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Traditional, fermented soybean meals compared in feeds for marine fish

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Both decreased dietary fishmeal levels before growth performance was affected

In trials, using both traditional and fermented soybean meals in feed allowed some decrease in dietary fishmeal levels before growth performance was affected.

Feedstuffs of plant origin are commonly incorporated into feed formulations to spare fishmeal as a principal protein source. These reduced-fishmeal feeds are often readily accepted and well-utilized by herbivorous and omnivorous species. However, carnivorous species may not respond as well to aggressive sparing of marine-origin protein with plant-based alternatives. The use of plant-based ingredients in feeds for carnivorous fish is often limited by issues related to the palatability, digestibility and biological value of plant proteins.

Soy products

Soybean meal illustrates this challenge well. Although soybean meal is one of the most common alternative protein sources used in aquafeeds, its incorporation in feeds for carnivorous fish is constrained by anti-nutritional factors such as protease inhibitors, phytate, saponins, lectins and oligosaccharides, which can affect feed palatability and utilization.

Various processing strategies can be used to reduce or eliminate anti-nutritional factors in soy-derived feedstuffs, such as heat treatment, extraction and purification into protein concentrates and isolates. Although these products offer advantages in terms of anti-nutritional factor levels, they are more costly than traditional soybean meal. Fermentation is another lower-cost approach to addressing anti-nutritional factors and increasing nutrient levels and digestibility in products for human consumption, as well as livestock feeding.

Recent studies with hybrid striped bass *Morone chrysops* x *M. saxatilis*; rainbow trout, *Oncorhynchus mykiss*; and Japanese amberjack, *Seriola quinqueradiata*; suggested that fermentation may be equally or more effective than other, more costly processing strategies to improve the acceptance and utilization of soy protein products in feeds for carnivorous fish.

The authors recently tested the relative suitability of traditional and fermented soybean meals in feeds for white seabass, *Atractoscion nobilis*, and California yellowtail, *Seriola lalandi*, important commercial and recreational species currently in development for intensive culture. The production performance of juvenile fish fed feeds containing graded levels of traditional or fermented soybean meal was compared to the performance of fish given previously validated diets based on fishmeal or other high-value alternative proteins (Tables 1 and 2).

Table 1. Dietary formulation (g/kg) and proximate composition (g/kg) of test diets for white seabass.

Ingredient	48% Fishmeal Control	24% Fishmeal Soybean Meal	24% Fishmeal Fermented Soy Meal	12% Fishmeal Soybean Meal	12% Fishmeal Fermented Soy Meal	Soybean Meal	Fermented Soy Meal	Poultry By-Product Meal Algae	Poultry By-Product Meal Fermented Soy Meal
Menhaden fishmeal	480.0	240.0	240.0	120.0	120.0	0	0	0	0
Soybean meal	100.0	150.0	0	250.0	0	411.2	0	0	0
Fermented soybean meal	0	0	150.0	0	250.0	0	477.2	0	450.0
Spirulina algal meal	0	0	0	0	0	0	0	200.0	0
Corn protein concentrate	36.7	119.9	117.9	156.4	154.6	157.7	172.1	200.0	20.2
Soy protein concentrate	80.0	186.0	175.0	200.0	180.0	215.0	120.0	0	40.0
Wheat flour	184.6	137.8	149.3	81.5	100.7	0	9.2	130.4	32.8
Poultry by-product meal	0	0	0	0	0	0	0	330.0	300.0
Menhaden fish oil	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Soybean oil	21.4	39.3	39.6	48.3	48.8	58.4	58.6	9.2	31.3
Dicalcium phosphate	0	22.2	22.4	35.9	36.2	48.0	48.7	20.2	18.8
Taurine	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Methionine	0.6	2.2	2.4	3.0	3.3	4.1	5.0	1.1	4.3
Lysine	2.5	8.5	9.4	10.8	12.3	11.4	15.0	14.9	8.4
Choline chloride	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Vitamin premix	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Mineral premix	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vitamin C	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Carboxymethyl cellulose	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Proximate Composition									
Dry matter	934 ± 2	936 ± 1	940 ± 0	939 ± 0	949 ± 0	935 ± 1	956 ± 1	922 ± 1	945 ± 0
Protein*	511 ± 0	508 ± 2	506 ± 2	508 ± 1	502 ± 1	507 ± 2	486 ± 2	563 ± 3	519 ± 2
Lipid	177 ± 12	155 ± 10	155 ± 7	141 ± 11	140 ± 2	161 ± 3	166 ± 17	174 ± 3	137 ± 3
Ash	127 ± 2	102 ± 2	101 ± 2	81 ± 2	86 ± 1	89 ± 1	78 ± 2	75 ± 2	90 ± 1

