Use of Defatted, Glandless Cottonseed Flour and Meal in Channel Catfish Diets

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Abstract: Defatted, glandless cottonseed flour and meal appear to be of relatively high nutritive value for fingerling channel catfish. Growth and feed conversions were not significantly different in fish fed diets in which glandless, defatted cottonseed flour or meal replaced varying amounts of solvent extracted soybean meal. Supplemental lysine did not significantly improve fish performance.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 37:358–363

Protein is the most expensive component of commercial catfish feeds; therefore, economical sources of high quality protein would be beneficial in reducing feed costs. Cottonseed meal, the second largest vegetable-protein concentrate by tonnage produced in the United States, is often priced competitively. However, cottonseed meal has been used sparingly in commercial catfish feeds primarily because of the adverse effects of gossypol found in the glanded meals. Gossypol has been shown to reduce available lysine from cottonseed meal (Wilson et al. 1981) and to depress growth in catfish (Dorsa et al. 1982).

Genetic selection has led to the development of a glandless cottonseed that is essentially free of gossypol. This has allowed the study of the nutritional characteristics of cottonseed protein without the detrimental effects of gossypol. A series of studies have been conducted in our laboratory to evaluate glandless cottonseed products in fish diets. The present report is based on studies to determine the suitability of using defatted, glandless cottonseed flour and meal as a substitute for soybean meal in catfish diets.

This research was supported by the Texas Agricultural Experiment Station under Project H-6556 and by Cotton Incorporated, Raleigh, North Caro-

Table 1. Percentage composition (dry weight basis) of experimental diets fed in Experiment 1.

Ingredient	Diet number 1	2	3	4	5
Soybean meal	50.0	37.5	25.0	0.0	0.0
Cottonseed flour[a] (glandless defatted)	0.0	11.2	22.3	44.6	44.6
Wheat	21.9	21.9	21.9	21.9	21.9
Menhaden fish meal	10.0	10.0	10.0	10.0	10.0
Vitamin mix[b]	0.5	0.5	0.5	0.5	0.5
Mineral mix[c]	5.7	5.7	5.7	5.7	5.7
Carboxymethyl cellulose	2.0	2.0	2.0	2.0	2.0
Lysine HCL	0.0	0.0	0.0	0.0	0.32
Ethoxyquin	0.0125	0.0125	0.0125	0.0125	0.0125
Soybean oil	6.7	6.6	6.6	6.6	6.6
Cellulose	3.2	4.6	6.0	8.7	8.4

[a] By analysis: approximately 59% crude protein, 5.7% fat, 6.8% ash, and 4.4% crude fiber.

[b] Per kilogram diet: Vitamin A, 5,500 international units (IU); vitamin D_3, 100,000 IU; vitamin E, 5,000 IU; thiamin, 2g; riboflavin, 2g; pyridoxine, 2g; folacin, 500mg; ascorbic acid, 40g; d-calcium pantothenate, 5g; biotin, 10mg; choline, 55g; niacin, 10g; vitamin B_{12}, 2g; vitamin K, 1g; inositol, 10g; ethoxyquin, 0.15g.

[c] Percent of feed: Defluorinated $CaPO_4$, 2.1%; NaCl, 0.6%; pulverized oyster shell, 1.1%, KH_2PO_4, 1.0%, KCL 0.1%; $MgSO_4$, 0.3% diet. Per kilogram feed: $FeSO_4$, 500mg; $MnSO_4$, 350mg; ZnO_3, 150mg; $CuSO_4$, 30mg; KIO_3, 10mg; $CoCl_2$, 1.7mg; MoO, 8.3mg; $NaSeO_3$, 0.2mg.

lina under agreement No. 81-520. Glandless cotton products and chemical analysis of the products were supplied by Cotton Incorporated. The assistance and cooperation of each contributor and the review of the manuscript by Robert R. Stickney is gratefully acknowledged.

