FEED SUSTAINABILITY (/ADVOCATE/CATEGORY/FEED-SUSTAINABILITY)

Saturated fatty acids limit effects of fish oil replacement in cobia diets

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Alternative lipid sources should be amended with DHA

Cobia fingerlings received diets with varied soy-based ingredient replacements for fish oil.

Alternative, non-fish oil lipid sources contain few or no long-chain polyunsaturated fatty acids (LC-PUFAs). Growth performance may therefore be impaired in some fish fed diets with reduced or no fish oil.

The authors' research with cobia indicated that juvenile fish fed alternative lipid sources amended with docosahexaenoic acid (22:6n-3) generally exhibited growth equivalent to those fed fish oil, regardless of dietary phospholipid supplementation. However, alternative lipids high in saturated fatty acids, such as fully hydrogenated soybean oil, yielded superior LC-PUFA retention compared to those rich in C18 polyunsaturated fatty acids.

Fatty acid requirements

The fast growth, high market value and robustness of cobia, Rachycentron canadum, have led to interest in further development and expansion of commercial cobia aquaculture. However, as marine carnivores, cobia demand high levels of dietary lipids and require certain long-chain polyunsaturated fatty acids for proper growth and health. Fish oil is a palatable, digestible source of LC-PUFAs, although concerns regarding future availability and pricing incentivize using fish oil more judiciously in aquafeeds.

Terrestrial plant-derived lipids such as soybean oil are attractive as substitutes for fish oil because of their wider availability and lower cost. However, if these lipids replace a large percentage of dietary fish oil, LC-PUFA deficiencies can develop, as plant-origin lipids do not contain these critical nutrients.

Research on fish oil sparing in other aquaculture species suggests that alternative lipids high in saturated fatty acids (SFAs) or monounsaturated fatty acids have a beneficial effect on the efficiency of LC-PUFA utilization and may effectively reduce LC-PUFA "requirements." Furthermore, phospholipids, which are critical to the development and ontogeny of juvenile fish – especially fast-growing species such as cobia – may also exert some influence over the success of fish oil sparing.

The authors' objective was to assess the growth performance and tissue fatty acid composition of juvenile cobia fed diets containing fish oil or 22:6n-3-amended soybean oils containing different levels of SFAs versus C18 PUFAs with or without supplemental phospholipid (P.L.) (Table 1).

Woitel, Dietary formulation (g/kg) and proximate composition, Table 1

Ingredient	FISH ONLY	STD SOY	STD SOY + P.L.	HYD SOY	HYD SOY + P.L.	FULL HYD SOY	Full HYD Soy + P.L.
Wheat bran	302.3	289.0	289.0	289.0	289.0	289.0	289.0
Menhaden fishmeal	245.5	245.6	245.6	245.6	245.6	245.6	245.6
Corn gluten meal	150.1	150.1	150.1	150.1	150.1	150.1	150.1
Soybean protein concentrate	137.0	137.2	137.2	137.2	137.2	137.2	137.2
Soybean protein isolate	79.2	79.2	79.2	79.2	79.2	79.2	79.2
Menhaden fish oil	53.1	0	0	0	0	0	0
Soybean-derived lipid	0	44.5	24.5	44.5	24.5	44.5	24.5
Carboxymethyl cellulose	20.2	20.2	20.2	20.2	20.2	20.2	20.2
Choline chloride	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Methionine chloride	3.3	3.3	3.3	3.3	3.3	3.3	3.3

Stabilized vitamin C	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Vitamin premix	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Mineral premix	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Soybean lecithin	0	0	20.0	0	20.0	0	20.0
Algal meal	0	21.6	21.6	21.6	21.6	21.6	21.6
Proximate Composition							
Dry matter	944	951	950	959	959	945	960
Protein	486 ± 2	486 ± 3	487 ± 6	491 ± 5	485 ± 7	487 ± 4	489 ± 5
Lipid	94 ± 1	100 ± 1	94 ± 1	100 ± 7	102 ± 3	98 ± 5	102 ± 2
Ash	87 ± 4	98 ± 6	82 ± 4	80 ± 5	95 ± 7	78 ± 6	83 ± 2

STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids
HYD SOY = Partially hydrogenated soybean oil, HYD SOY + P.L. = Partially hydrogenated soybean oil plus phospholipids
FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

Table 1. Dietary formulation (g/kg) and proximate composition (g/kg) of test diets.

SFA-rich lipids minimize fatty acid profile changes

After eight weeks of feeding, statistically significant differences were observed among treatments for feed conversion, weight gain and feed intake, although the magnitude of these differences was relatively small in most cases (Table 2). Only the HYD SOY + P.L. treatment group exhibited significantly reduced growth in comparison to the FISH ONLY control group.

