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The effects of combined use of soybean extract and mixture of several plant oils on the growth parameters and whole body and tissue amino acids and fatty acids compositions in juvenile Nile tilapia (*Oreochromis niloticus* Linnaeus, 1758)

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Introduction

The uncertainty in fishmeal and oil production necessitates the finding of cheaper and more available plant or animal by-product meals and oils for the sustainable production of fish and crustaceans under captivity. Several studies reported that soybean extract could replace minimum 50% of dietary fish meal protein without compromising the growth rates and nutrient utilization in different tilapia species including Nile tilapia [1,2]. Plant oils like sunflower, cotton and linseed and palm oils have also been tested in diets for tilapia spp. and these studies concluded that tilapia needed linoleic and arachidonic acid for optimal growth and had the capacity of biosynthesis of LC PUFA from 18 C PUFA's [6,7]. Hardly nothing is known about the effects of combined fishmeal and oil replacement on growth and amino acid and fatty acid utilization and metabolism in Nile tilapia. Therefore, the aim of this study was to investigate the effects of combined replacement of dietary fishmeal and added fish oil levels by soybean extract and mixtures of soy, canola and linseed oils on growth nutrient utilization and whole body and tissue amino acids and fatty acid compositions in Nile tilapia.

Materials and methods

Diets in which 50% of the fish meal crude protein was replaced by soybean extract along with 60 (60SCL), 80 (80SCL) and 100 (100SCL) % of dietary added fish oil replacement by mixture of soy, canola and linseed oils (1:1:1) were used in the study. Four iso-nitrogenous and iso-energetic diets were fed to juvenile Nile tilapia (16.2 g AIW) in triplicate (25 fish/tank) twice in equal portions at a fixed rate of 4% BW d^{-1} for 90 days. The rearing system used in the experiment was designed as semi-recirculating culture system containing rectangular fiberglass tanks. Nine fish per dietary treatment were sacrificed for the whole body and tissue (muscle and liver) nutrient, amino acid and fatty acid composition analysis. Standard methods of chemical analysis were used for the nutrient composition analysis [3]. Total amino acids were analyzed by Ultra Fast Liquid Chromatography (UFLC) using acetonitrile: methanol: trimethylamine mixture as internal standard. Fatty Acid Methyl Esters (FAME) were prepared and analyzed according to standard methods described in the literature [4,5].

Results and Discussion

No statistical difference found among dietary treatments in terms of measured growth parameters (Table 1). Diets supplemented with soybean extract and increasing amount of plant oil mixture proportionally increased the crude protein and significantly decreased the crude ash levels in fish whole body samples compared to that of fish fed fish meal and oil control diet. The crude lipid contents, however, were significantly lower in fish fed diets 60SCL, 80SCL and 100SCL compared to that of fish fed FO diet (Table 2) indicating effective β oxidation and metabolism of the predominant fatty acids in these plant oils [7].

Table 1. Growth parameters of juvenile Nile tilapia fed experimental diets following a 90 day feeding period

Growth Par.	FO	60SCL	80SCL	100SCL
IWW (g)	16.4±0.8	16.4±0.3	16.5±0.9	15.7±0.6
FWW (g)	34.3±1.2	33.8±2.7	31.4±1.7	32.5±1.5
SGR (% BW d^{-1})	0.7±0.0	0.7±0.1	0.6±0.0	0.7±0.1
FER	0.3±0.0	0.3±0.0	0.2±0.0	0.3±0.0
PER (%)	89.5±3.5	84.7±11.7	78.6±4.4	87.4±9.1
HSI	1.8±0.3	1.7±0.2	2.2±0.2	2.1±0.3
Survival R. (%)	100	100	100	100

Values are mean±SD, n=3.

Fish fed diets supplemented with soybean extract and increasing amount of plant oil mixture tended to

increase the tissue essential and non-essential amino acid levels indicating that L-lysine and DL-methionine used in diets were effectively used for growth in juvenile Nile tilapia [8] (Table 3).

Table 2. Muscle tissue nutrient composition (% DM basis) of juvenile Nile tilapia fed experimental diets following a 90 day feeding period

Nutrients	FO	60SCL	80SCL	100SCL
Crude Protein	82.6±0.3	83.4±1.0	83.8±1.6	84.3±0.4
Crude Lipid	7.2±0.0^{b}	5.1±0.0^{a}	4.9±0.0^{a}	5.7±0.0^{a}
Crude Ash	8.5±0.0	7.6±0.0	7.5±0.0	8.1±0.0

Values are mean±SD, n=3, different superscripts in the same row denotes significant difference among dietary treatments ANOVA, P<0.05.

