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Evaluation of Distillers Dried Grains with Solubles as an Ingredient in Diets for Pond Culture of the Freshwater Prawn *Macrobrachium rosenbergii*

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Abstract

Distillers dried grains with solubles (DDGS) were evaluated as an ingredient in practical diets for pond culture of the freshwater prawn *Macrobrachium rosenbergii*. Juvenile prawns averaging 0.66 ± 0.47 g were stocked into nine 0.02 ha ponds at 19,760/ha. Three isonitrogenous diets (29% crude protein) containing 0, 20, or 40% DDGS were fed to shrimp in triplicate ponds. Average yield, survival, individual weight, and feed conversion did not differ significantly ($P > 0.05$) among treatments. When averaged over the three diets, results were: yield, 833 kg/ha; survival, 75%; individual weight, 57 g; and feed conversion, 3.1. It appears that DDGS is a suitable ingredient for use in practical diets for freshwater prawns at levels of up to 40% of the total formulation, when prawns are stocked at the densities used in this study.

For approximately 20 years, research has been conducted directed toward the development of economically successful monoculture of the freshwater prawn *Macrobrachium rosenbergii* in temperate climates. These investigations have used a variety of feeds, but little effort has been devoted to improvement of feeds or feeding practices. Development of inexpensive high quality diets is extremely important because feed costs represent more than 50% of production costs for most aquaculture enterprises (Lovell 1989). At least a part of the development process involves investigation of alternative feed ingredients (D'Abramo and Lovell 1991).

Distillers dried grains with solubles (DDGS) are primary fermentation residues from yeast fermentation of cereal grains and are a good source of protein (29% crude protein), without the documented antinutritional factors present in soybean meal (Wilson and Poe 1985; Shiau et al. 1987) or cottonseed meal (Robinson and Brent 1989). It has been reported that DDGS could be incorporated at levels of up to 40% of the total formulation in diets for channel catfish *Ictalurus punctatus* without adverse effects on catfish growth (Tidwell et al. 1990; Webster et al. 1991). D'Abramo (1986) stated that the availability and chemical composition of DDGS make it an excellent candidate for inclusion in practical crustacean feeds.

The present study was designed to evaluate DDGS as a potential ingredient in diets for freshwater prawn *M. rosenbergii* grown in monoculture in earthen ponds.

Materials and Methods

Description, Preparation and Stocking of Ponds

Ponds were located at the Aquaculture Research Center, Kentucky State University, Frankfort, Kentucky. The surface area of all experimental ponds was 0.02 ha and average water depth was approximately 1.1 m. Less than one week prior to the anticipated stocking date, ponds were filled and treated with two applications of liquid fer-

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tilizer (10:34:0) at an initial rate of 9.0 kg/ha of phosphorus to achieve an algal bloom. One 7.6 cm air-lift pump operated continuously in the deepest area of each pond to prevent thermal stratification.

Juvenile prawns were transported from the Aquaculture Unit of the Mississippi Agricultural and Forestry Experiment Station (MAFES), Starkville, Mississippi, on 4 June 1991. On the stocking date (6 June 1991), the mean stocking weight was determined from a sample of 40 prawns that were blotted dry and individually weighed ($\bar{x} \pm SD = 0.66 \pm 0.47$). Three replicate ponds were randomly assigned to each of the three experimental diets containing different levels (0, 20, and 40%) of distillers dried grains with solubles (DDGS). Prawns were hand counted and distributed to the ponds at a density of 19,760/ha.

Samples

A 3.2 mm square mesh seine was used to collect a sample of individuals from each pond every three weeks during the growing season. Prawns composing the sample were individually weighed (wet weight) to the nearest 0.1 gram and returned to the pond.

Feed and Feeding Rates

Experimental diets were formulated to contain 32% crude protein. Due to variations in ingredient composition, diets assayed 29% crude protein after manufacture. The composition of the control diet was similar to that of the diet utilized by D'Abramo et al. (1989) and contained no DDGS (Table 1). For the two experimental diets, DDGS were added at 20% and 40% of the formulation, partially replacing soybean meal and corn. The DDGS used in the study was a homogenous composite from seven distilleries, provided by the Distillers Feed Research Council, Des Moines, Iowa. Dietary ingredients were processed into 5 mm sinking pellets by a commercial feed mill (Farmers Feed Mill, Lexington, Kentucky). Dietary protein levels were determined using macro-Kjeldahl, fat by acid hydrolysis, and moisture by drying to constant weight in a convection oven at 95 C (AOAC 1990) (Table 1).

