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Soy trials replace fishmeal in grouper feeds

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Carnivorous species requires high protein levels in feeds

Groupers, which fetch high prices in seafood restaurants in Malaysia and elsewhere, are carnivorous fish. In culture, however, soybean meal – especially with the additional inclusion of enzymes, attractants and amino acids – can make up a significant portion of their diets.

At present, soybean meal is the most important source of plant protein and comprises about 50 percent of the total oilseed crops of the world. Soybean meal is a preferred plant protein source due to its high protein content, currently lower price than fishmeal and steady production history.

Studies conducted on such marine fish species as spotted rose snapper, Asian sea bass, tiger puffer, sea bream and Japanese flounder have shown that soybean meal can replace fishmeal in diets at a level of up to 45 percent. However, not much information is available on the potential of soybean meal as a source of protein for groupers.

Grouper culture

Groupers have been identified as the most desired fish in the live reef food fish trade in Southeast Asia due to their desirable taste, hardiness in captivity, efficient feed conversion, rapid growth, high market demand and good price. Unfortunately, one of the limiting factors to the expansion of grouper culture is the high cost of feed.

Groupers are carnivorous fish that require high protein levels in feeds. Since the available pelleted feeds for tropical marine fish are mostly dependent on fishery-based ingredients, the feeds are becoming more expensive to produce. Replacement of fishmeal with a significant quantity of alternative ingredients is critical to reduce the feed cost.

At the Borneo Marine Research Institute at Universiti Malaysia Sabah, efforts to develop practical feeds with reduced amounts of fish-based ingredients for groupers have led to promising findings.

Anti-nutritional compounds

A well-reported constraint in utilizing soybean meal as a dietary protein source in fish feed is the presence of anti-nutritional compounds such as trypsin inhibitors and phytate. Unlike trypsin inhibitors, phytate is heat-stable and needs a phytase enzyme to improve its utilization. The presence of phytate in diets often results in negative effects on the growth, feed utilization and mineral uptake of the cultured fish. Soybean meal-based feeds are also facing issues regarding palatability and nutritional values.

Several approaches have been initiated to improve the utilization of soybean meal in aquafeeds through enzyme inclusion, amino acid supplementation and fermentation. At the Borneo Marine Research Institute, the performance of soybean meal-based feeds was improved with the inclusion of phytase in feed for juvenile tiger groupers, *Epinephelus fuscoguttatus*. Phytase is an enzyme naturally present in some plants and microorganisms, but not found in monogastric and agastric fish. Fortunately, commercial phytase is available for inclusion in animal feeds.

Feeding trials

The author performed two trials to evaluate the performance of tiger groupers fed soybean meal-based feeds and the effects of phytase inclusion in improving feed utilization. In trial 1, Danish fishmeal and defatted soybean meal were used as sources of protein. Industrial-grade fish oil and soybean oil were used as sources of lipid.

Feeds were formulated with 50 percent protein, 16 percent lipid and energy content of 365.8 kcal/100 g feed. Fishmeal protein was replaced with soybean meal protein at 0 (SM0), 10 (SM10), 20 (SM20), 30 (SM30) and 40 percent (SM40), and 20 percent plus phytase (SM20P) replacement levels. For SM20P, a phytase dose of 2,000 phytase units/kg enzyme was dissolved with water and added to the mixture of ingredients.

Fish weighing 13.9 ± 0.65 g were stocked at 10/tank in 150-L fiberglass tanks supplied with aeration using flow-through seawater system. The fish were fed the experimental feeds for 10 weeks.

In trial 2, the performance of soybean meal-based feeds was further evaluated with inclusion of phytase in the feeds based on the findings in trial 1. Similarly, five experimental feeds were formulated with the same protein, lipid and energy levels used in trial 1 but, except for the control feed, with soybean meal replacing fishmeal protein at 0 (SM0), 10 (SM0P), 20 (SM20P) and 30 percent (SM30P), and 40 percent with phytase supplementation of 2,000 phytase units/kg (SM40P).

Fish with an average initial body weight of 44.57 ± 0.28 g were randomly stocked into 15 cylindrical cages with 50-cm depth and diameter, and distributed in three, 5-ton fiberglass tanks. The fish were fed experimental feeds twice a day at satiation level for eight weeks. At the end of the trial, fish were transferred to experimental tanks for collection of feces and determination of apparent digestibility coefficient.

Fish performance

The essential amino acids such as methionine and lysine – the limiting amino acids in most plant-based feeds – were observed to be reduced with increasing soybean meal levels in the feeds. Methionine and lysine levels ranged from 0.92 to 1.53 percent and 3.28 to 3.75 percent, respectively. The lysine and methionine requirements of grouper were estimated to be 2.83 and 1.31 percent of dry feeds, respectively.

In the study, a methionine deficiency was observed when soybean meal was added above 10 percent in the feeds (Table 1). Interestingly, the growth rates of fish fed SM20 and SM30 were not significantly different from fish that received the control feed, which contained more methionine. Therefore, formulating feeds with up to 30 percent of soybean meal might be considered for rearing juvenile groupers, at least for a short period.

