <sup>b</sup>	101.28 $\pm$ 10.53 <sup>b</sup>	127.72 $\pm$ 7.26 <sup>c</sup>	125.49 $\pm$ 10.08 <sup>c</sup>	41.31 $\pm$ 6.04 <sup>a</sup>
Total PUFA	175.89 $\pm$ 18.95 <sup>a</sup>	187.51 $\pm$ 17.03 <sup>ab</sup>	213.89 $\pm$ 10.64 <sup>b</sup>	187.53 $\pm$ 13.29 <sup>b</sup>	212.61 $\pm$ 22.60 <sup>b</sup>
n-3 / n-6 PUFA	0.92 $\pm$ 0.03 <sup>a</sup>	1.17 $\pm$ 0.05 <sup>b</sup>	1.49 $\pm$ 0.07 <sup>c</sup>	2.02 $\pm$ 0.12 <sup>d</sup>	0.25 $\pm$ 0.05 <sup>e</sup>
Total saturated	180.04 $\pm$ 18.00	178.19 $\pm$ 16.05	167.17 $\pm$ 14.51	189.23 $\pm$ 9.42	175.11 $\pm$ 24.21
Total monoenes	156.28 $\pm$ 25.96	149.28 $\pm$ 22.87	123.33 $\pm$ 16.21	143.85 $\pm$ 9.72	138.23 $\pm$ 27.86
Total DMA	14.18 $\pm$ 2.41	13.65 $\pm$ 1.56	14.49 $\pm$ 0.73	13.06 $\pm$ 0.85	13.27 $\pm$ 2.02
Total FA	526.39 $\pm$ 51.96	528.64 $\pm$ 55.68	518.88 $\pm$ 37.60	533.67 $\pm$ 27.07	539.22 $\pm$ 67.42

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