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Aquafeeds
Aquafeeds

Mexico research studies digestibility in fishmeals

Responsible Seafood Advocate logo
1 October 2003 Eugenio J. Bortone, Ph.D., PAS

Menhaden product superior in terms of protein, dry matter, phosphorus, more

Among other factors, fishmeal digestibility depends on its protein quality and the processing conditions under which the fishmeal was produced.

Fishmeal is the main protein source in practical diets for shrimp, and also an important source of nutrients like cholesterol and omega-3 fatty acids. Its inclusion rates in feed vary with shrimp species from 40 percent for the more carnivorous to as less than 25 percent for the more omnivorous shrimp.

Regardless of the species, the nutritional value of fishmeal is of critical importance for nutritionists and shrimp feed manufacturers who want to achieve the lowest formula cost with the highest nutritional value, and shrimp producers looking to maximize their production and feed conversion.

Quality and digestibility

Fishmeal quality is heavily dependent on the freshness of the fish, oxidation of the fats, and digestibility. Protein digestibility depends largely on the processing conditions under which the fishmeal is produced.

Fishmeal dryers are designed to remove large amounts of moisture without exposing the sensitive protein fraction to excessive temperatures, which reduces digestibility. Drying efficiency is achieved by using relatively high temperatures at the outset of the drying process, when evaporative cooling prevents scorching of the meal. Much lower temperatures are used at the end of the drying process, when moisture levels are minimal.

Indirect steam and hot air dryers are generally considered superior to direct-flame dryers in delivering consistent quality. However, new-generation direct-flame dryers can also produce top-quality fishmeal through careful control of initial and final temperatures.

Study setup

With support from Omega Protein, Inc., the authors recently conducted a study at the University of Nuevo León in Monterrey, Mexico, to determine the protein, dry matter, energy, and phosphorous digestibilities of three commercial fishmeals fed to western white shrimp, (*Litopenaeus vannamei)*. The fishmeals tested included one processed by indirect steam drying (Mexican-1) and two by direct flame: Omega Protein Menhaden Special Select and Mexican-2.

Experimental diets

The experimental diets and one reference diet were prepared containing 1 percent chromic oxide as an inert marker (Table 1). The main ingredients were ground through a No. 35 screen and then mixed for 15 minutes in a food mixer. Water was added to the mix to facilitate pelleting through a meat grinder equipped with a 1.6-mm-diameter die. The pellets were then dried in a convection oven at 100 degrees-C for eight minutes, allowed to cool, and stored at 4 degrees-C.

Bortone, Reference and test diet formulas, Table 1

Ingredients	Reference (Diet 1)	Mexican-1 (Diet 2)	Mexican-2 (Diet 3)	Menhaden (Diet 4)
Steam-dried sardine meal		300		
Flame-dried sardine meal			300	
Flame-dried menhaden meal				300
Steam-dried Chilean fishmeal	97	67.35		
Wheat flour	619	429.8		
Soybean meal	100	69.43		
Shrimp meal	30	20.83		
Methionine	2	1.39	1.39	
Fish oil	25	17.36	17.36	17.36
Soy lecithin (crude)	48.5	33.68	33.68	33.68
Wheat gluten	60	41.66	41.66	41.66

Ingredients	Reference (Diet 1)	Mexican-1 (Diet 2)	Mexican-2 (Diet 3)	Menhaden (Diet 4)
Additives:				
Chromic oxide	10	10	10	10
Stay C	0.5	0.5	0.5	0.5
Mineral mix	2.5	2.5	2.5	2.5
Vitamin mix	2.5	2.5	2.5	2.5
Mold inhibitor	0.5	0.5	0.5	0.5
Ethoxiquin	0.5	0.5	0.5	0.5
Cholesterol	2	2	2	2

Table 1. Reference and test diet formulas (g/kg ingredient mixture).

The apparent digestibility of the test ingredients was determined following Cho and Slinger (1979) using a test diet wherein the test ingredients replaced 30 percent of the complete formula of the reference diet. The chemical composition, gross energy, and phosphorus of the experimental diets were determined using standard laboratory methods. The dry matter loss and crude protein loss after one-hour immersion of the experimental diets in synthetic 30-ppt seawater at 28 degrees-C were also determined and replicated 3 times per diet.

Feces collection

Test parameters were determined from feces collected from four replicate tanks per diet treatment. Each tank held six shrimp of 8 grams initial weight. Animals were fed twice a day at a fixed daily ration of 4 percent of their biomass. Feces collection started after two days of holding and feeding the experimental animals.

Feces were collected 90 to 120 minutes after feeding by first removing uneaten feed and then siphoning off the feces, which were immediately rinsed with distilled water and stored in a freezer. Feces were collected for 12 days and pooled into sample of at least 3 grams (wet weight) per tank. Chromic oxide and nitrogen in the experimental diets and feces were analyzed using a modified micro-Kjeldahl method.

Statistical analysis

The apparent dry matter and apparent protein digestibilities of the diets were calculated using the equations of Maynard et al. (1981). Additionally, these values were adjusted for losses by leaching before feed ingestion. The ingredients' apparent dry matter, crude protein digestibility values, apparent energy, and phosphorus digestibility were also calculated.

The digestibility coefficients calculated from the feces samples were evaluated by analysis of variance and Duncan's multiple range test to first determine whether significant differences existed among the experimental diets, and then identify where they occurred.

Proximal composition

The proximal compositions of the fishmeals and diets tested are presented in Tables 2 and 3, respectively. The Mexican fishmeals, made from sardines, had proximal compositions similar to that of the menhaden meal, except for the lower fat level of the Mexican-2 sample.

