SUSTAINABLE AND COST-EFFICIENT REPLACEMENT OF FISH MEAL BY ANIMAL AND PLANT PROTEIN IN FEEDS FOR ATLANTIC SALMON *SALMO SALAR*

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Introduction

By 2006 aquaculture produced more than 1.4 million metric tons of salmon (The state of world fisheries and aquaculture 2006, faostat@fao.org), consuming 2 million tons of feed in the process. The feed in turn contained large quantities of high-quality fish meals derived from wild-caught fish.

High-quality fish meal is both high priced and a limited resource. Thus, the salmon feed industry has an outspoken goal to reduce their dependency on fish meal. Adding to this, sustainability in aquaculture is commonly defined as low use of feedstuffs derived from often threatened fisheries. In this context, replacement of fish meal by non-marine protein is a highly sustainable strategy.

This experiment investigated how far fish meal can be replaced by plant protein and avian by-products in salmon feed based on current knowledge in salmon nutrition.

Materials and Methods

Four extruded experimental diets were formulated to contain 5, 10, 15 or 36% fish meal (FM), using the following basket of protein ingredients: FM, extracted soybean meal, corn gluten, feather meal, poultry by-product meal, shrimp meal, white lupine meal, and wheat gluten. All diets contained 41% crude protein (CP) and 30% lipid, and changes in the amino acid profile were adjusted for by supplementing crystalline amino acids.

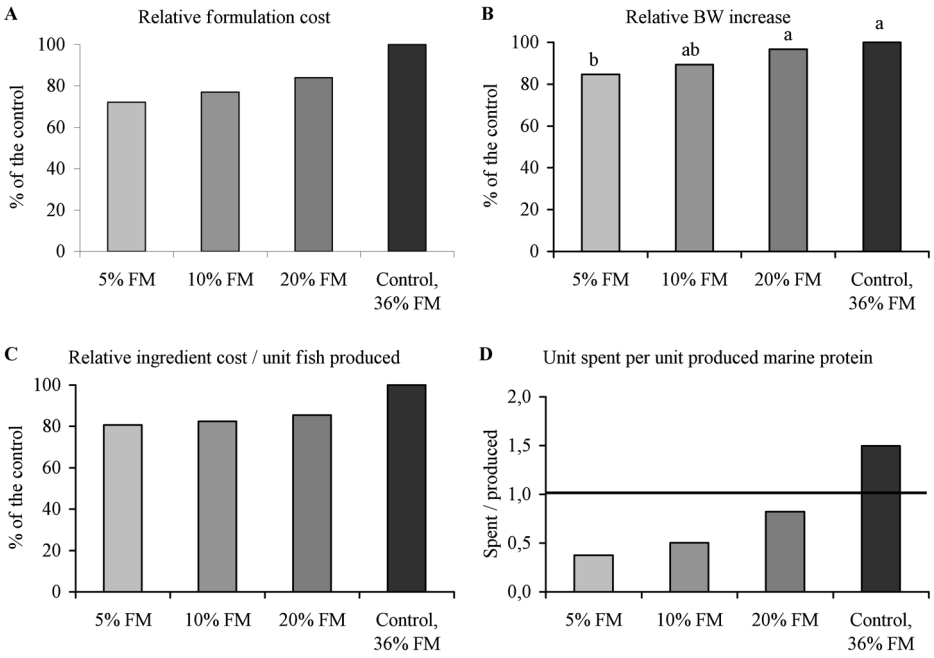

Figure 1. Relative formulation cost per unit feed with fish meal (FM) content varying from 5 to 36% (A), relative body weight (BW) increase when feeding these diets for 121 days (B), and feed ingredient cost (C) and ratio of unit spent (FM in feed) per unit produced (as salmon) marine protein (D) per unit salmon raised. The growth results are analysed by one-way ANOVA, and differences are indicated by Duncan's multiple range test ($p<0.05$).

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Effects on feed intake, growth, and feed utilisation were recorded over a period of 116 days of feeding in sea pens. The fish, which had average initial weight of 0.72 kg, were randomly allocated into triplicate groups of 1500 fish per pen for each feed group. The water temperature varied from 10.5 to 12.3 °C during the course of the experiment.

Economic calculations are based on raw material prices on Chiloe Island (Chile) in July 2006. Use of marine protein in feed is calculated from typical CP contents in Chilean FM and shrimp meal. Ratio of units spent per unit produced marine protein is calculated from typical CP content in Atlantic salmon of the given sizes (Shearer et al., 1994).

Results

By reducing the FM content in the feed from 36 to 5% the raw material cost per unit feed was reduced by 27%-units (Fig. 1A). This saving was a linear function in response to the FM-replacement.

The fish grew to final weights ranging from 2.19 to 2.45 kg at thermal-unit growth coefficients (TGC x 1000; Iwama and Tautz, 1981) ranging from 2.9 to 3.2. Over the whole period there was a linear increase in feed conversion ratio (feed intake / body weight gain; FCR) from 1.1 to 1.2 in response to lowered content of FM in the feed. This was mirrored by a linear decrease in TGC x 1000 during the first 34 days, and consequently in final body weight (Fig. 1B). After the first 34 days, however, low FER was compensated by higher feed intake, and during the last 82 days all groups grew at similar rates, showing that the salmon adapted to the low-FM diets.

Despite higher FCR in response to the FM replacement, the feed raw material cost was still 19%-units lower per unit fish produced at 5% than at 36% FM in the feed (Fig. 1C). Also this saving was linear in response to the FM-replacement.

At 36% FM in the feed the ratio of unit spent per unit produced marine protein was 1.5 (Fig. 1D), meaning that the salmon consumed 50% more marine protein derived from wild-caught fish (and some shrimp) than it produced by growth. When replacing the FM by plant and avian by-product protein this ratio was linearly reduced to 0.4. Thus, at 5% fish meal in the diet the salmon produced 2.5 times more marine protein than it consumed. Even at 20% FM in the feed the salmon was net-producer of marine protein.

The ultimate goal of the salmon industry is to treat FM as any other protein source in least cost formulation. This experiment demonstrates the cost efficiency in this strategy, and how it will transform salmon culture into a significant net producer of marine protein. Traditional production and processing of grains offers a vide variety of plant protein sources, and the bio-fuel industries now offer new possibilities for developing feedstuffs from extraction or fermentation residues. There is also a great potential for processing animal slaughter waste into by-products feasible for fish. Adding to this, slaughter waste from aquaculture may be processed into FM and recycled. Thus, the salmon industry may ultimately become independent of FM from wild-caught fish.

References

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