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Soybean Meal and Rendered Animal Protein Ingredients Replace Fishmeal in Practical Diets for Sea Bass

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Abstract

A 180-day feeding trial was carried out in net cages to examine replacement of fishmeal with soybean meal supported by meat/bone meal and blood meal in practical diets for sea bass (*Dicentrarchus labrax* L. 1758). Triplicate groups of fish (initial body weight 110 g) were fed one of four isonitrogenous (crude protein 46%) and isolipidic (10%) diets. A commercial sea bass diet containing 64% fishmeal as the sole animal protein served as the control. The other three diets contained 0, 20%, or 35% fishmeal and the reduced fishmeal was replaced by different levels of soybean meal, meat/bone meal, and blood meal. The final body weight of fish fed the diet containing 20% fishmeal, 50% soybean meal, 10% meat/bone meal, and 4% blood meal was significantly higher than that of the other three treatments. Results indicate that fishmeal can be reduced to 20% when soybean meal, meat/bone meal, and blood meal are used together in the diet.

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Introduction

Interest in sea bass culture has increased in most Mediterranean countries. Sea bass possess favorable traits important for commercial culture such as a pleasant flavor, good growth performance, and a large market demand. However, like other carnivorous fish, sea bass require a high dietary protein level (Amerio et al., 1989; Coves et al., 1991).

Historically, fishmeal has been the primary protein source in formulated feeds for sea bass. To reduce feed costs and develop a cost-effective and nutritionally balanced formulated diet for carnivorous fish, considerable research is being focused on alternative economical protein sources. Plant sources, e.g. soybean meal, and rendered animal protein, e.g. meat/bone and blood meals, have been investigated in feeds for gilthead sea bream (Robaina et al., 1997; Nengas et al., 1999), rainbow trout (Bureau et al., 2000), red drum (Kureshy et al., 2000), and sunshine bass (Webster et al., 2000). Rendered ingredients may be alternatives to fishmeal (Altan, 2002).

Materials and Methods

Feed. Meat/bone meal and blood meal were obtained from Tansas Co. Inc., Izmir, Turkey, while fishmeal, soybean meal, and fish oil were obtained from Camli Group, Izmir (Table 1).

Table 1. Chemical composition and amino acid profile of the major feed ingredients.

	<i>Ingredient</i>				
	<i>Fishmeal</i>	<i>Soybean meal</i>	<i>Meat/bone meal</i>	<i>Blood meal</i>	<i>Wheat meal</i>
<i>Chemical composition (%)</i>					
Dry matter	92.3	91.8	93.4	94.4	86.1
Crude protein	67	42	58.5	90.5	16.0
Crude lipid	9.3	2.2	13.2	0.0	1.5
Ash	16	6.6	21.7	3.9	0.8
Crude fiber	0.0	5.0	0.0	0.0	0.3
NFE	0.0	36	0.0	0.0	67.5
<i>Essential amino acids (%)</i>					
Thr	2.82	2.05	2.03	3.69	0.46
Val	3.17	2.27	2.70	7.75	0.68
Met	1.73	0.45	0.86	0.96	0.29
Ile	2.85	2.14	1.69	1.49	0.50
Leu	5.04	3.59	3.32	13.40	1.14
Tyr	2.20	1.34	1.31	2.53	0.38
Phe	3.01	2.37	2.24	6.58	0.9
Lys	5.24	3.18	3.85	9.52	0.35
His	1.82	1.33	1.05	7.54	0.38
Arg	4.70	3.31	4.78	4.02	0.64
Cys	0.60	0.41	0.56	1.03	0.27

Four test diets were formulated containing 46% crude protein and 10% crude lipid (Table 2). The control diet was commercial extruded sea bass pellets no. 3 (Camli Group, Izmir, Turkey). Experimental pellets were slow sinking (3 mm diameter), produced by a pelleting machine in the laboratory of the Department of Aquaculture and Fish Feed and Nutrition, Faculty of Fisheries, Ege University. After pelleting, diets were dried at 60°C and stored at room temperature, which ranged 22-28°C.

Samples of the diet ingredients and formulated diets were ground into a fine powder with a laboratory grinder. Dry matter was determined by drying to a constant weight at 105°C (AOAC, 1984). Nitrogen was determined using an elemental analyzer (Perkin-Elmer 2400, Norwalk, CT). Crude protein content was calculated from the nitrogen content by multiplying by 6.25. Crude lipid was determined by ether extraction, using a Soxtec system (Soxtec HT6, Hogenas, Sweden) and crude ash by combustion at 550°C (AOAC, 1984). Amino acid compositions in the ingredients and diets were determined by an official laboratory (TUBITAK, Ankara Test and Analysis Laboratory-ATAL, Ankara, Turkey) using high performance liquid chromatography and Official Method 982.30 Part E (AOAC, 2000).

Fish, feeding, experimental conditions. The experiment was conducted in an outdoor net cage system containing four 8.0-m³ net cages. Water temperature ranged 15-26°C, pH = 7.5, and dissolved oxygen ranged 6-6.5 mg/l. Sea bass (*Dicentrarchus labrax*) from the Department of Aquaculture facility were divided into the cages at a density of 190 fish per cage. For acclimation, the fish were fed an equal amount of the experimental diet twice a day (09:00 and 16:00) for ten days. At the beginning of the experiment, fish (avg wt 110±0.07 g) were not fed for one day, pooled, randomly selected, batch weighed, and allocated to 12 net cages at 50 fish per cage. The feeding trial lasted 180 days, during which the fish were fed thrice a day (09:00, 12:00, and 17:00).

