SHORT COMMUNICATION

Effect of distillers dried grains with solubles-incorporated diets on growth, immune function and disease resistance in Nile tilapia (Oreochromis niloticus L.)

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Feed is the primary expense for intensive tilapia production and protein is the most expensive component; therefore, substitution of expensive protein ingredients with lower cost ingredients, such as distillers dried grains with solubles (DDGS), would decrease feed costs. The production of DDGS has increased from 2.7 to 9.0 million tonnes from 2000 to 2005 (Renewable Fuels Association 2006). The production of DDGS will no doubt continue to increase and remain important as a feed additive.

A number of studies have shown that DDGS with supplemental lysine can be a protein source in fish diets (Webster, Tidwell & Yancey 1991; Webster, Tidwell, Goodgame, Clark & Yancey 1992; Wu, Rosati & Brown 1996; Wu, Rosati, & Brown 1997; Lim, Garcia, Yildrim-Aksoy, Klesius, Shoemaker & Evans 2007; Belyea, Rausch & Tumbleson 2004). While these studies clearly indicate the utility of DDGS as a protein supplement, they do not address the possible benefit of enhanced immunity from the yeast component, which may be as much as half the protein in DDGS (Belyea et al. 2004). Yeast and yeast components have been demonstrated to stimulate the immune system when added to the diets of fish (Cousu, Castro, Magarinos, Obach & Lamas 2003; Lara-Flores, Olivera-Novoa, Guzman-Mendez & Lopez-Madrid 2003; Bridle, Carter, Morrison & Nowak 2005; Kumari & Sahoo 2006). This experiment was conducted to determine whether growth performance was affected by the inclusion of 30% or 60% DDGS, with or without lysine supplementation, as a substitute for soy and corn meals in Nile tilapia diets, and also to assess the effects of DDGS on immune function and disease resistance to Streptococcus iniae challenge.

Nile tilapia bred and grown at the USDA-ARS Aquatic Animal Health Research Unit, Auburn, Alabama, were acclimated to the control diet for a period of 2 weeks. Thirty fish (mean weight 6.7–0.4 g) were stocked in quadruplicate aquaria (57 L) filled with 52 L of water. Aquaria were provided with flow-through heated dechlorinated municipal water. Water temperature and dissolved oxygen averaged 28–1°C and 4.2–1.2 mg L⁻¹ respectively.

Distillers dried grains with solubles were from US Energy Partners L.L.C., Russell, KS, USA. On an air-dried basis, this ingredient contained 32.5% protein and 5.7 g kg⁻¹ of β-glucans as determined by the American Association of Cereal Chemists method BG5/03 AACC 32–33 (N.P. Analytical Laboratories, St Louis, MO, USA). Five diets were formulated to contain approximately 30% crude protein and 11092 kJ of digestible energy per kilogram (National Research Council 1993). The diets contained 0%, 30% or 60% DDGS as partial substitutes, on an equal protein basis, for a combination of soy and corn meals (Table 1). In addition, Diets 3 and 5 were supplemented with lysine hydrochloride, at 0.5% and 0.9%, respectively, to equal the lysine level in the control diet (Diet 1). Corn starch and cellulose were used to adjust the levels of nitrogen-free extract and crude fibre respectively.
Table 1 Composition of experimental diets containing various levels of distillers grains and solubles with and without lysine supplementation

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Diet (% as-is basis)</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>45.0</td>
</tr>
<tr>
<td>Corn meal</td>
<td>30.0</td>
</tr>
<tr>
<td>Distillers grains with solubles</td>
<td>0.0</td>
</tr>
<tr>
<td>Corn oil</td>
<td>4.4</td>
</tr>
<tr>
<td>Corn starch</td>
<td>0.0</td>
</tr>
<tr>
<td>Menhaden fish meal</td>
<td>8.0</td>
</tr>
<tr>
<td>Wheat middlings</td>
<td>3.9</td>
</tr>
<tr>
<td>Celulose</td>
<td>3.7</td>
</tr>
<tr>
<td>Carboxymethylcellulose</td>
<td>3.0</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.0</td>
</tr>
<tr>
<td>Vitamin premix+</td>
<td>0.5</td>
</tr>
<tr>
<td>Mineral premix†</td>
<td>0.5</td>
</tr>
<tr>
<td>Proximate composition (%)</td>
<td>Moisture</td>
</tr>
<tr>
<td></td>
<td>Protein</td>
</tr>
<tr>
<td></td>
<td>Lipid</td>
</tr>
<tr>
<td></td>
<td>Ash</td>
</tr>
</tbody>
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Vitamin premix contained the following vitamins (mg kg⁻¹ diet): A, 8; D₃, 2; K, 10; E, 200; thiamin, 10; riboflavin, 12; pyridoxine, 10; calcium pantothenate, 12; nicotinic acid, 80; folic acid, 2; vitamin B₁₂, 0.01; biotin, 0.2; choline chloride, 400; l-ascorbyl-2-phosphate, 400.