Bortone, Fishmeal composition (%), Table 2

Parameter	Mexican-1 (Diet 2)	Mexican-2 (Diet 3)	Mexican-4 (Diet 4)
Moisture	6.93	8.60	6.13
Protein	62.50	62.04	62.84
Lipid	11.19	8.00	10.85
Ash	17.30	19.12	18.49
Phosphorus	2.68	2.90	2.75
Calcium	4.64	5.72	4.76
Analyzed energy content (Kcal/g)	4.52	4.62	4.49
Calculated energy content (Kcal/g)	4.56	4.23	4.55

Table 2. Fishmeal composition (%).

Bortone, Proximal analysis of diets (%) and dry matter, crude protein, and phosphorus losses, Table 3

Parameter	Reference (Diet 1)	Mexican-1 (Diet 2)	Mexican-2 (Diet3)	Menhaden (Diet 4)
Moisture	8.63	8.25	9.35	8.18
Protein	26.09	36.37	36.23	36.43
Lipid	9.85	9.88	8.78	9.63
Ash	4.34	8.30	9.14	8.55
Fiber	0.95	0.80	0.87	1.08
Nitrogen-free extract	50.15	36.40	35.63	36.13
Phosphorus	0.59	1.24	1.33	1.31
Calcium	0.53	1.57	1.81	1.55
Analyzed energy content (Kcal/g)	4.30	4.41	4.22	4.39
Calculated energy content (Kcal/g)	4.45	4.47	4.32	4.44
Dry matter loss	8.67	7.79	9.13	8.24
Crude protein loss	26.37	38.78	37.92	35.89
Phosphorus loss	20.4	19.7	13.7	18.5

Table 3. Proximal analysis of diets (%) and dry matter, crude protein, and phosphorus losses after one hour of immersion in seawater.

The three test diets had homogeneous proximal compositions, with protein and ash contents higher than those of the reference diet. The phosphorus and calcium contents were congruent with the global ash contents, with slightly higher values in the Mexican-2 diets, as expected in view of the higher ash content in the corresponding fishmeal.

Dry matter loss by immersion in seawater was homogeneous among the four diets at 8 percent, a normal value for diets made at the laboratory. Crude protein loss, however, was higher in the test diets, indicating a higher proportion of soluble protein in the test fishmeals than the reference diet. Loss of phosphorus in the Mexican-2 test diet was five points lower than the other diets.

Digestibility coefficients

Digestibility coefficients for protein, dry matter, phosphorus, and energy are presented in Table 4.

Bortone, Apparent protein, dry matter, phosphorus, and energy digestibilities in three types of fishmeal, Table 4

Parameter	Mexican-1 (Diet 2)	Mexican-2 (Diet 3)	Menhaden (Diet 4)
Apparent protein digestibility	73.9 ± 2.7^a	75.0 ± 1.9^a	86.3 ± 1.3^b
Apparent dry matter digestibility	72.9 ± 2.2^b	61.3 ± 2.0^a	78.3 ± 2.7^c
Apparent phosphorus digestibility	27.7 ± 6.3^b	13.9 ± 4.3^a	37.7 ± 3.2^c
Apparent energy digestibilitry	83.2 ± 3.7^b	67.7 ± 4.5^a	95.7 ± 3.4^c

Table 4. Apparent protein, dry matter, phosphorus, and energy digestibilities in three types of fishmeal, as obtained by standard determination (mean of four replicate values ± standard deviation).

The menhaden fishmeal showed significantly ($P < 0.001$) higher digestibility values than the Mexican sardine meals for protein, dry matter, phosphorus, and energy. Protein digestibility in the menhaden meal (86.3 percent) was 12 points higher than the Mexican sardine meals. This indicated improvements in processing conditions can have a positive effect, even using direct-flame dryers.

Regarding dry matter, phosphorus, and gross energy digestibility, the Mexican-1 fishmeal was 5, 10, and 12 points lower, respectively, than the menhaden fishmeal. There were even higher significant differences between the Mexican-2 and menhaden fishmeals for the same nutrients (18, 24, and 17 points, respectively). When leaching was considered by correcting the digestibility values for the nutrients that were not assimilated, these differences were maintained or increased (Table 5).

Bortone, Apparent protein and dry matter digestibilities, Table 5

Parameter	Mexican-1 (Diet 2)	Mexican-2 (Diet 3)	Menhaden (Diet 4)
Apparent protein digestibility	71.8 ± 2.9^a	71.4 ± 2.2^a	83.8 ± 1.6^b

Table 5. Apparent protein and dry matter digestibilities in three fishmeals, adjusted for leaching losses (mean of four replicate values ± standard deviation).

Conclusion

The menhaden fishmeal was superior to both Mexican fishmeals in terms of protein, dry matter, phosphorus, and energy digestibility. These results were not due to an excess of soluble nutrients, because the differences remained after correcting the data for the nutrients lost by leaching in seawater.

Because the Mexican fishmeals had ash content similar to that of the menhaden fishmeal, it can be speculated that the main differences in nutrient digestibility were due to specific processing conditions and not the method of drying or ash content. Controlling processing conditions resulted in increased digestibility and overall higher quality in the menhaden fishmeal.

Additional research is needed to further investigate the effects of processing conditions to determine the optimum area where fishmeal digestibility can be additionally improved and correlate this information to other factors like ash and total protein content.

Note: Cited references and further details of the experimental procedures used in this study are available from Dr. Eugenio Bortone.

(Editor's Note: This article was originally published in the October 2003 print edition of the Global Aquaculture Advocate.*)*

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