Fatty Acid Composition of Red Drum Maintained By Fishmeal, Fish Oil Substitutes in Diets

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Marine fish are a nutritious component of the human diet, providing important vitamins, proteins and essential long-chain omega-3 fatty acids such as docosahexaenoic acid (DHA) that are naturally abundant in marine food webs. Increasing consumer demand for these species will likely be met through aquaculture.

Recent concerns related to the potential degradation of ecological food chains, price instability and possible contaminants in aquaculture feeds based on fishmeal and fish oil have generated considerable interest in reducing or removing those fish products from aquaculture diets. However, animals raised on no-fish diets should still provide equivalent levels of the beneficial fatty acids that make seafood especially healthy.

Recent research by the authors evaluated strategies to reduce or eliminate fishmeal and fish oil in diets for red drum, *Sciaenops ocellatus*, by substituting terrestrial proteins and lipids while maintaining equivalent levels of beneficial fatty acids in the final product by incorporating DHA supplements derived from marine algae.

Test Diets

Four growout and four finishing diets were tested (Table 1). Each contained 44% protein, but lipid levels were 10% in the growout diets and 15% in the finishing diets. Poultry meal replaced fishmeal in diets 2, 2F, 3, 3F, 4 and 4F to maintain protein levels and palatability. Soy and flax oils replaced fish oil and were balanced to maintain consistent n6:n3 ratios and lipid levels in diets 3 and 4.

Weight and length measurements of individual fish were collected at the start of the experiment.

Table 1. Growout and finishing diets formulated and tested in study with red drum.

Treatment	Diet Type	Description
1	Growout	Control – 28% fishmeal, 6% fish oil
1F	Finishing	28% fishmeal, 6% fish oil, 5% commercial oil
2	Growout	5% fishmeal, 6% fish oil
2F	Finishing	5% fishmeal, 6% fish oil, 5% commercial oil
3	Growout	0% fishmeal, 0% fish oil
3F	Finishing	0% fishmeal, 5% fish oil
4	Growout	0% fishmeal, 0% fish oil, 3.4% algal extract, 0.9% microbial product
4F	Finishing	0% fish meal, 0% fish oil, 5% commercial oil

Commercial oil contained 40% DHA derived from marine algae.
Algal extract contained 15% DHA derived from microalgae.
Microbial product contained 12% arachidonic acid.

In order to produce a more healthful product for humans, the finishing diets were developed with the goal of increasing the concentration of DHA in fish during their last four weeks before harvest. The lipid content of growout diets 1, 2 and 4 was increased to 15% with the addition of a commercial oil containing 40% DHA derived from marine algae. Menhaden fish oil and flax seed oil were added to diet 3 to increase its lipid content to 15%, as well.

Experimental Design

Juvenile red drum with a starting mean weight of 252.00 ± 2.78 g, bred and raised by the South Carolina Department of Natural Resources, were fed commercial fishmeal/fish oil diets prior to the experiment. Twelve fish were stocked in each of 24, 1.4-m^3 indoor tanks. After two weeks of acclimation, three fish from each tank

Summary:
Recent research by the authors evaluated strategies to reduce fishmeal and fish oil in diets for red drum by substituting terrestrial proteins and lipids while maintaining beneficial fatty acids with DHA supplements derived from marine algae. Results suggested fatty acid-enriched finishing diets can be used with growout diets containing little or no fishmeal and fish oil to achieve the desired DHA content in the final fish fillets.

were sacrificed, filleted and analyzed to provide baseline lipid profiles of the edible flesh.

Diet treatments with six replicate tanks per treatment were assigned in a randomized block design across three closed recirculating systems. Diets prepared in the lab were fed at 3% body weight/day using automated belt feeders over a 20-week growout period. Fish were batch weighed monthly, and feed rates were adjusted accordingly. After 20 weeks, fish on the control diet were approaching harvestable size at a mean weight of 719 g.

