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Aquafeeds

Gauging fatty acid composition in hybrid striped bass

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Saturated and unsaturated fatty acids in aquafeeds have major influence on LC-PUFA content

In commercial aquaculture feeds, fish oil is used as a high-quality source of energy and long-chain polyunsaturated fatty acids (LC-PUFAs), but it is increasingly costly and supplies are limited. Oils and fats of terrestrial origin are typically used to improve the cost of aquafeed formulations, to spare or replace fish oil inclusion in aquafeeds. Aquafeeds with reduced content, or free of fish oil are generally well accepted and yield good growth performance as long as essential fatty acid requirements are met. However, these dietary manipulations cause the resulting fish fillets to have lower levels of beneficial LC-PUFAs.

With respect to fatty acid profiles, fish are largely what they eat. However, it is becoming increasingly clear that some lipids, particularly those rich in saturated fatty acids (SFAs) and monounsaturated fatty acids (MUFAs), do not affect fillet composition as much as lipids rich in C_{18} polyunsaturated fatty acids (C_{18} PUFAs). So called “omega 3 sparing effects” are typically associated with SFAs, but SFA-rich lipids may not be well digested by all aquacultured animals or under all circumstances. Consequently, lipids with high levels of monounsaturated fatty acids (MUFAs) may be a compromise between the digestibility of C_{18} PUFA-rich lipids and the “fatty acid profile conserving” attributes of SFA-rich lipids.

Soybean oil is a widely available lipid that typically contains high levels of C_{18} PUFAs.

The hybrid striped bass is an important aquaculture, food fish and game fish. USDA photo by Peggy Greb.

To increase its shelf stability or modify its physical characteristics, soybean oil is commonly hydrogenated, partially or fully, to reduce its levels of C_{18} PUFA. This hydrogenation process increases MUFA and SFA content, and the hydrogenated soybean oils have potential as tissue profile-conserving alternatives to fish oil in aquafeeds. Despite the advantages, hydrogenation has fallen out of favor as health professionals and the public have become aware of the hazards of trans fats generated by the hydrogenation process. To satisfy demand for MUFA-rich lipids, the ag-tech sector have developed lines of genetically modified soybeans that contain high levels of MUFAs and do not require additional processing to adjust the composition of the produced oil. Although feedstuffs derived from genetically modified crops are commonplace, non-hydrogenated MUFA-rich soybean oil had not been evaluated in aquafeeds.

Our study assessed the growth performance and fillet fatty acid composition of Hybrid Striped Bass (HSB; White Bass Morone chrysops × Striped Bass M. saxatilis) fed various experimental diets with graded levels of fish oil, C18 PUFA-rich soybean oil, non-hydrogenated MUFA-rich soybean oil, or blends of these lipids. We also assessed fish fed an equivalent diet containing SFA-rich, fully hydrogenated soybean oil for comparison. Here we summarize the results of an article published in 2015 in the North American Journal of Aquaculture (http://dx.doi.org/10.1080/15222055.2014.963769 (http://dx.doi.org/10.1080/15222055.2014.963769)) based on work conducted when the authors were affiliated with the Center for Fisheries, Aquaculture and Aquatic Sciences at Southern Illinois University in Carbondale, Ill.

Some of the fish used in the study (left), and gas chromatography equipment used to determine fatty acid composition of HSB fillets (right).

Study setup and methods

The experimental diets were prepared based on a previously validated HSB feed formulation containing 9.8 percent menhaden fish oil, which was also used as the control diet in this study.

The experimental diets contained 75:25, 50:50, 25:75, or 0:100 blends of fish oil and standard C18 PUFA-rich soybean oil (25 PUFA SOY, 50 PUFA SOY, 75 PUFA SOY, 100 PUFA SOY) or nonhydrogenated MUFA-rich soybean oil (25 MUFA SOY, 50 MUFA SOY, 75 MUFA SOY, 100 MUFA SOY).

An additional experimental diet contained fully hydrogenated, SFA-rich soybean oil (100 SFA SOY). Feed ingredients were blended using a commercial cutter–mixer, pelleted using a food grinder, dried using a commercial food dehydrator, and then stored frozen (−20◦C) for the duration of the study. Feeds were analyzed in triplicate to confirm proximate and fatty acid composition.

