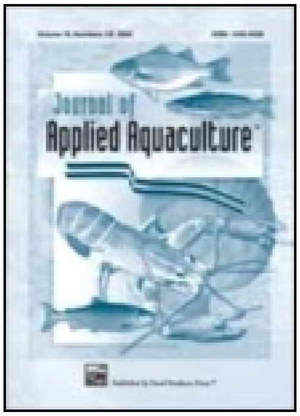

Journal of Applied Aquaculture
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjaa20

Winter Feeding and Growth of Channel Catfish Fed Diets Containing Varying Percentages of Distillers Grains with Solubles as a Total Replacement of Fish Meal

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Version of record first published: 18 Oct 2010.

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ABSTRACT. Channel catfish, *Ictalurus punctatus*, with an average initial weight of 515 g, were fed four experimental pelleted diets (1-4) with increasing percentages (0, 35, 55, or 90%) of distillers grains with solubles (DGS) during the winter. A fifth diet was formulated identical to diet 4 except that 0.6% supplemental lysine was added to meet the published requirement. Yield, individual weight, individual length, survival, and weight gain of fish were not significantly different ($P > 0.05$) among treatments. Average individual fish weight at harvest was 542 g and represented a weight gain of 5.4%. Percentage moisture, protein, and fat of waste (skin, head, and viscera) were not significantly different ($P > 0.05$) among treatments. Percentage protein of the dressed carcass of fish fed diet 4 (90% DGS without lysine) was significantly lower ($P < 0.05$) than in fish fed diet 3 (55% DGS), and percentage fat was significantly lower ($P < 0.05$) than in fish fed diet 5 (90% DGS + 0.6% lysine).

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Journal of Applied Aquaculture, Vol. 1(4) 1992

These data indicate that DGS is a suitable diet ingredient and can be used at levels up to 90% inclusion in winter diets for channel catfish without addition of supplemental amino acids. Use of DGS in diets may be economical, especially if prices of fish meal and soybean meal increase dramatically or if DGS is locally available.

INTRODUCTION

The pay-lake industry in some states, i.e., Kentucky, is an important market for cultured channel catfish, *Ictalurus punctatus*. These markets require large (700-800 g) fish, and peak needs are in the spring, making marketing potential especially good for producers who overwinter large fish (Cremer et al. 1984). Channel catfish raised in ponds are generally not fed or are fed restricted amounts during the winter. Lovell and Sirikul (1974) reported that channel catfish lost 10% of their body weight if held over winter without feeding. However, fish gained 20% of initial body weight during this period if fed at a rate of 1% of body weight when water temperatures were greater than 12°C.

Protein level in winter diets for channel catfish can be reduced from the standard 32% protein diet fed during the summer. Robinette et al. (1982) reported that winter growth in channel catfish fed a 25% crude protein diet was similar to that of fish fed a 35% crude protein diet. Dupree and Huner (1984) reported that animal protein, preferably fish meal, should comprise 50% of the protein in a winter diet for channel catfish. Fish meal is one of the most expensive ingredients in prepared fish diets. Fish nutritionists have tried to use less expensive plant protein sources to partially or totally replace fish meal. However, growth has tended to be reduced in fish fed diets in which plant protein has replaced all of the fish meal (Cowey et al. 1971; Lovell et al. 1974; Jackson et al. 1982).

Distillers grains with solubles (DGS) is a good protein source that is less expensive than fish meal and has been shown to be an acceptable ingredient in channel catfish diets (Tidwell et al. 1990; Webster et al. 1991). However, DGS is limiting in lysine if added in high percentages to a diet for channel catfish (NRC 1983).

Despite data indicting that winter feeding should be practiced (Felts 1977; Robinette et al. 1982; Mims and Tidwell 1989), little information has been reported concerning the use of economical, nutritious diets for feeding channel catfish during the winter. The objectives of this study were to evaluate growth, survival, and body composition of channel catfish overwintered in earthen ponds and fed diets containing various percentages of DGS as a partial replacement for soybean meal and as a total replacement for fish meal.

