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Salmon testes meal potential ingredient for Pacific threadfin diets

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Byproduct can be an effective protein source as well as a valuable feed additive

The authors are researching ingredient alternatives that can help lead to a more species-specific commercial feed for Pacific threadfin.

Pacific threadfin or moi is a tropical marine fish found in Hawaii, USA, and other Pacific regions that is being grown in different culture systems, including flow-through tanks, raceways and offshore submerged sea cages. It takes about six to eight month to raise this fish to market size.

Currently, aquaculture of Pacific threadfin depends on imported commercial feed containing 45 to 50 percent protein and 14 to 18 percent lipid. Recent studies by the authors estimated the optimal protein requirement to support growth performance of this fish is 40 percent. Thus, the current commercial feed has been overformulated with protein and is not optimally cost effective. More research is needed to investigate the nutrient requirements of this fish and look for alternative feed ingredients.

Fishmeal replacement

Recent research has shown that some fishery byproducts are promising as alternative ingredients in aquatic feeds. One of the by-products from the salmon fishery in the U.S. state of Alaska, pink salmon testes meal, has been shown to be highly digested by Pacific white shrimp and able to replace up to two-thirds of the fishmeal protein in a diet containing 15 percent fishmeal.

The application of this byproduct in feeds for tropical marine fish has not been investigated. Therefore, in a study, the authors investigated the potential of using pink salmon testes meal as a feed ingredient for juvenile Pacific threadfin based on growth performance and feed utilization. Funding for this study came through a grant from the U.S. Department of Agriculture Agricultural Research Service and a USDA-ARS cooperative agreement with the University of Alaska Fairbanks.

Experimental diets

Pink salmon testes meal was obtained from a commercial processing plant in Kodiak Alaska, dried at 71 degrees-C for 24 hours, mixed with the antioxidant ethoxyquin at a concentration of 150 mg/kg and stored at -30 degrees-C until use. Six test diets were prepared to contain 37 percent protein and 13 percent lipid with varied levels of fishmeal replacement (Table 1). A commercial feed containing 50 percent protein and 14 percent lipid was used as a reference diet.

Deng, Dietary formulation of test diets, Table 1

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Fishmeal protein replacement (%)	0	11	22	33	44	55
Pollock meal (g/kg)	350	310	270	230	190	150
Pink salmon testes meal (g/kg)	0	30	60	90	120	150
Dextrin (g/kg)	190	198	207	215	223	232
Menhaden oil (g/kg)	100	102	103	105	107	108
Soybean meal (g/kg)	250	250	250	250	250	250
Other (g/kg)	110	110	110	110	110	110

Table 1. Dietary formulation of test diets fed to juvenile Pacific threadfin for eight weeks.

Fish maintenance, data collection

While acclimating to laboratory conditions for seven days, the juvenile Pacific threadfin received the commercial feed prior to the beginning of the feeding trial. Three tanks were randomly assigned to each dietary treatment with 20 fish per tank. Fish were hand fed three times daily with total daily feeding volume based on 5 to 7 percent of body weight. Animal care, maintenance, handling and tissue sampling followed the protocols approved by the Oceanic Institute Animal Care and Use Committee.

At the end of eight weeks, total weights were recorded for each tank. Five whole fish from each tank were homogenized, freeze-dried and stored at minus-80 degrees-C until analysis for proximate composition.

The growth trial was conducted indoors in 150-L flow-through tanks with 31 g/kg seawater.

Results

Nutritional compositions

The testes meal contained a higher level of protein but a lower level of ash than the pollock fishmeal (Table 2). All test diets contained similar levels of protein, lipid and gross energy. The commercial diet had a higher level of protein and energy than the test diets. The total amino acid level (g/kg ingredient) was highest in the testes meal, followed by the pollock meal and lowest in the soybean meal (Table 3).

Deng, Proximate composition of major protein ingredient, Table 2

	Testes Meal	Pollock Meal	Soybean Meal	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Commercial
Fishmeal protein replacement (%)	–	–	–	0	11	22	33	44	55	–

Dry matter (g/kg)	924	945	925	936	932	933	932	915	925	954
Crude protein (g/kg)	77.5	670	478	373	369	359	367	360	369	539
Crude fat (g/kg)	64	79	19	127	128	130	131	128	132	136
Ash (g/kg)	117	185	68	98	95	91	91	86	85	81
Gross energy (kcal/kg)	4,587	4,428	4,233	4,646	4,647	4,643	4,641	4,570	4,621	5,222

Table 2. Proximate composition of major protein ingredients and test diets fed to juvenile Pacific threadfin.