Sample collection and chemical analysis. At the end of the 180 days, the fish were fasted for one day, then harvested and weighed to calculate survival, final body weight, and feeding efficiency ration (FER). FER was calculated as wet wt gain/dry feed intake × 100.

Statistical analysis. Results are presented as means±SD of three replicates. One-way analysis of variance was performed to examine the effects of diets. Tukey's procedure was used for multiple comparisons. Differences were regarded as significant when $p < 0.05$.

Table 2. Formulation, chemical composition, and amino acid profiles of the test diets.

	<i>Diet 1 Fishmeal (control)</i>	<i>Diet 2 50% soybean meal</i>	<i>Diet 3 70% soybean meal</i>	<i>Diet 4 35% soybean meal</i>
<i>Ingredient (%)</i>				
Fishmeal	64	20	-	35
Soybean meal	20	50	70	35
Meat/bone meal	-	10	10	10
Blood meal	-	4	4	4
Wheat meal	5	5	5	5
Fish oil	6	6	6	6
Vitamin premix	3	3	3	3
Mineral premix	1	1	1	1
Pellet binder	1	1	1	1
Antioxydant	0.1	0.1	0.1	0.1
<i>Chemical composition (%)</i>				
Dry matter	93.37	93.32	93.91	93.61
Crude protein	46.15	46.09	46.56	46.05
Crude lipid	10.09	10.70	10.17	10.82
Ash	9.65	10.69	9.17	10.35
Crude fiber	1.10	1.98	2.6	1.62
<i>Essential amino acids (%)</i>				
Thr	2.23	3.29	1.80	2.07
Val	2.50	2.38	2.20	2.52
Met	1.21	0.71	0.44	0.92
Ile	2.27	1.89	1.75	2.0
Leu	4.0	3.78	3.44	3.94
Tyr	1.69	1.36	1.19	1.49
Phe	2.44	2.32	2.19	2.41
Lys	4.0	3.42	1.0	3.72
His	1.50	1.45	1.36	1.52
Arg	3.70	3.26	2.99	3.47
Cys	0.48	0.44	0.40	0.46

Results

All diets were well accepted by the sea bass. Survival was 100% in all treatments. There were no significant differences in initial body weight among treatments (Table 3). The final body weight of fish fed the diet containing 20% fishmeal, 50% soybean meal, 10% meat/bone meal, and 4% bone meal was significantly higher than all other diet groups. There were no significant differences between the control and diets 3 and 4.

Table 3. Growth (g/fish) and feed efficiency ratio (FER) of sea bass fed diets in which fishmeal was replaced by soybean meal plus rendered animal protein sources (means±SD, n = 3 replicates of 50 fish each).

	<i>Diet 1</i> <i>Fishmeal</i> <i>(control)</i>	<i>Diet 2</i> <i>50% soybean</i> <i>meal</i>	<i>Diet 3</i> <i>70% soybean</i> <i>meal</i>	<i>Diet 4</i> <i>35% soybean</i> <i>meal</i>
Initial body wt	110.2±0.02	110.4±0.04	110.2±0.02	110.1±0.03
Final body wt	288.76±1.37	296.34±1.66	291.7±1.97	287.03±2.06
FER (%)	0.54	0.51	0.50	0.46

Discussion

Plant protein sources, such as soybean meal, and rendered animal protein sources, such as meat/bone meal and blood meal from rendering facilities, are generally considered inferior protein sources for feeding carnivorous fish. Rendered protein sources are rarely included in commercial diets for various reasons including poor digestibility, variable quality, amino acid deficiency, and mad cow disease (which appeared in Great Britain at the end of 1990s, causing serious concern for fear of contamination). Most fish producers refused feed from factories that used rendered ingredients. After that, when fishmeal prices started to increase rapidly, fish feed factories refused to reduce the fishmeal ration in fish feeds and use more rendered products as a way to control fishmeal prices.

Meat/bone meal is thought to be less than an ideal protein source than fishmeal due to its relatively poor amino acid profile. A lack of several indispensable amino acids such as lysine and methionine can lead to poor growth performance in trout (Watanabe and Pongmaneerat, 1991). Incorporation of a high level of meat/bone meal can result in a decrease in the digestible nutrient density of a feed. To meet the growth requirement and compensate for a low digestible nutrient density, fish fed nutrient-deficient diets must consume more feed. When fish consume more feed to achieve the same growth, feed efficiency is lowered (Bureau et al., 2000). Similar results were reported Robaina et al. (1997) and Yamamoto et al. (2002). In the present study, more than 30% of the fishmeal was replaced by a combination of soybean meal, meat/bone meal, and blood meal. According to our

formulations, the inclusion rate of soybean meal was the indicator for differences in final body weight among treatments.

Soybean products are generally high in protein, ranging from about 42% protein for soybean meal to over 70% protein for soy protein concentrate. Soybeans, like other plant-derived protein sources, have anti-nutritional factors that can reduce palatability, protein utilization, or growth (Hardy, 2000). Trypsin inhibitors decrease the activity of trypsin, a digestive enzyme that breaks down proteins in the intestine. Trypsin inhibitors lower protein digestibility in diets for salmon and trout (Arndt et al., 1999). This study showed that fishmeal in sea bass diets can be replaced with soybean meal when soybean meal is supported by rendered animal protein sources such as meat/bone and blood meal. Additionally, meat/bone and blood meals have nutritive value for sea bass.

It is predicted that there will be difficulty purchasing plant protein sources such as soybean meal in the future because of bio diesel applications. For that reason, if the health and nutritional value of rendered protein sources can be certified, they could become a useful component in commercial fish feeds. There are currently no precise rules regarding certification. However, if a process for certification of rendered animal sources develops, it will provide necessary assurances to fish producers and consumers alike.

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