MATERIALS AND METHODS

Diets

Fish were fed one of five pelleted diets that were formulated isonitrogenously (26% protein) and isocalorically (2.7 kcal DE/g of diet) (Table 1). Diets contained either 0 (control), 35, 55, or 90% DGS. Amino acid compositions of the diets were determined from tabular values provided for dietary ingredients (NRC 1983). The diet with 90% DGS (diet 4) was calculated to be deficient in lysine for channel catfish (NRC 1983). A fifth diet was formulated to be identical to diet 4 (90% DGS), except that 0.6% supplemental lysine (as L-lysine HCl) was added to meet the dietary requirement of channel catfish. All diets were pelleted by a commercial feed mill (Farmers Feed, Inc., Lexington, Kentucky) into 1.0-cm sinking pellets. Diets were analyzed for crude protein, fat, moisture, and lysine content. Crude protein was determined using a LECO FP-228[1] nitrogen determinator (LECO Corp., St. Joseph, Michigan) (Sweeney and Rexroad 1987). Crude fat was determined by ether extraction, and moisture was determined by placing 15 g of sample in a drying oven (95°C) for 24 hours (AOAC 1990). Diets were stored in bags at − 30°C until fed.

Grow-Out

Channel catfish (average weight = 515 g; average total length = 36.0 cm) were randomly stocked on 30 October 1990 in twenty 0.04-ha earthen ponds at the Aquaculture Research Center, Kentucky State University, at 4,400 fish/ha. Ponds were approximately

[1]Use of trade or manufacturer names does not imply endorsement.

TABLE 1. Composition of diets containing various percentages of distillers grains with solubles (DGS) or DGS + L-lysine (LYS) fed to channel catfish raised in earthen ponds in the winter in Kentucky. Protein and lipid percentages are expressed on a dry weight basis.

	Diet				
	Diet 1 0% DGS	Diet 2 35% DGS	Diet 3 55% DGS	Diet 4 90% DGS	Diet 5 90% DGS+LYS
Ingredient					
Fish meal (67%)	12.0	12.0	12.0	0.0	0.0
Soybean meal (44%)	29.5	12.0	2.0	4.0	4.0
Corn	52.5	35.0	25.0	0.0	0.0
DGS[1]	0.0	35.0	54.75	90.0	89.4
CMC[2]	2.0	2.0	2.0	2.0	2.0
Premix[3]	0.005	0.005	0.005	0.005	0.005
L-lysine HCl	0.0	0.0	0.25	0.0	0.60

TABLE 1 (continued)

Dicalcium phosphate	1.0	1.0	1.0	1.0	1.0
Menhaden oil	1.5	1.5	1.5	1.5	1.5
Ascorbic acid	0.025	0.025	0.025	0.025	0.025
Lignosulfunate	1.47	1.47	1.47	1.47	1.47
Chemical analysis					
Dry matter (%)	90.74±0.07	91.64±0.06	93.42±1.08	92.50±0.11	92.54±0.07
Protein(%)	26.87±1.05	25.82±1.26	25.44±0.53	25.53±1.21	27.41±1.08
Lipid (%)	16.56±1.22	10.87±1.38	10.24±0.13	14.28±0.34	15.22±0.75
Lysine content (%)	1.24±0.09	1.16±0.07	1.13±0.10	0.75±0.10	1.08±0.06

TABLE 1 (continued)

	Diet				
	Diet 1 0% DGS	Diet 2 35% DGS	Diet 3 55% DGS	Diet 4 90% DGS	Diet 5 90% DGS+LYS
Cost[4]					
$/kg	$0.22/kg	$0.22/kg	$0.23/kg	$0.20/kg	$0.24/kg

[1]DGS = Distillers grains with solubles.

[2]CMC = Carboxymethylcellulose.

