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Evaluation of Distillers Grains with Solubles in Prepared Channel Catfish Diets

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ABSTRACT

A feeding experiment was conducted for an 11-wk period in aquaria in which channel catfish, *Ictalurus punctatus*, fingerlings were fed diets containing 0, 10, 20, and 40% distillers grains with solubles (DGS), replacing some of the soybean meal and corn. After 11 wk, no significant differences in individual fish weight, percentage survival, or feed conversion were found among treatments ($P > 0.05$). Final individual weights were 17.3, 15.2, 13.2, and 16.5 g for fish fed diets containing 0, 10, 20, and 40% DGS, respectively. Feed conversion values averaged 3.0 for all treatments. Total length of fish fed 20% DGS were significantly smaller (107.4 mm) than fish fed the other diets ($P < 0.05$). These data indicate that distillers grains with solubles are suitable ingredients in channel catfish diets.

INTRODUCTION

Fish meal is the preferred protein source in fish diets; however, high cost has encouraged evaluation of other protein sources (1, 2, 3). Soybean meal has been used as a major protein source in diets of channel catfish, *Ictalurus punctatus* (4); tilapia, *Oreochromis aurea* (5); trout, *Oncorhynchus mykiss*, (6); and common carp, *Cyprinus carpio* (7). However, fish meal and soybean meal are usually the most expensive diet ingredients. Fixed-feed formulations, currently used in the preparation of channel catfish diets, use a set list of ingredients irrespective of ingredient prices. "Least-cost" feed formulations offer economic advantages in the preparation of a nutritious diet by changing formulations as ingredient prices fluctuate. However, before individual feedstuffs can be considered for inclusion, nutritional quality must be evaluated.

Distillers by-products were evaluated in fish diets as early as the 1940s (8). However, their use has been extremely limited. Sinnhuber (9) reported that a diet with 3% distillers dried solubles was readily accepted by trout. Robinette (10) stated that 7.5% distillers grains with solubles (DGS) could be included in a 36% protein channel catfish diet. A diet containing 15% distillers dried solubles was found to be adequate in catfish diets (11).

The nutritional requirements of channel catfish have been further elucidated since these early studies (12, 13, 14). It seems likely that a higher percentage of DGS could be included in a channel catfish diet. Biochemical composition of DGS indicates that a rate of 30% could probably be used in catfish diets when 10% fish meal is added (15). The objective of this study was to evaluate DGS as a partial replacement for soybean meal and corn in a 32% protein channel catfish fingerling diet.

MATERIALS AND METHODS

Ten full-sibling channel catfish (1.5 g) were randomly stocked into 16 40-liter glass aquaria provided with continuously-flowing water (26°C). The water-flow rate through each aquarium was maintained constant throughout the experiment (1.6 liters/min). Water was recirculated through a biological filter for metabolite removal and was treated by UV illumination to control pathogenic organisms.

Black plastic covered the front and sides of all aquaria to minimize disturbances (16). Dissolved oxygen and temperature were measured daily (Yellow Springs Instruments, Model 57). Ammonia, nitrite, and nitrate concentrations were measured twice weekly and alkalinity, hardness, and chloride were measured every two wk using a DREL/5 spectrophotometer (Hach Company, Loveland, Colorado) (Table 1). Determination of pH was made twice weekly using an electronic pH meter (Omega Engineering, Inc., Stamford, Connecticut).

All diets were formulated isocaloric (2.4 kcal/

TABLE 1. Summary of water quality analyses throughout the 11 week experiment.

Parameter	N[1]	Concentration (mg/liter)[2]
Alkalinity	5	33.3 ± 3.1
Chloride	5	1,489.2 ± 113.6
Dissolved oxygen	76	7.1 ± 0.2
Hardness	5	272.0 ± 58.7
Nitrate	22	11.5 ± 1.5
Nitrite	22	0.06 ± 0.01
pH	22	7.1 ± 0.2
Temperature (°C)	76	27.0 ± 1.0
Total ammonia nitrogen	22	0.13 ± 0.01

[1] Represents the number of samples analyzed throughout the experiment.
[2] Values are means ± SE.

g diet) and isonitrogenous (32% crude protein) (Table 2). The control diet was similar to a common commercial formulation and was composed of soybean meal, corn, fish meal, and vitamin and mineral supplements. Three experimental diets contained 10, 20, and 40% DGS, replacing equal parts of soybean meal and corn. All formulations met established nutrient requirements of channel catfish (14).

In preparing diets, dry ingredients were first ground to a small particle size (approximately 250 μm) in a Wiley mill. Ingredients were thoroughly mixed and water was added to obtain a 50% moisture level. Diets were extruded into 1.6 mm-diameter strands and dried (32°C) for 24 hr. Percentage protein was determined using a nitrogen determinator (LECO FP-228, LECO Corp.) and percentage fat was determined by ether extraction (17). Digestible energy (DE) values were estimated from DE values of the diet ingredients (14).

TABLE 2. Composition of four diets fed to channel catfish fingerlings.

