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Alternative lipids spare fish oil in rainbow trout feeds

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1 March 2011 Jesse Trushenski Patrick Blaufuss Bonnie Mulligan Jérôme Laporte

Soybean, coconut, palm or modified canola oils don’t impair growth but alter fatty acid profiles

After seven weeks, rainbow trout growth performance was not impaired by partial replacement of dietary fish oil with any of the alternative lipids evaluated.

Although many consider fish oil a standard for aquafeed formulation, acceptable growth performance can be achieved with a wide range of alternative lipids, so long as essential fatty acid requirements are met. However, plant and terrestrial animal-derived fats and oils contain, at most, trace levels of beneficial long-chain polyunsaturated fatty acids (LC-PUFAs).

Over time, feeding alternative lipid-based grow-out feeds typically results in the loss of these bioactive nutrients, including eicosapentaenoic (20:5n-3) and docosahexaenoic (22:6n-3) acids. Although switching back to a fish oil-based finishing feed will restore tissue levels of LC-PUFAs, the extent of fillet profile restoration varies.

Previous research by the authors showed that grow-out feeds containing higher levels of saturated fatty acids (SFAs) with no double bonds yielded fillets with greater LC-PUFA content or greater amenability to LC-PUFA restoration during finishing.

Alternative lipids

Selective breeding, transgenic modifications and processing strategies developed in the agribusiness sector have yielded a range of crops and products with altered fatty acid composition. A number of modified lipids have become commercially available, but few have been evaluated in the context of aquaculture nutrition.

Accordingly, the authors evaluated practical rainbow trout feeds (Table 1) containing fish oil (FISH) or 50:50 blends of fish oil and palm (PALM), coconut (COCONUT), standard soybean (STD-SBO), hydrogenated soybean (HYD-SBO), low 18:3n-3 soybean (LO-ALA-SBO) or low 18:3n-3 canola (LO-ALA-CAN) oils. Feeds with SFA-enriched lipid streams derived from cottonseed (SFA-COT) or soybean (SFA-SBO) processing were also studied.

Trushenski, Experimental feed formulation, Table 1

Ingredient	FISH	COCONUT	PALM	STD-SBO	HYD-SBO	LOW-ALA-SBO	LOW-ALA-CAN	SFA-SBO	SFA-COT
Fishmeal	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
Soybean meal (47% protein)	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
Blood meal	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Wheat bran	150.8	150.8	150.8	150.8	150.8	150.8	150.8	150.8	150.8
Corn gluten meal	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Fish oil	91.0	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5
Alternative lipid source	0	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5
Sodium phosphate	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Dicalcium phosphate	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Vitamin premix*	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Mineral premix**	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Choline chloride	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Carboxymethylcellulose	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Proximate Composition									
Dry matter	882 ± 2	869 ± 2	865 ± 2	877 ± 2	881 ± 2	853 ± 2	887 ± 2	869 ± 2	865 ± 2
Protein	477 ± 3	483 ± 3	476 ± 3	473 ± 3	478 ± 3	477 ± 3	484 ± 3	482 ± 3	484 ± 3
Lipid	145 ± 6	139 ± 6	135 ± 6	139 ± 6	144 ± 6	161 ± 6	126 ± 6	145 ± 6	146 ± 6
Ash	125 ± 5	84 ± 4	115 ± 4	114 ± 6	101 ± 4	101 ± 4	110 ± 4	105 ± 4	119 ± 4

* Formulated to contain 25.00% L-ascorbyl-2-polyphosphate, 13.16% vitamin K, 12.50% inositol, 12.50% nicotinic acid, 7.50% riboflavin, 6.25% calcium pantothenate, 2.50% pyridoxine hydrochloride, 1.25% thiamine mononitrate, 1.00% vitamin A palmitate, 0.50% cyanocobalamin, 0.45% folic acid, 0.12% biotin and 0.01% cholecalciferol in a cellulose base.
** Formulated to contain 24.90% zinc oxide, 14.93% ferrous sulfate, 3.47% manganese oxide, 0.97% cupric carbonate, 0.26% potassium iodide, 0.06% sodium selenate and 0.03% cobalt carbonate in a cellulose base.

Table 1. Experimental feed formulation and proximate composition (g/kg, dry-matter basis).

Fish oil sparing

After seven weeks, rainbow trout growth performance was not impaired by partial replacement of dietary fish oil with any of the alternative lipids evaluated (Table 2). Although significant differences in feed-conversion ratios were observed, only the LOW-ALA-CAN treatment group differed from the FISH control group, and this group actually exhibited improved efficiency relative to the control.