[3]Vitamin and mineral premix provided the following (%, IU, or mg/kg of premix): Z, 3.45%; Fe, 1.20%; Mn, 3.60%; Cu, 0.15%; I, 0.075%; Co, 0.03%; vitamin A, 880,000 IU; D_3, 44,000 IU; vitamin E, 11,000 IU; B_{12}, 1.76 mg; vitamin Kachsito, 2,200 mg; menadione, 500.5 mg; riboflavin, 2,640 mg; pantothenic acid, 7,040 mg; thiamine, 2,200 mg; niacin, 17,600 mg; B_6, 2,200 mg; folic acid, 440 mg; choline chloride, 103,096 mg; choline, 89,487 mg; ascorbic acid, 155,674 mg.

[4]Costs were based on ingredient prices in Anon. (1991).

1.5 m deep and were supplied with water from a reservoir filled by rain runoff. Water levels were maintained at a constant depth by periodic additions.

Fish were fed once daily (1330) according to a feeding chart (Robinette et al. 1982) based on prevailing water temperature recorded at a depth of 0.75 m. Daily feed amounts were adjusted every two weeks, based upon a 3:1 estimated feed conversion ratio. Fish were fed a total of 89 days, with fish being fed at 0.5% of body weight for 45 days, at 1.0% of body weight for 33 days, and at 2.0% of body weight for 11 days. Fish were not fed 73 days during the study, due to low (<7°C) water temperatures. Each treatment was replicated in four ponds.

Dissolved oxygen (DO) and temperature of all ponds were monitored twice daily (0900 and 1430) at a depth of 0.75 m, using a YSI Model 57 oxygen meter. When the dissolved oxygen level of any pond was predicted (graphically) to decline to below 5.0 mg/l, emergency aeration was provided. Total ammonia nitrogen (TAN) and nitrite were measured once weekly (1330) using a Hach DREL/5 spectrophotometer; alkalinity was measured once weekly using a sulfuric acid titration method (Hach Co.); pH was measured once weekly using an electronic pH meter (Accumet Model 900; Fisher Scientific).

Harvest Data

Fish were not fed 24 hours prior to harvest. Ponds were partially drained, and fish were harvested by seine on 23 April 1991. Total number and weight of fish in each pond were determined at harvest. Twenty-five fish were randomly sampled from each pond, individually weighed to the nearest gram, and measured (total length) to the nearest centimeter. Ten fish were randomly sampled from each pond and analyzed for dressout percentage. Three of these fish were randomly sampled for analyses of body composition. Fish were skinned by machine and dressed by removing head and viscera. Dressed carcass and waste (head, skin, and viscera) from the fish were homogenized separately in a blender and analyzed for moisture, protein, and fat, using the techniques described earlier.

Statistical Analysis

Data were analyzed using the SAS ANOVA procedure (Statistical Analysis Systems 1988) for significance. Duncan's multiple range test was used to determine statistical differences ($P < 0.05$) among means. All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984).

RESULTS AND DISCUSSION

Water Quality

No significant differences ($P > 0.05$) were found among treatments, so water quality values were pooled and averaged ± SE: dissolved oxygen (morning) – 11.48 ± 0.08 mg/l; dissolved oxygen (afternoon) – 13.10 ± 0.15mg/l; water temperature (morning) – 8.00 ± 0.05°C; water temperature (afternoon) – 9.03 ± 0.08°C; total ammonia nitrogen – 0.44 ± 0.03 mg/l; nitrite – 0.005 ± 0.001mg/l; pH – 8.33 ± 0.04.

Fish Growth

There were no significant differences ($P > 0.05$) in net production, individual fish weight, individual fish length, survival, or weight gain for channel catfish fed any diet (Table 2). Percentage dressout of fish fed the diet containing 0% fish meal and 90% DGS (diet 4) was significantly ($P < 0.05$) lower (52.4%) than fish fed diet 3 (55.1%) but was not significantly different ($P > 0.05$) from fish fed other diets. Channel catfish fed diet 4 had growth similar to fish fed other diets. These results should be viewed with some caution because of the variation within each treatment. Fish fed diet 2 had the highest, although not statistically significant, weight gain (44.4 g/fish), while fish fed diet 4 had the lowest weight gain (12.2 g/fish). Tidwell and Mims (1991) reported similar weight gains (40 g/fish) in adult channel catfish (544 g) fed a 32% protein diet.