Woitel, Mean production performance by dietary treatment, Table 2

Parameter	FISH ONLY	STD SOY	STD SOY + P.L.	HYD SOY	HYD SOY + P.L.	FULL HYD SOY	FULL HYD SOY + P.L.	P Value
Survival (%)	97 ± 3	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	0.463
Initial weight (g)	55 ± 1	55 ± 0	55 ± 0	56 ± 0	56 ± 1	54 ± 1	55 ± 1	0.379
Final weight (g)	172 ± 9	177 ± 4	189 ± 9	169 ± 2	160 ± 3	176 ± 7	167 ± 1	0.078

Weight gain (%)	211 ± 17^{z}	220 ± 8^{yz}	241 ± 16^{z}	201 ± 7^{yz}	185 ± 4y	224 ± 8^{yz}	206 ± 3^{yz}	0.039
Feed-conversion ratio	1.40 ± 0.05	1.42 ± 0.03	1.45 ± 0.02	1.45 ± 0.01	1.51 ± 0.01	1.55 ± 0.05	1.53 ± 0.01	0.036*
Specific growth rate (% body weight/day)	2.02 ± 0.10^{yz}	2.08 ± 0.04^{yz}	2.19 ± 0.08^{z}	1.97 ± 0.04^{yz}	1.87 ± 0.03^{y}	2.10 ± 0.04^{yz}	2.00 ± 0.01^{yz}	0.034
Feed intake (% body weight/day)	2.98 ± 0.07^{x}	3.12 ± 0.02^{xy}	3.37 ± 0.10^{yz}	3.00 ± 0.10^{x}	2.94 ± 0.03^{x}	3.44 ± 0.04^{z}	3.21 ± 0.04^{xyz}	< 0.001

STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids
HYD SOY = Partially hydrogenated soybean oil, HYD SOY + P.L. = Partially hydrogenated soybean oil plus phospholipids
FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

* Although the one-way ANOVA indicated significant treatment effects, more conservative Tukey's HSD pairwise comparison tests indicated no significant differences among means.

Table 2. Mean production performance by dietary treatment. Means with common letter labels are not significantly different (P > 0.05).

Feed intake was significantly increased relative to the FISH ONLY control only among fish fed the STD SOY + P.L. and FULL HYD SOY feeds. Dietary protein content and feed intake were both lowest in the HYD SOY + P.L. group, which may explain the impaired growth performance of this group, rather than P.L. supplementation or the lipid source used. Otherwise, neither P.L. supplementation nor alternative lipid source appeared to have any effect on growth performance.

The fatty acid profiles of fish tissues tended to reflect the fatty acid profiles of the dietary lipid sources.

Tissue fatty acid profiles tended to reflect the fatty acid profile of the dietary lipid source, but fillet profile distortion varied among the dietary treatment groups (Fig. 1). Fillet LC-PUFA retention was best in the dietary treatments that contained the greatest amounts of SFAs and low amounts of C18 PUFAs – the fully hydrogenated soy treatments. This may be due to the selective catabolism of SFAs over LC-PUFAs for energy when they are provided in dietary surplus and also the tendency of C18 PUFAs to “compete” with LC-PUFAs for deposition in tissues.

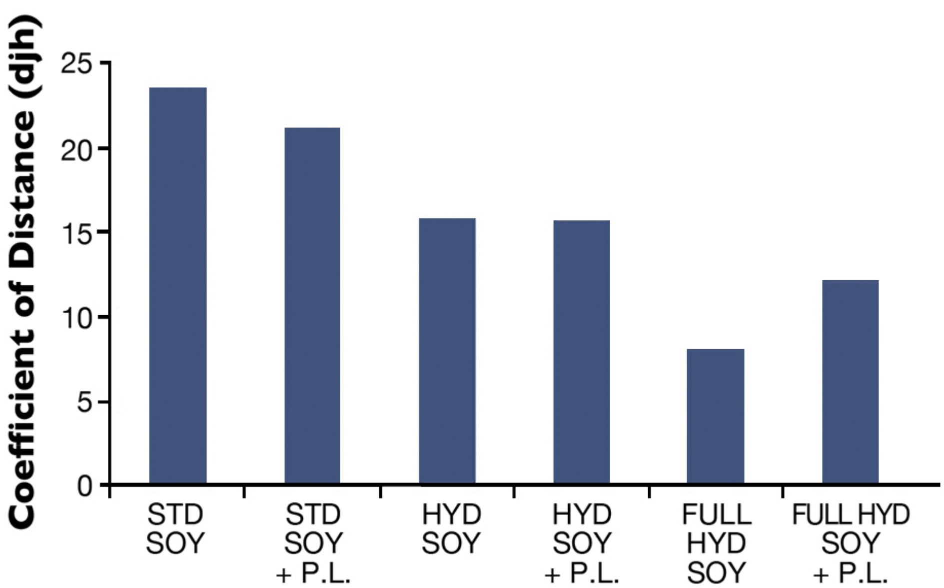

Fig. 1: Fillet coefficient of distance values by dietary treatment. Values compare overall fatty acid profiles between the experimental treatments and the FISH ONLY positive control treatment, with smaller values

indicating greater profile similarity between the experimental treatment and the control.
STD SOY = Standard soybean oil, STD SOY + P.L. = Standard soybean oil plus phospholipids HYD SOY = Partially hydrogenated soybean oil, HYD SOY + P.L. = Partially hydrogenated soybean oil plus phospholipids FULL HYD SOY = Fully hydrogenated soybean oil, FULL HYD SOY + P.L. = Fully hydrogenated soybean oil plus phospholipids

Perspectives

These results suggested that high-SFA, low-C18 PUFA lipid sources can replace a large percentage of fish oil in feeds for juvenile cobia if they are amended with 22:6n-3, yielding acceptable growth performance and maximizing the nutritional value of the final product for the consumer.

Editor's Note: This article was based on "Saturated Fatty Acids Limit the Effects of Replacing Fish Oil With Soybean Oil With or Without Phospholipid Supplementation in Feeds for Juvenile Cobia," a paper recently published by the authors in the North American Journal of Aquaculture*.*

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