At that time half of the tanks in each treatment were switched to finishing diets to enhance levels of DHA in the final product or at least restore lipid profiles similar to those of the control fish. Both the original diets and corresponding finishing diets were fed for an additional four weeks. Three fish from each tank were harvested with individual weights and lengths measured and fatty acid profiles determined for individual skinless fillets.

Production Results

The final weights of fish switched to the plant oil, DHA-enriched finishing diets 1F, 2F and 4F for the final month of the study were not significantly different from those for fish that remained on the original diets during the finishing phase (Figure 1). When fish on diet 3 without fishmeal, fish oil or fatty acid supplementation were supplied with fish oil as 5% of the finishing diet 3F, their growth rate increased rapidly over those that remained on the original diet.

By the end of the 24-week study, mean weights of the fish fed the conventional fishmeal, fish oil diet 1 were not significantly ($P > 0.05$) different from those for fish fed diet 4 with fatty acid supplementation but no fishmeal or fish oil. Fish fed both the low-fishmeal diet 2 and diet 3 without fishmeal, fish oil or fatty acid supplementation lagged significantly in growth.

It is essential that red drum on no-fish diets receive fatty acid supplementation, specifically docosahexaenoic and arachidonic acids (DHA, ARA).

Fatty Acid Results

A goal of this study was not only to explore the production potential of diets with no fishmeal or fish oil, but also to consider the healthfulness of the product for human consumption in terms of the beneficial fatty acid DHA. In all cases, fish switched to finishing diets high in DHA responded with increased accumulation of this fatty acid in their tissues, independent of whether it influenced growth rate (Figure 2).

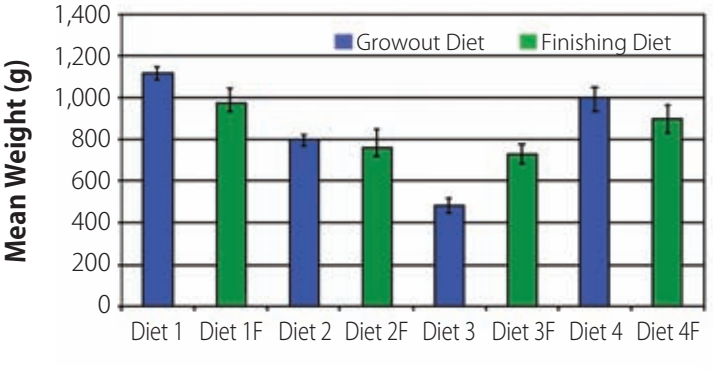

Figure 1. *Mean weights of red drum after 24 weeks of growout/finishing.*

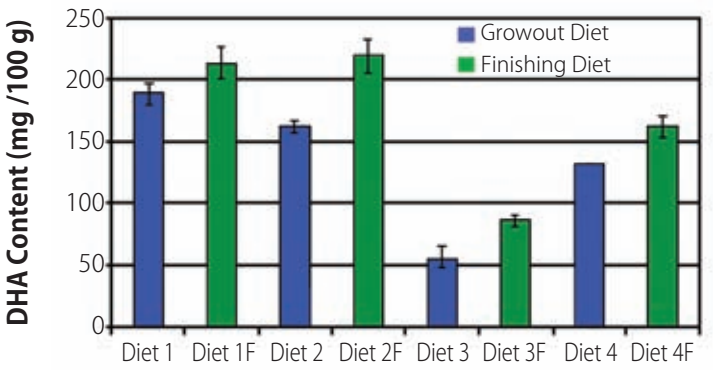

Figure 2. *DHA content of red drum fillets after 24 weeks of growout/finishing.*

Fish raised on diet 4 responded to the finishing diet 4F and achieved tissue concentrations of DHA statistically indistinguishable from fish raised solely on the conventional fishmeal, fish oil diet. The highest DHA levels were found in diets 1F, 2F – treatments where a DHA-enriched finishing diet was used in conjunction with a fishmeal-based growout diet.

Fish fed diet 3 were significantly lower in DHA than those on the other diets. With no DHA in their diets, these fish probably survived only on stored reserves developed prior to this study.