Deng, Essential amino acid and taurine profiles, Table 3

Amino Acid	Testes Meal	Pollock Meal	Soybean Meal	Testes Meal	Pollock Meal	Soybean Meal
Arginine (g/kg)	109.1	54.0	35.6	144.7	87.0	82.6
Histidine (g/kg)	17.1	15.4	14.2	22.8	24.8	33.0
Isoleucine (g/kg)	40.3	32.9	24.0	53.4	53.0	55.7
Leucine (g/kg)	61.4	49.5	34.1	81.5	79.8	79.2
Lysine (g/kg)	65.6	49.9	30.4	87.1	80.4	70.6
Methionine (g/kg)	10.3	19.3	6.3	13.7	26.4	9.9
Phenylalanine (g/kg)	27.4	23.0	24.7	36.4	37.0	57.3
Threonine (g/kg)	44.3	38.0	17.6	58.8	61.3	40.8
Valine (g/kg)	44.1	33.1	22.7	58.5	53.3	52.8
Total	753.5	623.9	428.6	1,000.0	1,000.0	1,000.0
Taurine (g/kg)	30.1	6.7	0.4	40.0	10.7	1.0

Table 3.Essential amino acid and taurine profiles of protein ingredients used in test diets.

The amino acid levels of the testes meal were lower in methionine, glycine, glutamine + glutamate, and asparagine + aspartate than in the pollock meal. Taurine, lysine and arginine, however, were higher in testes meal than pollock meal. The amino acid composition of the test diets showed an increasing level of arginine and a decreasing level of methionine with the increasing amount of testes meal added. The taurine level was also increased with the replacement of testes meal for fishmeal.

Growth performance

No mortality was observed in any treatment during the growth trial. Replacement of fishmeal protein by the testes meal did not cause any adverse effect on fish weight gain ($P > 0.05$, Table 4). Feed-conversion ratios (FCRs) were lower for the fish fed diets 2 and 3 than those fed diet 1 with no testes meal included ($P < 0.05$).

Deng, Growth performance of Pacific threadfin, Table 4

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Commercial
Fishmeal protein replacement	0	11	22	33	44	55	–
(%)Weight gain (%)	934 ± 14^{a}	990 ± 22^{a}	959 ± 40^{a}	924 ± 15^{a}	953 ± 25^{a}	934 ± 42^{a}	983 ± 24^{a}
Feed-conversion ratio	1.20 ± 0.01^{b}	1.15 ± 0.01^{c}	1.14 ± 0.01^{c}	1.16 ± 0^{ab}	1.16 ± 0^{ab}	1.17 ± 0.02^{ab}	1.32 ± 0.02^{a}
Protein efficiency ratio	1.98 ± 0.02^{c}	2.06 ± 0.01^{b}	2.14 ± 0.02^{a}	2.06 ± 0.02^{b}	2.07 ± 0.01^{ab}	2.03 ± 0.05^{bc}	1.27 ± 0.02^{d}
Protein retention (%)	35.6 ± 0.1^{bc}	36.5 ± 0.4^{bc}	38.8 ± 0.3^{a}	36.9 ± 0.6^{a}	36.2 ± 0.4^{bc}	35.0 ± 1.2^{c}	22.5 ± 0.3^{d}

Table 4. Growth performance of Pacific threadfin fed different diets.

Protein efficiency ratios (PERs) were increased by the supplementation of testes meal, except PERs were similar for fish fed diets 5 and 1. Protein retention was the highest for fish fed diet 3. Among all treatments, fish fed the commercial feed had the highest FCRs and lowest PERs and protein retentions. The proximate composition among fish fed the test diets was similar.

Perspectives

This study showed that pink salmon testes meal can be an effective protein source as well as a valuable feed additive in feeds for Pacific threadfin. The testes meal replaced up to 50 percent of the fishmeal protein in the test diet without any detrimental effect on the growth performance and proximate composition of fish. At a low level of supplementation with 22 percent fishmeal protein replaced, the testes meal reduced FCR and improved PER and protein retention of fish.

Both taurine and arginine were high in the testes meal compared to the fishmeal. Taurine is a conditionally essential nutrient for some marine species that has been shown effective in stimulating growth and decreasing FCR in fish such as cobia, Japanese flounders and red sea bream.

Arginine is an indispensable amino acid for optimal growth of fish as well as a precursor for creatine. Supplementation of arginine has been shown to increase growth, feed efficiency and protein deposition in fish.

Taurine is normally absent or found at very low levels in plant proteins. Arginine levels are low in some plant protein concentrates, such as canola meal (0.49 to 2.32 percent), corn gluten meal (1.90 percent) and safflower meal (1.20 to 1.90 percent), compared to the arginine levels in most fishmeal (3.60 to 6.80 percent).

As a result, a diet with a high level of plant proteins could easily become deficient in taurine or arginine. In this study, the increased values of PER and protein retention, and decreased FCR observed for the diet with 22 percent fishmeal protein replaced may be partly due to the increased levels of dietary taurine and/or arginine contributed by the supplementation of the testes meal.

On the other hand, the level of methionine was relatively low in testes meal when compared with fishmeal. When 55 percent of the fishmeal protein was replaced by the testes meal, the dietary methionine level was 0.81 percent. This level of methionine was within the published 0.7 to 1.2 percent diet range of methionine requirements for most species that have been studied.

It is possible that complete replacement of fishmeal with the testes meal could result in a methionine deficiency in diets for Pacific threadfin. Supplementation of methionine should be considered if a higher level of replacement (more than 55 percent fishmeal protein) is needed. However, this warrants further investigation.

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