TABLE 1. *Ingredient composition, proximate analysis, and relative ingredient costs of experimental diets containing different percentages of distillers dried grains with solubles (DDGS).*

Ingredient	Diet DDGS (%)		
	0%	20%	40%
Fish meal (67%)	15.00	15.00	15.00
Soybean meal (44%)	30.00	30.00	19.00
DDGS	0.00	20.00	40.00
Ground corn	23.75	11.75	2.75
Meat & bone meal	8.00	0.00	0.00
Wheat flour	13.00	13.00	13.00
Mineral mix[a]	0.10	0.10	0.10
Vitamin mix[b]	0.10	0.10	0.10
Choline	0.05	0.05	0.05
Binder[c]	10.00	10.00	10.00
Analyzed composition (as fed)			
Protein	29.37	28.70	29.28
Lipid	5.18	5.46	6.88
Moisture	9.69	9.75	9.75
Relative ingredient cost[d]	1.051	1.027	1.000

[a] Mineral mix contained: Mn, 10.0% (as $MnSO_4$); Zn, 10.0% (as $ZnSO_4$); Fe, 7.0% (as $FeSO_4$), Cu, 0.7% (as $CuSO_4$); I, 0.24% (as $CaIO_3$); Co, 0.10% (as $COSO_4$); Ca, as carrier.

[b] Vitamin mix contained: thiamin (B_1), 1.01%; riboflavin (B_2), 1.32%; pyridoxine (B_6), 0.9%; nicotinic acid, 8.82%; folic acid 0.22%; cyanocobalamine (B_{12}), 0.001%; pantothenic acid, 3.53%; menadione (K), 0.2%; ascorbic acid (C), 33.1%; retinol palmitate (A), 4,409 IU/kg; cholecalciferol (D_3), 2,204,600 IU/kg; alpha-tocopherol (E), 66.2 IU/kg; ethoxyquin, 0.66%.

[c] Lignin sulfonate.

[d] Ingredient costs were based on prices quoted in *Feedstuffs* 1992,64(3):62.

Two separate feedings, each consisting of one-half of the total daily ration, were distributed over the entire surface of each pond between 0900–1000 h and between 1500–1600 h. Prawns were fed a percentage of body weight based on a feeding schedule reported by D'Abramo et al. (1989). Feeding rates were adjusted weekly based on an assumed 3.0 feed conversion (D'Abramo et al. 1989) throughout the study. Every three weeks, biomass estimates were adjusted ac-

cording to sample weights. Survival was assumed to be 100%.

Water Quality Management

Dissolved oxygen (DO) and water temperature in all ponds were monitored twice daily (0900 h and 1530 h) by means of a YSI Model 57 oxygen meter (Yellow Springs Instruments, Yellow Springs, Ohio). When the DO level of any pond was predicted (graphically) to decline to below 4.0 mg/L, nightly aeration was provided to that pond using an electric vertical pump aerator. Levels of total ammonia nitrogen (TAN) and nitrite in water samples collected from each pond (approximately 1300 h) were determined weekly according to the outlined procedures for a Hach DREL/5 spectrophotometer (Hach Co., Loveland, Colorado). The pH of each pond was determined daily (at 1300 h) using an electronic pH meter (Omega Engineering, Inc., Stamford, Connecticut).

Harvest

One day prior to harvest, water levels in ponds were lowered to approximately 0.9 m at the drain end. Each pond was seined three times on 15 September 1991 using a 1.3 cm square mesh seine. A complete draining of the ponds followed and remaining prawns were manually harvested from the pond bottom and purged in clean water. Total weight and number of prawns from each pond were recorded at harvest. A sample of 50 prawns per pond were randomly collected, individually weighed, and classified into three female morphotypes: berried (egg carrying), non-berried (previously egg carrying), and virgin; and three male morphotypes, blue-claw, orange-claw, and small (<20 g), as described by Cohen et al. (1981). Ten prawns from each pond were randomly selected and sacrificed. Tails of these individuals were removed, peeled and homogenized in a blender. Samples were stored in polyethylene bags, and frozen (−15 C) for subsequent moisture, protein, and lipid analysis. Moisture and protein levels were determined according to the procedures previously described for diets. Lipid was determined by ether extraction (AOAC 1990).

Sensory Evaluation

Preparation for sensory evaluation of prawns from the three dietary treatments consisted of thawing overnight at 2 C, cooking in boiling water for approximately eight minutes, and cooling to room temperature (Silva and Ammerman 1989). Each member of an eight-member panel evaluated two shrimp, randomly sampled from each of the nine ponds, for odor, appearance, texture, and flavor. A 9 point hedonic scale was used to rank the samples with the 9 rating being "like extremely" and 1 rating being "dislike extremely" (Larmond 1977).

Statistical Analysis

Growth performance and feed conversion were measured in terms of final individual prawn weight (g), percentage survival, total yield (kg/ha), and feed conversion ratio (FCR). Data, including sensory evaluation results, were analyzed by ANOVA using the SAS ANOVA procedure (SAS Institute, Inc. 1988). Duncan's multiple range test was used to compare treatment means. Percentage survival, FCR, and tail composition (percentage moisture, protein, and lipid) were transformed to arc sin values prior to analysis (Zar 1984).

