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Replacement of fishmeal with poultry by-product meal in the diet of Florida pompano *Trachinotus carolinus* L.

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ABSTRACT

The development of cost-effective and growth-promoting diets for Florida pompano (*Trachinotus carolinus* L.) is necessary for a feasible pompano aquaculture industry in the United States. However, research efforts to reduce the utilization of marine ingredients in aquatic feeds are needed to accomplish such a goal. Three independent growth trials were conducted to evaluate the replacement of fishmeal in the diet of Florida pompano. The basal diets were formulated to contain 40% crude protein and 10% lipid using solvent extracted soybean meal and corn gluten as the primary and fixed protein sources. In Trial I (10 weeks) the basal diet containing 15% fishmeal (FM15) was modified by the isonitrogenous replacement of fishmeal with poultry by-product meal resulting in diets containing 10% (FM10), 5% (FM5) and 0% (FM0) fishmeal. In Trial II (12 weeks), the FM0 diet was supplemented with methionine (M), lysine (L), and taurine (T), serving as the basal diet (MLT) for the evaluation of potential limitations in these amino acids. By deleting individual amino acids, test diets without methionine (LT), lysine (MT) or taurine (ML) supplements were formulated. In Trial III (8 weeks), the FM0 diet from Trial I served as the basal diet (0% Tau) for the evaluation of potential limitations in taurine. Fish in replicate tanks ($n=3$) were fed one of the randomly assigned test diets two times daily. The total replacement of fishmeal in Trial I resulted in depression of fish performance while the performance of fish offered test diets with 5–15% fishmeal did not differ significantly. Reductions in weight gain (from 338.1 to 260.4%), feed efficiency (from 0.53 to 0.40), protein and energy retention (from 19.6 to 12.4% and from 20.4 to14.2%, respectively) were observed in fish fed the FM15 and FM0 diets, respectively ($P<0.05$). In Trial II, growth performance of pompano did not change ($P>0.05$) by the removal of supplemental methionine, lysine or taurine from the FM0 diet albeit, numerically the removal of taurine produced the smallest fish. In Trial III, the supplementation of taurine to the FM0 diet at 0.75 g/100 (0.75% Tau) improved the weight gain (from 587.7 to 773.3%), feed efficiency (from 0.50 to 0.64), and protein retention (from 20.5 to 24.3%) of pompano ($P<0.05$). Based on these results, we concluded that poultry by-product meal is a good alternative ingredient for fishmeal in the diet of Florida pompano and that this species appears to have a minimum dietary requirement for taurine.

1. Introduction

Florida pompano has excellent potential as an important species for marine aquaculture in the United States. Since the early 1960s, when research studies were initially conducted with the species (Berry and Iversen, 1967; Finucane, 1969; Moe et al., 1968), Florida pompano was rated as one of the best food fishes by consumers. Today, private operations are beginning to produce pompano in cages and intensive recirculating systems targeting the production of marketable sized fish year-round. The increasing interest for commercial production in the United States is driven by the strong consumer demand that consistently exceeds supply and by attractive prices. The prices of pompano filets can range from US$ 35 to US$ 45/kg, depending on the time of the year and availability (Weirich, 2011), making pompano aquaculture economically attractive.

Albeit most bottlenecks related with pompano production have been overcome, such as spawning in captivity and larval rearing, work is still necessary on the design of growth promoting diets that combine cost-effectiveness with low dependence on fishmeal as the primary protein source. Generally, fishmeal is incorporated in feeds for marine fishes at levels ranging from 30 to 60% (Wang et al., 2006). Research efforts have consistently reduced the levels of fishmeal used in aquatic feeds with the inclusion of plant based ingredients such as soybean meal. However, relative low levels of methionine and lysine, the presence of antinutritional factors, and palatability problems may limit high inclusion levels of soybean in diets of aquatic animals (Gatlin et al., 2007). The utilization of high levels of soy-based products to replace fishmeal has resulted in depressed growth of pompano (Davis et al., 2009; Lazo et al., 1998;

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Riche and Williams, 2011). Therefore, the evaluation of other potential alternative ingredients for fishmeal is necessary.