* Although crude protein levels varied, all feeds were formulated to contain 450 g/kg digestible protein.

Table 2. Dietary formulation (g/kg) and proximate composition (g/kg) of test diets for California yellowtail.

Ingredient	40% Fishmeal Control	20% Fishmeal Soy Protein Concentrate	20% Fishmeal Soybean Meal	20% Fishmeal Fermented Soy Meal	Soybean Meal	Fermented Soy Meal	Poultry By-Product Meal Algae	Poultry By-Product Meal Fermented Soy Meal
Menhaden fishmeal	400.0	200.0	200.0	200.0	0	0	0	0
Soybean meal	180.0	0	350.0	0	422.7	0	0	0
Fermented soybean meal	0	0	0	462.5	0	521.0	0	500.0
Spirulina algal meal	0	0	0	0	0	0	196.3	0
Corn protein concentrate	0	75.0	104.1	50.0	164.7	115.0	199.6	30.0
Soy protein concentrate	0	361.5	120.0	70.0	200.0	148.7	0	50.0
Wheat flour	166.3	190.6	57.8	47.7	0	0	130.0	17.9
Poultry by-product meal	63.2	0	0	0	0	0	333.0	234.5
Menhaden fish oil	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Soybean oil	22.4	44.5	42.9	45.3	58.1	60.5	9.2	38.0
Blood meal	70.0	0	0	0	0	0	0	0
Dicalcium phosphate	0	26.4	24.6	22.9	48.1	46.7	25.1	24.4
Taurine	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Methionine	2.0	3.2	2.6	3.5	4.1	5.0	1.2	5.0
Lysine	2.0	4.7	3.8	3.9	8.2	9.0	11.5	6.0
Choline	6.0	6.0	6.0	6.0	6.0	6.0	36.0	6.0
Vitamin premix	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Mineral premix	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vitamin C	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Carboxymethyl cellulose	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Proximate Composition								
Dry matter	943 ± 0	936 ± 0	938 ± 0	960 ± 0	955 ± 0	964 ± 0	946 ± 0	957 ± 0
Protein*	509 ± 4	488 ± 1	502 ± 3	493 ± 0	494 ± 2	498 ± 3	575 ± 2	523 ± 3
Lipid	145 ± 4	139 ± 1	139 ± 3	136 ± 2	133 ± 1	134 ± 2	152 ± 3	143 ± 1
Ash	109 ± 6	100 ± 5	103 ± 2	102 ± 2	91 ± 4	99 ± 4	85 ± 3	96 ± 4

* Although crude protein levels varied, all feeds were formulated to contain 470 g/kg digestible protein.

Trial 1 – White sea bass

After 34 days, white sea bass fed the soybean meal and fermented soybean meal diets without fishmeal exhibited very poor growth performance (Fig. 1). According to the animal welfare procedures of Hubbs-SeaWorld Research Institute, fish in these treatments were euthanized.

After 68 days, fish fed a diet that contained poultry by-product meal and algae, but no fishmeal exhibited significantly reduced weight gain and specific growth rates, but the performance of fish fed the remaining experimental diets was equivalent to that of fish fed the control feed with 48 percent fishmeal (Fig. 1).

