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Determining the Viability of Algae Protein as a Fish Meal Component in Aquaculture

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BACKGROUND According to the U.S. Department of Commerce, total U.S. aquaculture production is about $1 billion annually. The Ohio aquaculture industry represents a very small percentage of that total, so the potential for it to grow and strengthen the state's economy is large. Currently, fish meal and plant protein concentrates constitute the vast majority of feed for farmed fish. However, evaluating alternative protein sources, such as microalgae, in fish diets is critical to the economic success of the aquaculture industry. Demand for fish meal is high — hence one of the main reasons for the existence of the aquaculture industry, plant protein concentrates are expensive, and fish are unable to absorb much of the protein from soybean meal in their diets. In addition, the use of fish for aquaculture feed shapes a public perception of aquaculture as depleting ocean resources.

Microalgae are increasingly incorporated in animal feeds, and in fish diets in particular, to replace plant protein concentrates. Research has demonstrated that in *Tilapia* diets, substituting soybean meal for six percent of fish meal or 10 percent of meat-and-blood meal, can be accomplished without compromising fish growth. The benefits of introducing algae as the protein source, feed additive, and source of antibacterial compounds might further increase aquaculture's usefulness in human food production.

The high protein content of microalgae and their amino acid profiles are the main reason that they are considered valuable components of fish diets. Microalgae are also carriers of high-value molecules that produce numerous antioxidant and antimicrobial compounds, although they still need to be screened for their activity and utility in fish diet formulations. For instance, it was observed that live *Spirulina* algae added to tilapia diets had a growth-promoting effect, and even more importantly, enhanced immune response against common pathogenic bacteria. However, it has been well documented that there are significant differences in acceptability, digestibility, and bioavailability of various algae species when included in diet formulations for fish. Currently, the primary use of industrial algae is for biofuel production. Determining the utility of microalgae in animal feedstuffs, will be a challenge.

OBJECTIVES

This research project aimed to examine the impact of microalgae — initially produced for biofuels — in the diets of Nile *Tilapia*, the fish species used in Ohio aquaculture.

RESULTS

Preliminary results indicate that microalgae positively affect food consumption and fish growth. Replacing up to 50 percent of dietary corn gluten meal protein with microalgae was found to significantly enhance fish growth. Microalgae were also a source of minerals. Differences in concentration of individual minerals in whole fish were significant and might have affected growth when fish were fed diets in which microalgae replaced more than 75 percent of plant protein.

The results show that the growth rate was significantly improved when up to 50 percent of the plant protein was replaced. This experimental design was based on restricted feeding — feed rations were adjusted in accordance to body biomass increase. However, feed consumption analyses suggested that when fish are fed to satiation, *Tilapia* may grow at an even faster rate than fish fed the control diet. In many respects, the mineral levels in the bodies of these fish are in excess of the minerals reported thus far in fish feeding studies, and the issue requires separate attention in order to determine possible waterborne and foodborne toxic effects, as well as possible dietary remedies to counteract toxic elements accumulation.

IMPACTS

The results of this project will be directly transferable to *Tilapia* producers and feed mills in the Ohio and throughout the Midwest. Specifically, the research team will encourage wide participation in extension workshops on Tilapia nutrition and feed formulation, and diet recommendations will be presented at such workshops.

The findings will also play a significant role in the development of the U.S. and Ohio aquaculture industry. Due to the wide availability of algae meal and algal oil from biodiesel outdoor mass production — already scaled up by Ohio's Independence Bio-Product Development, LLC — there is tremendous potential to use algae in the aquaculture industry that could prove beneficial for the fish and profitable to producers by enhancing feed acceptance and growth rate. Incorporating algae meal and algae oil in fish diets could also be a significant impetus towards organic aquaculture.

The U.S.'s role in global aquaculture is still small compared to global production of about $70 billion. Any improvements in fish growth that result from the use of microalgae in fish diets would be immensely beneficial to U.S. fish farmers, including in Ohio, as they compete in the global economy.

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