A recirculation aquaculture system (RAS) was used in the feeding study. It included 30, 270L circular tanks with mechanical (sand filter) and biological filtration (trickle-down biofilters). A blower with air stones provided supplemental to each tank. Experimental diet treatments were randomly assigned to triplicate tanks of fish. Each tank was stocked with 10 fish with an initial weight of 29.1 ± 0.2 g [mean ± SE]), and fish were fed once daily to apparent satiation.

Water quality was maintained through the study within ranges suitable for HSB production. Temperature and dissolved oxygen were monitored daily throughout the study using a commercial oxygen meter, and alkalinity, total ammonia nitrogen, nitrite-nitrogen, and nitrate-nitrogen were measured weekly using a commercial spectrophotometer. All fish husbandry practices and sampling procedures were conducted according to the standards of the Southern Illinois University Institutional Animal Care and Use Committee under Animal Care and Use Protocol 12–023.

After eight weeks, all fish were counted and group-weighed by tank, and production performance metrics were calculated. Subsamples of fish were harvested from each tank to determine organosomatic indices and fillet (white muscle) fatty acid composition.

For more detailed procedures on the experimental setup – including laboratory methods, water quality conditions, and statistical analyses – readers are referred to the original publication.

Preparation of fish samples for analysis (left, center), and determination of fish weights (right).

Study results and discussion

Hybrid Striped Bass reportedly can utilize many types of alternative lipids well, and most assessments of fish oil sparing indicate equivalent or near-equivalent growth performance among fish fed a variety of lipid sources. The results of our study agree with these findings, but our FCR was significantly higher among fish fed the 100 SFA SOY feed. Reduced performance has been observed in HSB in association with feeds having reduced or no fish oil, but essential fatty acid deficiencies were implicated as a contributing factor in these cases.

HSB reportedly need 5–10 g of 20:5(n-3) plus 22:6(n-3) per kilogram of diet (0.5–1.0 percent). Considering the information currently available on nutritional requirements and that each of our experimental diets contained at least 5 g of 20:5(n-3) plus 22:6(n-3) per kilogram feed (0.5 percent), it is unlikely that n-3 LC-PUFA deficiency was involved in the higher FCR observed in the 100 SFA SOY treatment group. Instead, it is probable that the 100 SFA SOY feed digestibility was reduced to some degree compared with the other feeds.

Results of our study showed that the fatty acid composition of HSB fillets was strongly influenced by dietary lipid source and fatty acid profile. Generally, fillets of fish fed diets containing more soybean-derived lipids had reduced levels of fish-oil-associated n-3 LC-PUFAs

compared to those fed the 100 FISH control feed. Conversely, fillets of fish fed diets containing C_{18} PUFA-rich soybean oil and non-hydrogenated MUFA-rich soybean oil had higher levels of these fatty acids. Although the 100 SFA SOY diet contained substantially more SFAs than the other diets, these fatty acids were not correspondingly increased in the fillets.

Coefficient of distance (Djh) values distill various differences in fatty acid profiles into a single value representing the magnitude of profile distortion, i.e., a value of zero indicates the profile is identical to the control whereas larger values indicate the profiles are more dissimilar. Djh values were comparable among fish fed corresponding formulations based on C_{18} PUFA-rich soybean oil and non-hydrogenated MUFA-rich soybean oil. But the Djh value for fish fed the 100 SFA SOY diet was substantially lower than that of fish fed the 100 PUFA SOY and 100 MUFA SOY diets (12.0 versus 30.7 and 34.3, respectively).

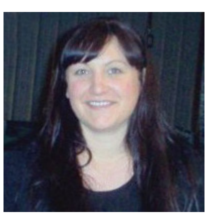
Results of this study suggest that alternative lipid composition influences the degree of tissue fatty acid profile distortion.

Perspectives

Collectively, our results indicate that SFA-rich lipids are the best option for conserving tissue LC-PUFA levels and overall fatty acid profile, however, digestibility of these lipids may be an issue in some contexts. Although our previous research with SFA-rich lipids has not suggested digestibility is a major limiting factor, fish may not utilize SFAs as well as other fatty acids, and consequently growth performance may be inhibited in some taxa by long-term feeding with diets that include predominantly SFAs. Perhaps blending SFA-rich lipids with ingredients containing some level of unsaturated fatty acids or other dietary modification could effectively address digestibility limitations while still mitigating the effects of fish oil sparing on tissue composition. We recommend further research to this effect.

References available from first author.

Authors



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