Animal by-products are potential alternative ingredients for fishmeal and are largely available in the United States. Poultry by-product meal is one of these alternative ingredients and has long been evaluated as a potential substitute for fishmeal in aquatic feeds (Fowler, 1991). It consists of rendered material from the waste generated from poultry processing plants and is composed of rendered parts of slaughtered poultry (Hardy and Barrows, 2002). The protein level and amino acid profile of poultry by-product meal are relatively similar to fishmeal (NRC, 2011) making the ingredient a valuable protein source for many species. Positive results on the utilization of poultry by-product meal to replace fishmeal in aquatic feeds have been reported for species such as black sea turbot *Scophthalmus maeoticus* (Turker et al., 2005), cuneate drum *Nibea miichthioides* (Wang et al., 2006), and hybrid striped bass *Morone chrysops* x *M. saxatilis* (Gaylord and Rawles, 2005; Rawles et al., 2006; Webster et al., 2000). In Florida pompano, considerably good poultry by-product meal digestibility was observed in the study conducted by Williams (2008), demonstrating its potential as an alternative ingredient.

As with many protein sources the supplementation of indispensable amino acids in low fishmeal diets containing poultry by-product meal may be necessary to optimize the growth of Florida pompano. The primary amino acids of concern are methionine and lysine because of their relative low levels in poultry by-product meal and plant based ingredients such as soybean meal. Another potential amino acid of concern is taurine. In the event of reducing fishmeal content in aquatic feeds, positive responses to supplemental taurine have been observed in an increasing number of species such as Japanese flounder *Paralichthys olivaceus* and Yellow tail *Seriola quinqueradiata*, indicating that a minimal taurine requirement must be satisfied for maximum growth and/or normal health. Considering that the ability of taurine biosynthesis varies among fish species (Goto et al., 2003; Yokoyama et al., 2001) and that plant based ingredients and poultry by-product contain little taurine, the evaluation of potential limitations in taurine and its potential indispensability in low fishmeal diets for Florida pompano is warranted.

The objective of this research was to explore the possibility of using poultry by-product meal in practical diets for juvenile Florida pompano. Due to potential limitation in amino acids, the need for lysine, methionine and taurine supplements was also evaluated.

2. Material and methods

2.1. Fish

Juvenile pompano (1.73 g mean weight) were obtained from Harbor Branch Oceanographic Institute, Fort Pierce, FL. Fish were loaded into a hauling tank equipped with a supplemental oxygen supply system and transported to the Alabama Department of Conservation and Natural Resources Marine Resource Division, Claude Peteet Mariculture Center (CPMC), in Gulf Shores, Alabama. At CPMC, fish were acclimated by slowly replacing the hauling water with local brackish water (12.0 g/L salinity, 6.6 mg/L dissolved oxygen and 7.75 pH) and subsequently stocked into a 5 m^3 fiberglass recirculating tank equipped with an independent biological filter, air lift pumps and supplemental aeration provided by a regenerative air blower and air diffusers. Fish remained in this tank for approximately 30 days acclimating to local conditions until adequate size for the growth trials was achieved. During this period fish were fed to apparent satiation with a 40% crude protein and 12% crude fat commercial diet (EXTR 400, Rangen Inc., Map Angleton, TX).

2.2. Diets

Experimental diets were produced at Auburn University, Department of Fisheries and Allied Aquacultures, Auburn, AL, USA. They were prepared by mixing pre-ground dry ingredients and menhaden fish oil in a food mixer (Hobart A200FT, Troy, OH, USA) for 15 min. Boiling water was blended into the mixture to promote appropriate consistency for pelleting. Subsequently, the moist mash from each diet was passed through a 3.0 mm die in the grinder. Wet diets were then placed into a forced air drying oven (<45 °C) for approximately 24 h attaining a moisture content of less than 10%. Dry diets were stored at −20 °C, and prior to use each diet was crumbled and sieved to an appropriate size. All experimental diets were formulated to be isonitrogenous and isolipidic, containing 40% crude protein crude protein and 8.0% lipid, using 50% soybean meal and approximately 5% corn gluten meal as the primary and fixed protein source.