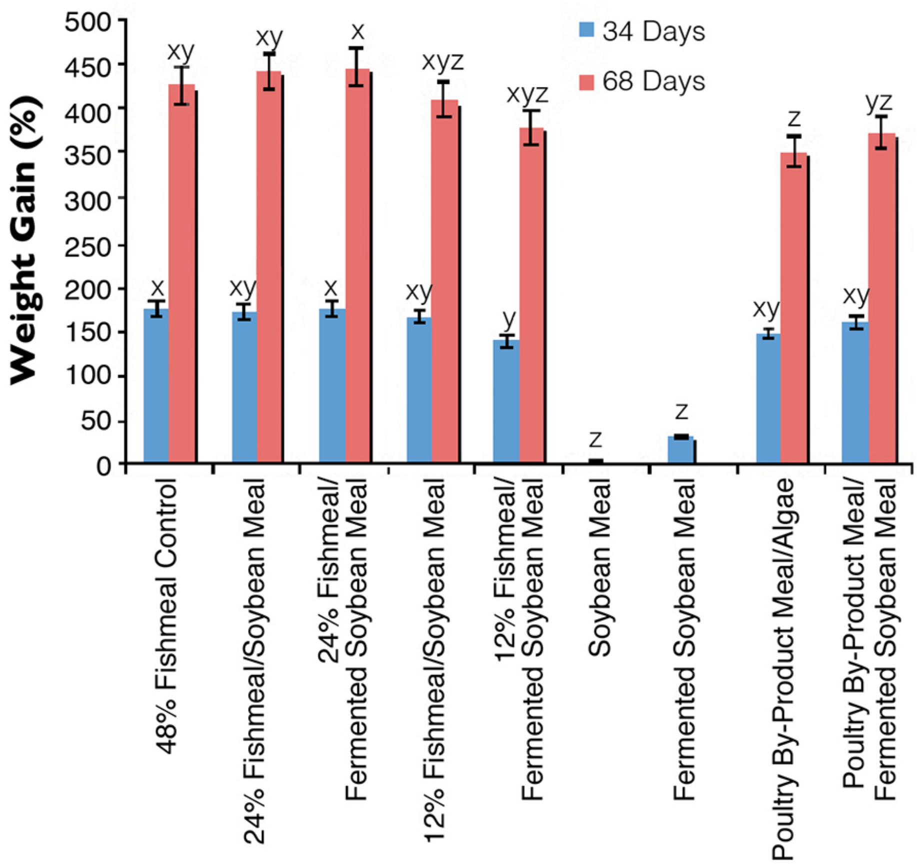

Fig. 1: Mean weight gain by dietary treatment for juvenile white seabass.
Means with common letters are not significantly different (P > 0.05).

Trial 2 – California yellowtail

After 65 days, weight gain, specific growth rates and feed-conversion ratios were equivalent among California yellowtails fed the 40 percent fishmeal control diet, the feed with soy protein concentrate and 20 percent fishmeal, and the diet with soybean meal and 20 percent fishmeal (Fig. 2). All other diets resulted in significantly inferior weight gain, growth rates and feed conversion compared to the 40 percent fishmeal feed. Minor differences were observed in feed intake, but survival did not vary among treatments.