Table 3. Muscle tissue amino acid composition of juvenile Nile tilapia fed experimental diets following a 90 day feeding period (g/kg DM basis)

Essent. A. Acids	Init.	FO	60SCL	80SCL	100SCL
L-Methionine (Met)	13.7	14.5	15.4	18.4	15.9
L-Phenylalanine(Phe)	20.6	21.5	23.8	26.7	23
L-Lysine (Lys)	89.3	96.9	107.6	73.8	100.2
L-Histidine (His)	19.6	20.3	21.9	23.8	22.1
L-Valine (Val)	25.6	30.7	32.6	34.9	33.3
L-Leucine (Leu)	40.2	44.6	47.9	53.1	47.8
L-Isoleucine (Ile)	30.7	34.1	35.4	40.1	65.2
L-Threonine (Thr)	45.8	44.6	45.2	55.7	46.3
L-Arginine (Arg)	47	50.2	48.8	31.8	52.2
Non-Essent A. acids					
L-Alanine (Ala)	24.9	30.6	28.3	33.4	26
L-Asp. acid (Asp)	179	182	194.6	190	206.8
Glysine (Gly)	21.9	28.2	29.8	33.4	29.6
L-Glu. acid (Glu)	117.9	135.5	135.1	139.5	140.1
L-Proline (Pro)	22.1	22.7	26.7	28.3	28.9
L-Serine (Ser)	28.2	29.1	30.8	34.7	29.9
L-Tyrosine (Tyr)	16.4	17.7	18.2	23.1	19.9

Values are mean±SD, n=1.

Whole body and tissue fatty acid compositions demonstrated that DHA was probably deposited whereas EPA was used for energy production in fish fed diets supplemented with soybean extract and increasing amount of plant oil mixture. Significantly higher intermediate metabolites of the n-6 LC HUFA biosynthesis in whole body and tissue samples compared to that of fish fed the control diet also implicated that Nile tilapia might have activated the Δ5 and Δ6 elongation and desaturation enzymes [9] (Table 4).

Conclusions

It was concluded that the partial replacement of dietary fish meal and 100 % replacement of dietary added fish oil by soy bean extract and plant oil mixture did not compromise growth rates, drastically change whole body and tissue amino acid and fatty acid compositions and muscle tissue n-3/n-6 ratios in Nile tilapia. Further research targeting higher combined fishmeal and total fish oil replacement by soybean extract and these plant oils with special consideration to fatty acid metabolism, organ histology and immune response would be highly useful in this species

Table 4. Muscle tissue fatty acid composition of juvenile Nile tilapia fed experimental diets following a 90 day feeding period (% of total fatty acids)

Fatty acids	Init.	FO	60SCL	80SCL	100SCL
ΣSFA	33.7±0.7	35.8±1.0^{b}	34.7±0.7^{b}	33.9±0.5^{ab}	31.7±0.7^{a}
ΣMonoenes	35.4±0.1	30.0±1.3	28.5±1.6	28.5±0.6	28.8±0.8
Σn-9	31.8±0.2	26.9±0.5	26.6±0.4	26.4±0.2	26.8±0.4
18:1n9	28.0±0.3	22.1±1.1	22.5±0.7	22.4±0.6	23.0±0.8
Σn-6	13.8±0.6	12.0±0.2	15.7±0.8	17.3±0.5	18.9±0.0
18:2n6	11.9±0.5	9.9±0.2^{a}	13.5±0.5^{b}	15.3±0.5^{c}	17.0±0.1^{d}
20:4n6	0.3±0.0	0.3±0.0	0.3±0.0	0.3±0.0	0.2±0.1
Σn-3	13.8±0.5	17.2±1.1	18.0±1.7	16.6±0.5	16.9±1.2
18:3n3	2.1±0.1	1.4±0.1^{a}	1.7±0.1^{b}	2.2±0.1^{c}	2.6±0.0^{d}
Σn-3 HUFA	11.7±0.2	15.8±0.5^{b}	15.5±0.3^{b}	14.4±0.2^{a}	14.3±0.6^{a}
20:5n3	1.5±0.1	2.6±0.2^{b}	2.2±0.2^{ab}	2.1±0.1^{a}	2.1±0.1^{a}
22:6n3	9.4±0.4	12.5±0.9	12.6±0.9	11.5±0.5	11.4±1.1
n-3/n-6	1.0±0.0	1.4±0.1^{c}	1.2±0.2^{bc}	1.0±0.1^{ab}	0.9±0.1^{a}

Values are mean±SD, n=3, different superscripts in the same row denotes significant difference among dietary treatments one-way ANOVA P<0.05.

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