Methods

Two experiments were conducted to evaluate defatted, glandless cottonseed flour and meal. Experimental diets (Tables 1, 2) were formulated to contain 35% crude protein and 2,800 kcal/kg digestible energy (Cruz 1975). All diets were maintained isocaloric by adjusting the level of soybean oil. Experimental diets used in Experiment 1 (Table 1) were formulated by replacing soybean meal with glandless, defatted cottonseed flour on a protein basis. The amount of soybean meal that was replaced by the flour was 0%, 25%, 50%, and 100% in diets 1, 2, 3, and 4 respectively. Diet 5 was identical to Diet 4 except supplemental lysine was added to Diet 5 to increase its dietary level to meet the requirement of channel catfish (5.1% of dietary protein). An equivalent amount of cellulose was removed.

Experimental diets used in Experiment 2 (Table 2) were formulated in the same manner as above except glandless, defatted cottonseed meal was used to replace soybean meal.

Table 2. Percentage composition (dry weight basis) of experimental diets fed in Experiment 2.

Ingredient	Diet number 1	2	3	4	5
Soybean meal	50.0	37.5	25.0	0.0	0.0
Cottonseed meal[a] (glandless defatted)	0.0	13.6	27.2	54.4	54.4
Wheat	21.2	21.2	21.2	21.2	21.2
Menhaden fish meal	10.0	10.0	10.0	10.0	10.0
Vitamin mix[b]	0.5	0.5	0.5	0.5	0.5
Mineral mix[b]	5.7	5.7	5.7	5.7	5.7
Carboxymethyl cellulose	2.0	2.0	2.0	2.0	2.0
Lysine HCL	0.0	0.0	0.0	0.0	0.41
Ethoxyquin	0.0125	0.0125	0.0125	0.0125	0.0125
Soybean oil	6.6	6.0	5.2	3.6	3.6
Cellulose	4.0	3.5	3.2	2.6	2.2

[a] By analysis: approximately 45.0% crude protein, 0.9% fat, 6.5% ash and 14% crude fiber.
[b] *Vitamin and mineral mix compositions as presented in Table 1.*

Experimental diets were prepared at the Aquaculture Research Center of Texas A&M University and the Texas Agricultural Experiment Station. The diets were mechanically mixed, pressure-pelleted, air dried, and frozen. Prior to feeding, each diet was thawed and broken into the appropriate particle size.

Each experiment was conducted in 40-liter flow-through aquaria. Well water was supplied to each aquarium at a rate of 0.95 liters/minute. Supplemental aeration was provided by a low pressure blower system. Water quality was maintained in the range desirable for channel catfish throughout the experiments.

At the start of each experiment period, channel catfish fingerlings previously conditioned to experimental conditions for a 2-week period were sorted into groups of 16 ± 1 fish. Each group weighed 47 to 58 g. Beginning the day following initial weighing, triplicate random groups of fish were fed the appropriate diet at a rate equaling 6% of their wet weight every day for 12 weeks. This amount of diet was divided into 2 equal feedings. The fish were weighed biweekly after which feeding rates were adjusted. A prophylactic treatment of acriflavin was administered after weighing to reduce bacteriological infestations caused by handling.

Growth and feed conversion data were analyzed with the Statistical Analysis System, SAS-79 (Helwig and Council 1979), using the General Linear Models procedure and Duncan's Multiple Range test. Significance was evaluated at the 0.05 level.

Results

Experiment 1

Growth, feed conversion, and survival data from Experiment 1 are presented in Table 3. There were no statistically significant differences. Growth and feed conversion data agreed fairly well among treatments except for fish fed diets 3 and 5. These fish appeared to grow faster; however, due to variation within treatments the weight gains were not significantly higher. Supplemental lysine did not significantly improve growth or feed conversion.

Survival was excellent, ranging from 89% to 100%. The only mortalities occurred in the groups of fish receiving the basal soybean diet (Diet 1). The cause of the mortalities was not determined; however, external pathology was not evident.

Experiment 2

Growth, feed conversion, and survival data from Experiment 2 are presented in Table 4. As in Experiment 1, there were no significant differences in growth and feed conversion. Fish receiving diets containing the glandless cottonseed meal performed as well as those receiving the basal soybean diet (Diet 1). Supplement lysine did not significantly improve growth or feed conversion.

Survival ranged from 96% to 100%. The cause of the few mortalities which occurred was not determined. As in Experiment 1, external pathology was not apparent.