Trace mineral premix provided by following minerals (mg kg⁻¹ diet): zinc (as ZnSO₄·7H₂O), 150; iron (as FeSO₄·7H₂O), 40; manganese (as MnSO₄·7H₂O), 25; copper (as CuCl₂), 1; iodine (as KI); 5; cobalt (as CoCl₂·6H₂O), 0.05%; selenium (as Na₂SeO₃), 0.00.

Table 2 Mean weight gain and feed intake, feed efficiency ratio (FER) and survival of Nile tilapia fed various experimental diets for 12 weeks

<table>
<thead>
<tr>
<th>Diet</th>
<th>Final wt/fish (g)</th>
<th>Gain/ fish (g)</th>
<th>Feed intake (g)</th>
<th>FER†</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet 1</td>
<td>72.8⁺</td>
<td>56.0⁺</td>
<td>107.2</td>
<td>0.61⁺</td>
<td>99</td>
</tr>
<tr>
<td>Diet 2</td>
<td>69.3⁺</td>
<td>62.0⁺</td>
<td>109.7</td>
<td>0.57⁺</td>
<td>93</td>
</tr>
<tr>
<td>Diet 3</td>
<td>72.6⁺</td>
<td>65.9⁺</td>
<td>108.1</td>
<td>0.64⁺</td>
<td>100</td>
</tr>
<tr>
<td>Diet 4</td>
<td>61.1⁺</td>
<td>53.8⁺</td>
<td>106.2</td>
<td>0.49⁺</td>
<td>93</td>
</tr>
<tr>
<td>Diet 5 (60% DDGS)</td>
<td>68.6⁵⁺</td>
<td>61.4⁵⁺</td>
<td>105.8</td>
<td>0.57⁻</td>
<td>93</td>
</tr>
</tbody>
</table>

Mean values followed by different letters are significantly different (P < 0.05).

*Final feed consumed (dry weight).
†FER = fish weight gain (g)/dry weight of feed consumed (g).

Dietary lysine supplementation was determined using the method of Nonaka, Yamaguchu, Natsume-Saki and Takahashi (1981). A disease challenge was conducted using a 24-h broth culture of S. iniae (isolate ARS-60) injected intraperitoneally at 1 × 10⁵ CFU fish⁻¹. Fish were monitored for morbidity and mortality for 13 days. All data were analysed by one-way analysis of variance using the general linear model of SAS (ver 5.0, SAS Institute, Cary, NC, USA). Duncan’s new multiple range test was used to compare treatment means.

The final weight gain and FER of Nile tilapia fed Diet 4 (60% DDGS without added lysine) were significantly lower compared with the control diet and diets containing lesser amounts of DDGS (Table 2). The addition of lysine (Diet 5) to the 60% DDGS diet (Diet 4) did not increase weight gains significantly. Feed consumption did not differ among dietary treatments. Mortality before challenge was not affected by diet. Microscopic observations of blood cells did not reveal significant differences in haematological properties or oxidative burst among diet treatments (data not shown). None of the serological measurements differed among diet treatments. Disease challenge with S. iniae resulted in an overall 55% mortality after 12 days; however, there were no significant differences in mortality or morbidity related to diets.

Nile tilapia require approximately 4.6% lysine in the diet (Santiago 1985); therefore, lysine is added to the diets of tilapia (Wu et al. 1996, 1977) when high levels of DDGS are used. Unlike soy protein, corn is relatively low in this essential amino acid and therefore it must be added to satisfy the nutritional requirement. The significantly poorer weight, weight gain and FER of Diet 4 suggests that lysine was a limiting factor in the diet containing 60% DDGS. This
observation is in agreement with our previous research in which lysine was a limiting factor in Nile tilapia diets containing 40% DDGS (Lim et al. 2007). Interestingly, the addition of lysine to the 60% DDGS diet improved weight gains, which were not statistically significant, suggesting that levels higher than 40% DDGS may be incorporated into tilapia diets. In our experiments, no immune function or disease resistance effects of the yeast component were evident. We were unable to determine any other direct effect on antibody response when yeast components in the form of DDGS were added to the diets of Nile tilapia.

Acknowledgments

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References


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