Trushenski, Survival and growth performance, Table 2

Parameter	FISH	COCONUT	PALM	STD-SBO	HYD-SBO	LOW-ALA-SBO	LOW-ALA-CAN	SFA-SBO	SFA-COT
Survival (%)	90.0 ± 4.3	92.5 ± 4.3	97.5 ± 4.3	92.5 ± 4.3	87.5 ± 4.3	92.5 ± 4.3	87.5 ± 4.3	87.5 ± 4.3	92.5 ± 4.3
Initial weight (g)	18.8 ± 1.1	18.8 ± 1.1	18.5 ± 1.1	18.3 ± 1.1	20.4 ± 1.1	20.6 ± 1.1	21.6 ± 1.1	20.2 ± 1.1	21.0 ± 1.1
Final weight (g)	53.2 ± 4.6	62.5 ± 4.6	58.9 ± 4.6	57.4 ± 4.6	59.0 ± 4.6	65.8 ± 4.6	69.2 ± 4.6	580±4.X6	58.5 ± 4.6
Weight gain (%)	182 ± 16	234 ± 16	218 ± 16	214 ± 16	188 ± 16	218 ± 16	221 ± 16	187 ± 16	178 ± 16
Growth rate (%/day)	2.0 ± 0.1	2.3 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	2.0 ± 0.1	2.2 ± 0.1	2.2 ± 0.1	2.0 ± 0.1	1.9 ± 0.1
Total consumption (g/fish, dry matter)	39.2 ± 3.6	41.7 ± 3.6	40.6 ± 3.6	36.5 ± 3.6	35.7 ± 3.6	41.2 ± 3.6	41.0 ± 3.6	38.7 ± 3.6	44.0 ± 3.6
Feed intake (% body weight/day)	2.4 ± 0.1	2.3 ± 0.1	2.4 ± 0.1	2.2 ± 0.1	2.0 ± 0.1	2.1 ± 0.1	2.0 ± 0.1	2.2 ± 0.1	2.4 ± 0.1
Feed-conversion ratio	1.1 ± 0^{xy}	1.0 ± 0^{xyz}	1.0 ± 0^{xyz}	0.9 ± 0^{yz}	0.9 ± 0^{yz}	0.9 ± 0^{yz}	0.9 ± 0^{z}	1.0 ± 0^{xyz}	1.2 ± 0^{x}
Hepatosomatic index	2.2 ± 0.2	2.4 ± 0.2	2.4 ± 0.2	2.3 ± 0.2	1.8 ± 0.2	1.9 ± 0.2	2.1 ± 0.2	2.0 ± 0.2	2.4 ± 0.2

Table 2. Survival and growth performance by dietary treatment.

Survival, weight gain, specific growth rate, feed intake and hepatosomatic index did not vary among treatments. Although fillet lipid content was equivalent among treatments, fatty acids that were abundant in the different feeds tended to become enriched in the fillets of fish fed those feeds. For example, 18:1n-9 levels were highest among fish fed the PALM and LOW-ALA-CAN diets, and 18:2n-6 levels were significantly elevated in fish fed the STD-SBO and LOW-ALA-SBO diets.

Despite very high dietary levels of SFAs in the COCONUT, SFA-SBO and SFA-COT feeds, the SFAs were not proportionately reflected within the fillets. The varying response of fillet tissues to dietary intake of certain fatty acids and fatty acid groupings resulted in fillet signatures that deviated to varied extents from the profile observed in the FISH control group.

In terms of overall profile similarity, fillets from the SFA-SBO and SFA-COT groups were most similar to those from the FISH group. Signatures were increasingly distorted in the COCONUT, PALM, HYD-SBO, STD-SBO, LOW-ALA-SBO and LOW-ALA-CAN groups, respectively, reflecting a relative loss of LC-PUFAs, an accumulation of monounsaturated fatty acids (MUFAs), medium-chain polyunsaturated fatty acids (MC-PUFAs), or both.

Replacement practical

From a practical perspective, the authors concluded that feeding rainbow trout feeds containing a blend of fish oil and modified soy- or cottonseed-derived lipids yielded equivalent growth performance and fillet LC-PUFA content. Although feeding standard soybean, coconut, palm or modified canola oils did not impair growth or efficiency values, use of these lipids significantly altered fillet fatty acid profiles. Depending on the desired fillet composition, one or more of these lipids could be used to manipulate fillet LC-PUFA content, MUFA content or levels of other fatty acids.

Rainbow trout were found to be somewhat different from other fish in terms of their response to varying dietary fatty acid composition. However, a pattern of greater LC-PUFA retention/deposition among fish fed SFA-rich feeds compared to MC-PUFA-rich feeds appeared to be largely consistent among those fish assessed.

The authors recommend that SFA-rich feed formulations be tested further in rainbow trout culture, preferably in the context of longer-term studies including finishing trials to validate the promising results achieved in the present work.

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