2.2.1. Trial I: replacement of fishmeal with poultry by-product meal in pompano diets

This growth trial was conducted over a 10 week period to evaluate the replacement of fishmeal with poultry by-product meal on the growth performance and body composition of Florida pompano. The basal diet (FM15) was formulated to contain 15% fishmeal and the other three test diets were designed by gradually replacing 5% of the fishmeal with poultry by-product meal on an isonitrogenous basis (Table 1). The three test diets resulting from the fishmeal replacement contained 10% (FM10), 5% (FM05) and 0% (FM0) fishmeal. Supplemental methionine was used to maintain equal levels of this amino acid across diets.

Table 1
Composition of diets containing different levels of fishmeal and poultry by-product meal fed to juvenile Florida pompano (3.48 ± 019 g mean initial weight) for 10 weeks (Trial I).

	FM15	FM10	FM05	FM0
Ingredients (g/100 g as is basis)				
Menhaden Fishmeal special select[a]	15.0	10.0	5.00	0.00
Poultry by-product meal[b]	0.00	4.90	9.80	14.70
Soybean meal[c]	50.00	50.00	50.00	50.00
Menhaden fish oil[a]	5.30	5.25	5.20	5.15
Corn starch[d]	5.65	5.56	5.47	5.38
Whole wheat[d]	16.00	16.00	16.00	16.00
Corn gluten meal[e]	5.00	5.00	5.00	5.00
Lecithin (soy refined)[d]	1.00	1.00	1.00	1.00
ASA mineral premix[f]	0.25	0.25	0.25	0.25
ASA vitamin premix[g]	0.50	0.50	0.50	0.50
Choline chloride[d]	0.20	0.20	0.20	0.20
Stay C 250 mg/kg[h]	0.10	0.10	0.10	0.10
$CaPO_4$[d]	1.00	1.20	1.40	1.60
DL-methionine[i]	0.00	0.04	0.08	0.12
*Analyzed values (Dry matter basis)**				
Crude protein	37.5	37.8	37.9	38.5
Gross energy (kcal/100 g)	479.3	465.1	459.5	479.5

* Means: Percentage, otherwise noted.
[a] Omega Protein Inc., Reedville, Virginia, USA.
[b] Low ash poultry by-product meal (65% CP, pet food grade), Griffin Industries, Cold Spring, Kentucky.
[c] De-hulled solvent extracted soybean meal, Faithway Feed Co. Inc., Guntersville, Alabama, USA.
[d] MP Biochemicals Inc., Solon, Ohio, USA.
[e] Grain Processing Corporation, Muscatine, IA, USA.
[f] ASA Premix (g 100 g^{-1} premix): cobalt chloride, 0.004; cupric sulfate pentahydrate, 0.250, ferrous sulfate heptahydrate, 4.0, manganous sulfate anhydrous, 0.650; potassium iodide, 0.067; sodium selenite, 0.010; zinc sulfate heptahydrate, 13.193, and α cellulose 81.826.
[g] ASA Premix (g/kg Premix): thiamin HCL, 0.5; riboflavin, 8.0; pyridoxine HCl, 5.0; Ca-pantothenate, 20.0; niacin, 40.0; biotin, 0.040; folic acid, 1.80; cyanocobalamin, 0.002; vitamin A acetate (500,000 IU g^{-1}), 2.40; vitamin D_3 (400,000 IU g^{-1}), 0.50; DL-α-tocopheryl acetate, 80.0; and α cellulose, 834.258.
[h] Stay C®, (L-ascorbyl-2-polyphosphate 35% Active C), Roche Vitamins Inc., Parsippany, NJ, USA.
[i] Aldrich-Sigma, St. Louis, MO.