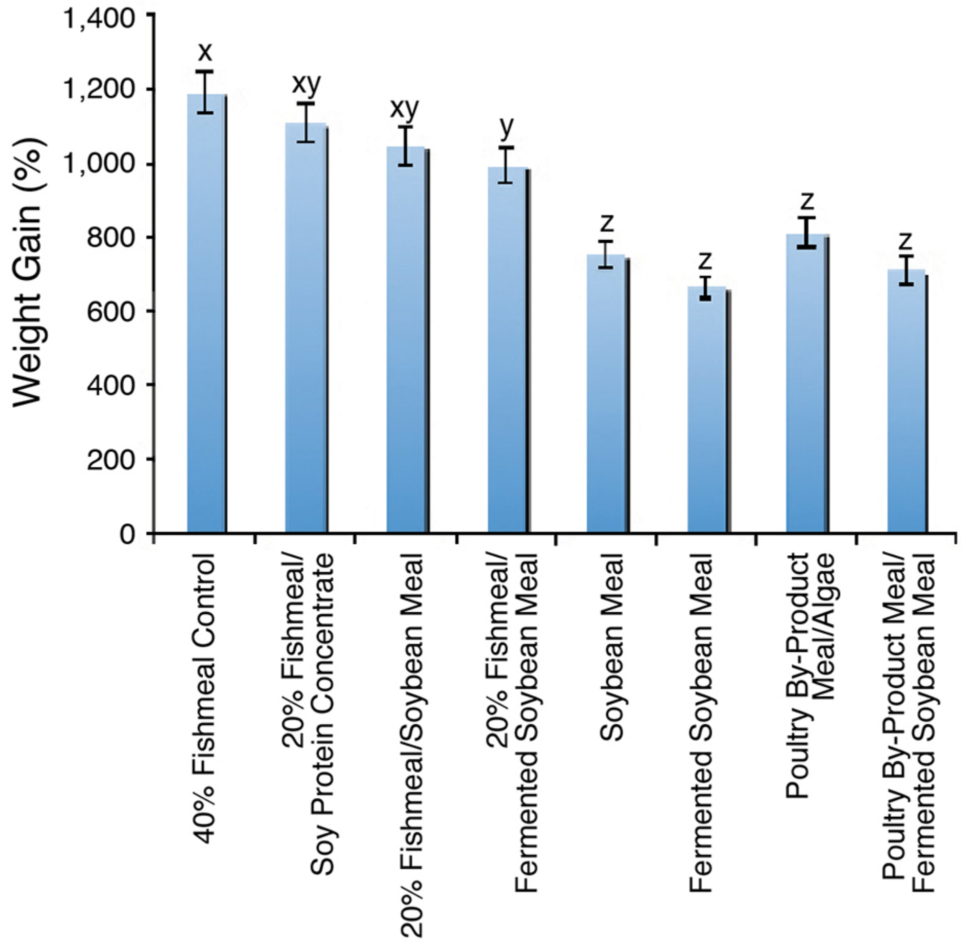

Fig. 2: Mean weight gain by dietary treatment for juvenile California yellowtail. Means with common letters are not significantly different (P > 0.05).

Challenges, opportunities

Although fishmeal inclusion was decreased to some extent, reducing fishmeal levels below 12 and 20 percent reduced the performance of white sea bass and California yellowtail, respectively. Reduced performance in carnivorous species fed diets containing elevated levels of plant products can be associated with failures to account for differences in nutrient levels or digestibility among ingredients, feed palatability and the presence of anti-nutritional factors.

Since the test feeds were formulated to contain equivalent levels of digestible protein and supplemented to meet the estimated essential amino acid requirements of the fish, it seems unlikely that differences in nutrient availability were the major causes of reduced performance. Feed palatability appeared to be a factor among the sea bass fed the fishmeal-free feeds. However, feed intake by the sea bass appeared otherwise equivalent and was nearly equivalent in the California yellowtails.

Based on assumptions of reduced anti-nutritional factors levels in the fermented soybean meal, it is surprising this ingredient offered no apparent advantage over traditional soybean meal. It is possible the microbial cultures used for fermentation affected the quality and posterior utilization of the final product. It is also possible that, when used as a primary protein source, fermented soybean meal provided more microbial content than is beneficial for juvenile sea bass or yellowtail.

It is also worth noting that the previously validated feeds based on poultry by-product meal and spirulina algal meal did not perform as well as the fishmeal-based controls in either trial, and fish growth was somewhat reduced in comparison with the typical performance observed by the Hubbs-SeaWorld Research Institute.

The Hubbs-SeaWorld Research Institute hatchery program still relies on white sea bass and California yellowtail broodstock of unknown pedigree for fingerling production. Therefore, there may be some inconsistency in progeny quality from year to year. Although no overt abnormalities or performance issues were observed during larviculture or the feeding trials, it is possible that unknown factors contributed to the performance observed in the recent trials.

Perspectives

Although fermented soybean meal does not appear to be uniquely advantageous in feeds for juvenile white sea bass and California yellowtails, it does not appear to be problematic either. By using both traditional and fermented soybean meals, the authors were able to decrease dietary fishmeal levels to some extent before growth performance was affected. Greater consistency in sea bass and yellowtail fingerling production will likely lead to greater repeatability among trials and confidence in evaluations of feed formulations.

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