Alternative Feeds and Nutrition

NOAA FISHERIES

Northwest Fisheries Science Center

About us

The Northwest Fisheries Science Center (NWFSC) Fish Feed and Nutrition Team is the only research group in NOAA engaged in feeds development. We develop nutritious feeds that improve the health and growth of cultured marine fish. Also, we evaluate more affordable and sustainable alternatives to fish meal and fish oil ingredients in fish feeds. This shift from fish meal and fish oil reduces the pressure on pelagic fisheries, the source of these ingredients, and as a result, increases the environmental sustainability of domestic aquaculture.

Background

Aquaculture is the fastest-growing food-producing sector globally, and demand for traditional feed ingredients such as fish meal and fish oil has increased dramatically in recent years. To further develop and grow the aquaculture industry, alternative protein and oil sources are needed. Researchers are not yet able to simultaneously replace both fish meal and fish oil with terrestrial plant-based alternatives for marine fish. At NWFSC, we are evaluating whether a combination of plant-protein ingredients (e.g., soy, corn) and marine macroalgae can yield a complete protein ingredient and prove a suitable alternative to fish meal in aquaculture feeds.

Previous NWFSC research developed novel fish protein meals from fishery processing waste. We found several of these meals to be as nutritious or more nutritious than commercially produced fish meal. The protein meals were highly palatable and, when combined with other ingredients, increased the consumption of alternative, plant-based feeds for marine fish. These findings demonstrate the potential of combining fishery processing waste and plant-based ingredients to develop more nutritionally complete alternative feeds. In a series of on-going studies, we are evaluating the ability of these ingredient formulations to improve feed consumption, nutritional value, and feed efficiency in salmonids and marine fish.

Plant-Based Ingredients

TERRESTRIAL PLANTS

Terrestrial plant-proteins may adequately replace a significant portion of the protein in fish meal in aquaculture feeds. However, plant-proteins lack certain essential nutrients and vary in effectiveness due to species sensitivity and tolerance. Also, there are difficulties in the transition from fish meal protein feeds to alternative plant-protein feeds such as:

- Reduced consumption by fish.
- An increase in suspended solids in culture water.
- Other water quality problems that are limiting their use.

Top left: Sablefish angle fingerlings.
Top right: Alternative feed pellets.
Bottom right: Whole soybeans and Pacific whiting waste.

MARINE MACROALGAE

Macroalgae contain many essential nutrients not found in terrestrial plant proteins (e.g., taurine, trace minerals, omega-3 fatty acids). Culture of macroalgae does not require the use of freshwater or fertilizer, and its use in alternative plant-based feeds can significantly increase their sustainability. Also, ingredients derived from macroalgae may increase feed consumption by some species, resulting in more rapid growth. Researchers have shown the use of macroalgae in feeds improves the water quality in culture systems.

Essential Nutrients

Taurine, an amino-sulfonic acid, is critical to the health of all vertebrates, including fish. It plays a role in maintaining the balance of fluids and electrolytes, regulating the digestion of fats, and maintaining the proper function of the central nervous system. Taurine is commonly found in animal proteins, but absent from terrestrial plant-proteins widely used in alternative fish feeds. Some animals can produce taurine, but felines and some marine finfish are limited in this ability. In cats, taurine-deficient diets can result in blindness and congenital disabilities. Before 2017, taurine was approved only for cat, dog, and poultry feeds in the United States but was generally recognized as safe for humans, and allowed for use in energy drinks.

TAURINE

Taurine supplementation of alternative plant-based aquaculture feeds is critical for optimal growth, nutrient retention, and overall health of many cultured marine species. Through a series of experiments, we demonstrated taurine is a beneficial and safe supplement to alternative plant-based feeds for sablefish Anoplopoma fimbria, a model cold-water marine fish. These studies additionally showed that human consumption of sablefish fed taurine-supplemented feeds would result in low-to-moderate exposure to taurine, with minimal health risks. As a result of our and others' investigations, the United States allows taurine use in fish feeds.

HIGHLY UNSATURATED FATTY ACIDS (HUFAS)

Marine fish have a limited ability to biosynthesize the long-chain HUFAs needed to meet physiological requirements. Their diet must supply these fatty acids. Traditionally, high amounts of fishmeal and fish oil in marine fish feeds helped meet these dietary requirements. The replacement of these ingredients with more sustainable, terrestrial ingredients in alternative fish feeds have resulted in HUFA deficient diets.

Growth, reproduction, and a competent immune system in marine fish require both omega-3 and omega-6 HUFAs. We are studying the effects of replacing the added fish oil in marine fish feeds with combinations of vegetable oils and terrestrially produced, microalgae, and fungal oils containing the omega-3 HUFA docosahexanenoic acid, DHA, and the omega-6 HUFA arachidonic acid, ARA. Results show these specialty oils can meet HUFA nutritional requirements in marine fish as well as demonstrate the potential to formulate marine fish feeds exclusively with terrestrially produced oils.

Top left: Green macroalgae, Ulva spp, for alternative fish feeds. Bottom left: Turkish towel macroalgae. Top right: Processing fish waste. Bottom right:Alternative feed processing.