Discussion

Growth was good in each experiment, ranging from 559% to 695% weight increase in Experiment 1 and from 392% to 479% weight increase in

Table 3. Twelve-week growth, feed conversion, and survival of channel catfish fed diets containing defatted, glandless cottonseed flour (Experiment 1). There were no significant differences ($P \leq 0.05$) in weight gain or feed conversion.[a]

Diet no.	Cottonseed flour % dry matter	Weight gain %	Feed conversion[b]	Survival %
1	0.0	570	1.70	89
2	11.2	559	1.79	100
3	22.3	695	1.78	100
4	44.6	578	1.77	100
5[c]	44.6	646	1.78	100

[a] Pooled standard errors were 31.5 and 0.048 for weight gain and feed conversion, respectively.
[b] Dry weight feed/wet weight gain.
[c] Lysine added.

Table 4. Twelve-week growth, feed conversion, and survival of channel catfish fed diets containing defatted, glandless cottonseed meal (Experiment 2). There were no significant differences ($P \leq 0.05$) in weight gain or feed conversion.[a]

Diet no.	Cottonseed meal % dry matter	Weight gain %	Feed conversion[b]	Survival %
1	0.0	394	1.99	100
2	13.6	438	1.91	100
3	27.3	392	2.02	96
4	54.4	421	2.02	100
5[c]	54.4	479	1.81	100

[a] Pooled standard errors were 13.5 and 0.006 for weight gains and feed conversion, respectively.
[b] Dry weight feed/wet weight gain.
[c] Lysine added.

Experiment 2. Although the magnitude of growth differences were fairly large, there were no statistical differences in growth. Based on growth data, glandless cottonseed products appear to be good protein sources for catfish. This agrees with earlier work which showed that glandless cottonseed protein was of high nutritive value for chicks (Jonston and Watts 1964).

Feed conversions were in fairly close agreement in each experiment ranging from 1.70:1 to 1.79:1 in Experiment 1 and from 1.80:1 to 2.02:1 in Experiment 2. Feed conversions were higher in the present study than have been observed in similar studies in our laboratory. However, the fish in the present study may have been overfed. A 6% body weight feeding rate was used in the present study instead of 3% or 4% used in prior studies. Apparently, catfish can utilize glandless cottonseed protein as efficiently as soybean protein since there were no significant differences in feed conversions in fish fed diets containing glandless cottonseed products.

Growth and feed conversions of fish fed diets containing glandless cotton protein were good when compared on an available lysine basis. Replacement of soybean meal with glandless cotton protein reduced the estimated available lysine. Based on the amino acid availability work of Wilson et al. (1981), a lysine value of 4.0% of dietary protein for glandless cotton protein (by analysis), and an estimated 80% availability value for lysine from glandless cotton protein, Diets 1,2,3,4, and 5 contained 1.78%, 1.69%, 1.58%, 1.40%, and 1.78% available lysine respectively. Diets 1 and 5 contained the dietary level of lysine recommended for channel catfish fed 35% crude protein diets (Wilson and Robinson 1982).

The lack of significant growth depression and increased feed conversion in fish fed glandless cottonseed protein diets without supplemental lysine suggest that these diets were adequate in available lysine, although they were estimated to be deficient. In addition, the lack of a significant response to supplemental lysine in fish fed Diet 5 (Experiments 1 and 2) supports the hypothesis that available lysine was sufficient. Had available lysine been deficient in Diets 4 and 5, there should have been a significant response to the supplemental lysine in Diet 5 since lysine can be utilized by catfish when added to lysine-deficient proteins (Robinson et al. 1980, Dorsa et al. 1982). Apparently, available lysine is higher in glandless cottonseed protein than estimated above. Jones and Smith (1977) demonstrated that the addition of lysine to a 10% protein diet of glandless cottonseed meal did not improve weight gains in rats.

Although data from the present study indicate that defatted, glandless cottonseed flour and meal can effectively replace soybean meal in catfish diets when substituted on a nitrogen basis, commercial availability of these products is still a few years away. Also, their relative cost in relation to other plant proteins sources is not definitely established. From an economic standpoint, the glandless meal probably has the most potential for use in commercial catfish feeds. However, the meal is relatively high in fiber (14%) which might limit its use. Pond studies are currently underway to evaluate the glandless meal in commercial diets.

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