At low water temperatures, protein requirements of fish tend to decrease, allowing for diets with lower protein levels to be effectively utilized. Delong et al. (1958) reported that chinook salmon, *Oncorhynchus tshawytscha*, required a higher protein diet as water

TABLE 2. Mean ± SE total pond yield, individual weight, individual length, survival, weight gain, and dressout percentage for channel catfish fed diets containing various percentages of distillers grains with solubles (DGS) or DGS + L-lysine (LYS). Means in the same row followed by different letters were significantly different ($P < 0.05$).

	Diet				
	1 (0% DGS)	2 (35% DGS)	3 (55% DGS)	4 (90% DGS)	5 (90% DGS+LYS)
Pond yield (kg/ha)	2680.0±110.0a	2741.2±186.2a	2649.1±150.9a	2488.0±101.0a	2606.6±96.1a
Indiv. wt (g)	566.1±23.4a	577.0±26.8a	574.5±34.5a	556.2±38.5a	553.6±24.0a
Indiv. length (cm)	38.4±0.3a	38.3±0.1a	38.5±0.7a	38.5±0.6a	38.3±0.2a
Survival (%)	98.5±1.2a	94.9±2.9a	98.8±0.6a	96.9±1.3a	98.4±1.2a
Weight gain (%)	6.9±4.3a	2.7±2.00a	4.4±6.0a	2.5±3.9a	4.9±3.3a
Weight gain (g)	35.2±21.9a	44.4±39.5a	22.6±30.7a	12.2±19.7a	25.2±16.9a
Dressout (%)	54.1±0.9ab	53.8±0.6ab	55.1±0.4a	52.4±0.8b	53.5±0.6ab

temperature increased. Hastings (1974) reported that lower protein diets could be used as efficiently by channel catfish as higher protein diets if water temperatures were below 24°C. Robinette et al. (1982) stated that channel catfish fed a low protein (25%) diet had growth similar to fish fed a high protein (35%) diet at low (9-10°C) water temperatures.

Results from this study indicate that channel catfish fed a diet containing 26% protein with 0% fishmeal (diets 4 and 5) did not have significantly different weight gains than did fish that were fed a 26% protein diet containing 12% fish meal (diet 1). Efficient utilization of low protein diets (25-27%) during cold water temperatures may indicate lower amino acid requirements than reported for warmer temperatures. The lysine requirement of channel catfish has been established as 5% of protein (NRC 1983). For a 26% protein diet, the lysine requirement should be 1.30% of diet. However, channel catfish fed a lysine "deficient" diet (diet 4, with only 0.72% lysine) had weight gains that were not statistically different from fish fed diets with 1.1-1.3% lysine. Supplemental lysine added to a diet (diet 5) did not significantly improve weight gain.

Total replacement of fish meal, one of the most expensive diet ingredients, with less expensive plant proteins, has been attempted by numerous fish nutritionists with limited success (Appler 1985; Ng and Wee 1989; El-Sayed 1990). Data from this study indicate that the decreased protein levels of winter diets in temperate regions could be supplied by 0% fish meal and 90% DGS. Reductions in percentage protein and in fish meal in winter diets for channel catfish may provide an economic advantage to fish culturists, especially since supplemental amino acids do not appear to be necessary. Diet 4 cost approximately $20/ton less than did diets 1-3.

Dupree and Huner (1984) stated that animal protein may be more readily digested under winter feeding conditions than plant proteins and that at least 50% of the protein should be from animal sources. Data from this study suggest that a diet with 90% DGS is sufficient for growth of overwintered channel catfish in temperate regions. However, results could differ in regions with warmer winter temperatures (Robinette et al. 1982). Diets with higher protein and fish meal percentages could be required for optimal fish growth and health in these regions.