Ingredient	Diet			
	Control	1	2	3
Soybean meal	49.5	44.5	39.5	29.5
Corn	38.0	33.0	28.0	18.0
Fish meal	8.0	8.0	8.0	8.0
Rice bran	4.0	4.0	4.0	4.0
DGS[1]	0.0	10.0	20.0	40.0
Premix[2]	0.5	0.5	0.5	0.5
Protein (%)	32.2	32.7	32.6	33.0
Crude fat (%)	4.9	6.9	6.1	6.8
DE (kcal/g diet)[3]	2.33	2.38	2.43	2.52

[1] DGS, distillers grains with solubles.
[2] Premix provided the following vitamins and minerals (IU or mg/kg diet): A (4532 IU), D (2266 IU), E (55 IU), K (11 mg), B12 (0.0088 mg), ascorbic acid (777.7 mg), folic acid (2.2 mg), riboflavin (13.2 mg), pantothenic acid (35.2 mg), niacin, (88 mg), choline (447.7 mg), choline chloride (515.9 mg), thiamine (1.1 mg), pyridoxine (11 mg), zinc (173 mg), iron (60 mg), copper (7.5 mg), iodine (3.75 mg), cobalt (1.6 mg), and manganese (180 mg).
[3] Digestible energy was calculated from tabular values of the feed ingredients (National Research Council (14)).

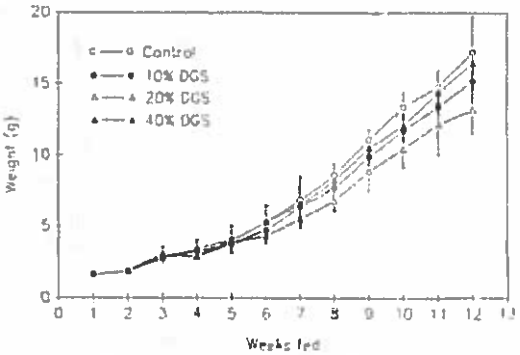

FIG. 1. Weight of channel catfish fingerlings fed four diets containing 0, 10, 20, and 40% distillers grains with solubles. Values are means of 4 replications ± SE. Means were not significantly different among treatments ($P > 0.05$).

Fish were fed 8% of body weight per day in 2 equal feedings at 0800 and 1600 hr for 11 weeks. The total number and weight of fish were determined and feed amounts were adjusted weekly. Total length of all fish was measured to the nearest 1.0 mm at the conclusion of the experiment. Feed conversion values were calculated as weight of food fed per wet weight gain. Protein efficiency ratio (PER) was defined as wet weight gain per gram of protein intake. All data were analyzed by analysis of variance using the SAS ANOVA procedure (18). Duncan's multiple-range test was used to determine where differences existed among treatments (19).

RESULTS AND DISCUSSION

Results indicate that distillers grains with solubles (DGS) can be used as partial replacements for soybean meal in channel catfish diets. After 11 weeks, no significant difference in individual body weight was observed in fish fed any of the diets ($P > 0.05$) (Fig. 1). Fish fed the control diet had a final body weight of 17.3 g while fish fed diets with 10, 20, and 40% DGS weighed 15.2, 13.2, and 16.5 g, respectively. Using published amino acid levels from the National Research Council (14) when combined with 10% fish meal (rich in lysine), up to 30% DGS should be suitable in catfish diets (15). This study indicates that channel catfish

TABLE 3. Length, survival, feed conversion ratio (FCR), and protein efficiency ratio (PER) in channel catfish fingerlings fed four diets containing distillers grains with solubles.[1]

Diet	Length (mm)	Survival (%)	FCR	PER
Control	115.2 ± 15.4[ab]	67.5 ± 12.6[a]	2.85 ± 0.40[a]	0.99[a]
10% DGS	114.1 ± 17.3[ab]	70.0 ± 25.8[a]	3.23 ± 0.86[a]	0.87[a]
20% DGS	107.4 ± 16.7[b]	80.0 ± 21.6[a]	3.20 ± 0.91[a]	0.88[a]
40% DGS	117.8 ± 13.4[a]	90.0 ± 14.1[a]	2.60 ± 0.14[a]	1.05[a]

[1] Values are means ± std. dev. of 4 replications. Means with the same superscript are not significantly different ($P > 0.05$)

fed a diet containing 40% DGS had growth rates similar to fish fed the control diet.

Diets containing DGS appeared to be palatable to channel catfish. Although percentage survival and feed conversion values were not significantly different ($P > 0.05$), fish fed a diet with 40% DGS had the highest survival (90.0%) and the lowest feed conversion (2.6) (Table 3). Fermentation and brewery by-products usually are highly palatable and may be beneficial as flavor enhancers (15). Mortalities were probably the result of stocking extremely small (1.5 g) fish. Some fish could not be trained to accept prepared diets. No mortalities were found after the fourth week of feeding.

Feed conversion values in this study were higher than usually reported for aquarium studies. This was probably due to feeding at a high percentage of body weight (8%) per day. This is higher than recommended (20); however, feed supply must not be limiting in nutrition experiments and overfeeding is more desirable than underfeeding (21).

The protein efficiency ratio (PER) value averaged 0.95 for all treatments and did not differ significantly among treatments ($P > 0.05$). Higher PER values indicate more efficient use of the diet. Overfeeding of fish probably resulted in lower PER values than reported by Lovell (22) and Robinson et al. (2), 1.70 and 2.04, respectively. However, PER values are influenced by dietary protein percentage (23). Robinson et al. (2) fed low protein diets which may have resulted in the higher PER value.

These data indicate that approximately 20% of the soybean meal can be replaced by DGS in conjunction with a 20% reduction in corn. Distillers grains with solubles are currently cheaper ($140/ton) and appear to be nutritionally adequate as a partial replacement for soybean meal ($200/ton). This should allow for greater flexibility in formulation of channel catfish diets.

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