Shapawi, Amino acid composition, Table 1

Amino Acid	Feed Treatment SM0	Feed Treatment SM10	Feed Treatment SM20	Feed Treatment SM30	Feed Treatment SM40	Feed Treatment SM20P
Aspartic acid	3.94	3.97	4.03	4.18	4.44	4.17
Glutamic acid	8.59	8.40	8.36	8.40	8.13	8.38
Serine	2.03	2.10	2.27	2.26	2.40	2.17
Glycine	4.44	4.60	4.75	4.72	4.92	4.65
Histidine	1.21	1.28	1.33	1.36	1.45	1.24
Arginine	2.50	2.88	2.94	2.99	3.20	3.07
Threonine	2.55	2.47	2.53	2.67	2.41	2.53
Alanine	2.74	2.49	2.44	2.47	2.31	2.43
Proline	1.87	1.87	1.94	2.01	1.94	1.93
Tyrosine	1.37	1.47	1.53	1.53	1.87	1.52
Valine	2.36	2.35	2.37	2.36	2.34	2.33
Methionine	1.53	1.34	1.28	1.16	0.92	1.31
Cystine	0.31	0.37	0.36	0.46	0.56	0.40
Isoleusine	2.49	2.20	2.29	2.25	2.24	2.21
Leusine	3.89	3.96	4.17	4.39	4.50	4.30
Phenylalanine	2.65	2.63	2.87	2.78	2.81	2.79
Tryptophan	0.27	0.32	0.32	0.33	0.41	0.33
Lysine	3.75	3.65	3.59	3.41	3.28	3.66

Table 1. Growth performance of hybrid tilapia and their pure-bred parents.

It was also observed that fish fed phytase supplemented-feed (SM20P) performed better than those without phytase supplementation (Table 2). In trial 2, growth rates were lower than in trial 1 due to the larger fish size used in the second trial. However, similar trends were observed in terms of weight gain, specific growth rate and feed conversion, where replacement of fishmeal with soybean meal at 40 percent consistently gave the poorest performance (Table 3).

Shapawi, Fish growth and feed conversion, Table 2

Feed Treatment	Weight Gain (%)	Specific Growth Rate (%/day)	Feed-Conversion Ratio	Survival (%)
SM0	119.51	1.38	1.39	93
SM10	92.89	1.15	1.72	93
SM20	112.71	1.32	1.45	97
SM30	115.18	1.34	1.54	93
SM40	89.75	1.12	1.77	93
SM20P	116.57	1.36	1.42	90

Initial weight of fish was 13.9 ± 0.65 g.

Table 2. Fish growth and feed conversion in trial 1.

Shapawi, Fish growth and feed conversion, Table 3

Feed Treatment	Weight Gain (%)	Specific Growth Rate (%/day)	Feed-Conversion Ratio	Survival (%)
SM0	80.3	1.03	1.25	98
SM10P	79.4	1.03	1.32	100
SM20P	81.4	1.04	1.33	98
SM30P	82.5	1.06	1.33	100
SM40P	72.9	0.96	1.47	98

Initial weight of fish was 44.57 ± 0.28 g.

Table 3. Fish growth and feed conversion in trial 2.

Feed-conversion rates were all below 2.0 in both trials, indicating efficient utilization of feeds by the fish. The survival rates of the fish were not affected by the inclusion of soybean meal in the diets. The apparent digestibility coefficients of the feeds are presented in Figure 1. The dry matter coefficients ranged from 64.3 to 74.2 percent. SM40P had the lowest crude protein digestibility coefficients. Meanwhile, the lipid digestibility coefficients of all experimental feeds was very high, ranging from 97.1 to 97.7 percent.

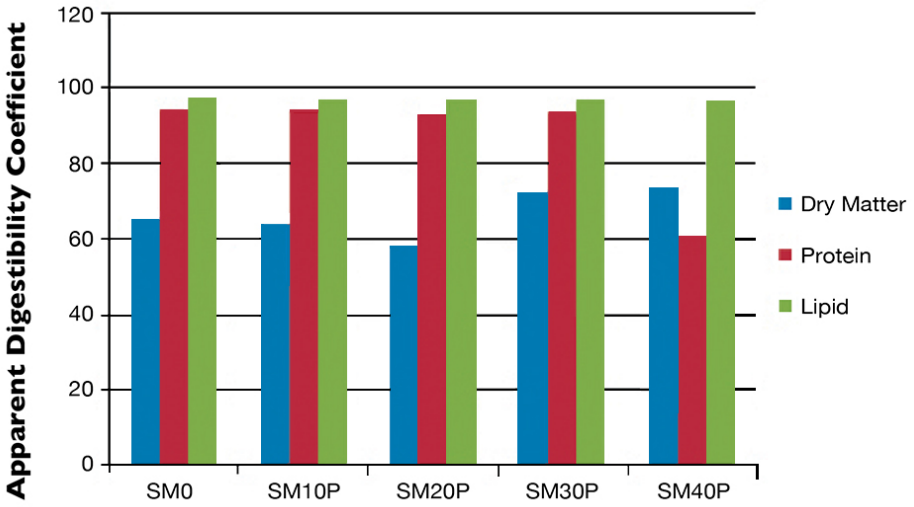

Fig. 1: Apparent digestibility coefficients of soybean meal-based feeds.

Perspectives

Finding alternative feed ingredients whose global production can keep pace with the growth of the aquaculture sector is critical to support the sustainability of this industry. Soybean meal is seen as the most promising protein candidate in formulated fish feeds, but thorough evaluation considering species-specific fish responses must be carried out to understand the full potential of soybean meal as an ingredient in aquafeed.

In general, the inclusion of soybean meal in feeds for groupers might be hindered by the limiting amino acids, reduced digestibility and palatability. Based on the current findings, the inclusion of soybean meal in grouper diets should not be above 30 percent of dry feed. However, inclusion of feed enzymes and attractants, as well as supplementation of amino acids, might be able to increase the utilization efficiency of soybean meal-based feeds. This will not only reduce the cost of aquafeed production, but also aquaculture's dependency on fish-based ingredients.

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