Body Composition

Percentage composition (dry-weight basis) of waste (head, skin, and viscera) were not significantly different ($P > 0.05$) among treatments (Table 3). Percentage protein and fat averaged 46.7% and 31.5%, respectively. In the waste portion, percentage moisture was significantly ($P < 0.05$) higher in fish fed diet 4 (67.8%) than in fish fed diet 5 (64.2%); however, the difference was not significantly ($P > 0.05$) different from those fish fed other diets.

Percentage moisture of the dressed carcass was not significantly different among treatments ($P > 0.05$) and averaged 69.3% (Table 3). Percentage protein in the carcass of fish fed diet 3 was significantly higher ($P < 0.05$) (60.0%) than in fish fed diet 4 (50.8%) but was not significantly different ($P > 0.05$) from fish fed the other diets. Percentage fat in the carcass of fish fed diet 4 was significantly lower ($P < 0.05$) than in fish fed diet 5 but was not significantly different ($P > 0.05$) from fish fed the other diets. Carcass composition data from this study are in agreement with values reported by Lovell and Sirikul (1974) for winter growth of channel catfish.

This study suggests that body composition of channel catfish was generally not affected when fish were fed diets containing various percentages of DGS during the winter. Weight gain of the fish represented muscle growth, as indicated by the percentage of protein in the carcass (Table 3). By feeding channel catfish during the winter, muscle loss can be avoided. Lovell and Sirikul (1974) reported that during the winter, fasting channel catfish catabolize body protein for their energy requirements. They found that fish that were not fed during the winter lose weight but have a higher percentage of body fat and have a lower percent of body protein compared to fish that were fed. However, data from this study suggest that fish did not use protein to meet energy requirements. This is in agreement with Robinette et al. (1982).

It appears that DGS is a suitable ingredient for winter catfish feeds with inclusion rates as high as 90%. In most geographical areas, DGS is economical and readily available. Presently, a DGS-based diet has only a small economic advantage ($18/ton savings) over the fish meal/soybean meal diets currently used. However, use

TABLE 3. Mean ± SE percentage protein, fat (dry-weight basis), and moisture of waste (head, skin, and viscera) and dressed carcass of channel catfish fed diets containing various percentages of distillers grains with solubles (DGS) and DGS + L-lysine (LYS). Means in the same row followed by a different letter are significantly different ($P < 0.05$).

	Diet				
	1 (0% DGS)	2 (35% DGS)	3 (55% DGS)	4 (90% DGS)	5 (90% DGS+LYS)
Waste					
Protein (%)	49.46±1.92a	42.39±4.16a	50.22±4.85a	42.63±1.89a	48.76±3.96a
Fat (%)	30.45±1.20a	31.10±1.32a	31.15±2.33a	31.37±2.38a	33.17±1.84a
Moisture (%)	68.28±1.11a	65.08±1.31ab	66.07±0.58ab	67.80±0.71a	64.22±0.99b
Carcass					
Protein (%)	58.20±4.62ab	55.93±4.11ab	60.01±4.12a	50.81±2.09b	53.73±1.68ab
Fat (%)	32.17±1.77ab	33.35±1.21ab	34.76±4.13ab	26.64±3.94b	34.95±0.71a
Moisture (%)	68.95±1.83a	70.32±0.92a	69.28±1.05a	69.03±1.38a	69.12±0.48a

of DGS may allow producers greater flexibility in diet formulation without loss of fish performance, should the price of fish meal or soybean meal increase. Further research should be conducted before high percentages of DGS (>50%) are used in commercial diets, especially in regions with more moderate winter climates.

ACKNOWLEDGMENTS

We thank Eddie Reed and Robert Harrod for their technical assistance and Paul Weston for use of his laboratory. This research was partially funded by a USDA/CSRS grant to Kentucky State University under agreement KYX-89-88-03A.

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