Results and Discussion

Through the duration of the study, water quality parameters did not differ significantly ($P > 0.05$) among treatments. Water quality parameters averaged (±SE): water temperature (AM), 25.6 ± 0.9 C; water temperature (PM), 27.3 ± 1.1 C; DO (AM), 7.5 ± 0.7 mg/L; DO (PM), 11.0 ± 0.7 mg/L; TAN, 0.05 ± 0.02 mg/L; nitrite, 0.000 ± 0.001 mg/L; and pH, 8.5 ± 0.2. Maximum recorded pH was 9.8.

Pond culture was terminated after 101 days. Mean weight of prawns fed diets containing 0, 20, and 40% DDGS averaged 59.0,

TABLE 2. *Harvest weight, survival, yield, feed conversion (FCR), and proximate composition of tails from prawns fed diets containing different levels of distillers dried grains with solubles (DDGS) for 101 days.*[a]

Parameter	Diet (% DDGS)		
	0%	20%	40%
Harvest weight (g)	59.0 ± 5.0	60.7 ± 10.2	50.9 ± 3.4
Survival (%)	68.6 ± 4.6	75.5 ± 12.4	81.3 ± 11.3
Yield (kg/ha)	797.3 ± 49.0	889.1 ± 52.1	815.1 ± 11.3
FCR[b]	3.1 ± 0.3	3.1 ± 0.3	3.2 ± 0.7
Tail composition at end of test (%)			
Moisture	77.2 ± 0.8	77.5 ± 1.2	78.3 ± 0.5
Protein	20.3 ± 0.5	20.5 ± 1.0	20.0 ± 0.5
Lipid	<0.1	<0.1	<0.1

[a] There were no significant differences ($P > 0.05$) for any variables among treatments.
[b] FCR = feed conversion ratio; total diet fed/total weight gain.

60.7, and 50.9 g, respectively (Table 2) and were not significantly different ($P > 0.05$). Average weights were comparable to those reported for *M. rosenbergii* at low stocking densities in polyculture studies (30–70 g) (D'Abramo et al. 1986; Heinen et al. 1987; Heinen et al. 1989) and higher than average weights reported for prawns fed unpelleted distillers by-products at similar densities (11 g) (Kohler 1987).

Survival, feed conversion, and yield did not differ significantly ($P > 0.05$) among treatments (Table 2). Survival in individual ponds ranged from 62% to 91%, averaging 75% overall. D'Abramo et al. (1989) reported a similar range of survivals (54% to 90%) with an overall average of 70%. Feed conversions in this study averaged 3.1 and were similar to an average of 3.5 for pond culture studies conducted by D'Abramo et al. (1989) over two separate growing seasons. Mean yield was 834 kg/ha overall and was much higher than reported by Kohler (1987) who averaged 229 kg/ha feeding unpelleted DDGS under similar conditions (i.e., density and growing season).

Water stability of pellets may be an important factor. Fair and Fortner (1981) compared growth responses of prawns fed a water-stable pelleted diet with animals fed pulverized pellets. Prawns fed water-stable pellets grew twice as fast. Densities in this study were lower (19,760/ha), but total yields were similar to those obtained at higher stocking densities (39,536/ha) in monoculture (D'Abramo et al. 1989), because of the larger average prawn size (57 and 32 g, respectively). With similar total yields and larger average prawn size production economics may be improved. These similar yields are especially notable when the 35–40 day shorter culture period in this study is considered.

Average number, size, and percent contribution to total weight by each morphotype did not differ significantly among treatments ($P > 0.05$) and were comparable to those reported by D'Abramo et al. (1989), except for biomass contributed by blue-claw males (20%) that was 10–15% greater. The ratio of small male (<20 g) to orange-claw to blue-claw male prawns averaged 0.7:2.5:1 and the ratio of berried to non-berried female prawns 0.83:1 in our pond populations.

Organoleptic evaluations of prawns from each of the three dietary treatments indicated no negative impact on sensory characteristics from the inclusion of up to 40% DDGS in the diets. There were no significant differences ($P > 0.05$) among shrimp fed the three diets in odor, appearance, texture, or taste. Johnson and Dupree (1991) found that sensory attributes of channel catfish were not affected when distillers solids were incorporated at 10% of a diet formulation.

Results suggest that DDGS is a suitable

ingredient for inclusion in practical diets for pond culture of prawns at levels of 40% of the total formulation. Future studies should investigate diets containing higher DDGS percentages, higher culture densities, and effects of reducing feed costs by decreases in premix and fish meal levels.

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