Livestock Science 163 (2014) 110–119

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Feed enzymes, probiotic, or chitosan can improve the nutritional efficacy of broiler chicken diets containing a high level of distillers dried grains with solubles

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ARTICLE INFO

Article history:
Received 8 October 2013
Received in revised form
28 February 2014
Accepted 3 March 2014

Keywords:
Broilers
Distillers dried grains with solubles
Feed additives
Breast meat composition
Balance indices
Bone quality

ABSTRACT

The aim of the experiment was to evaluate the effect of selected feed additives on performance, nutrient digestibility, meat quality, and bone characteristics of broiler chickens fed diets containing a high level of corn dried distillers grains with solubles (DDGS). A total of 480 one-day-old Ross 308 male chicks were randomly allocated to 1 of 8 treatments, each comprising 6 replicate cages with 10 birds per cage. In a 6-wk experiment, chickens were fed isocaloric and isonitrogenous experimental diets containing 0 (control) or 120 g (starter phase) or 180 g (finisher phase) DDGS/kg. The diet containing DDGS was not supplemented or supplemented with feed enzymes [200 mg of enzyme with endo-1,4-β-xylanase activity (1000 fungal xylanase units/g)/kg, 200 mg of enzyme with phytase activity (10,000 phytase units/g)/kg], 700 mg sodium butyrate/kg, 10^8 cfu probiotic bacteria (*Lactobacillus salivarius*)/kg, 250 mg of each herb extract (*Taraxaci siccum*, *Urticae siccum*, and *Salviae siccum*)/kg, 5 g inulin/kg, or 3 mL chitosan/kg. The incorporation of DDGS into the diet had no effect on growth performance at 21 and 42 d of age and breast meat proximate composition, but negatively affected ($P<0.05$) apparent digestibility of dry matter and organic matter, metabolizable energy content of the diet, and retention of N and Ca. Inclusion of DDGS increased ($P<0.05$) the percentage of linoleic acid and total polyunsaturated fatty acids (PUFA), and decreased ($P<0.05$) the content of palmitic and stearic acid, as well as total monosaturated (MUFA) and saturated fatty acids (SFA) in breast lipids. At 42 d, incorporation of DDGS into the diet decreased ($P<0.05$) bone breaking strength of femurs, without any effect on tibia indices. Some of the additives, i.e., feed enzymes, probiotic, or chitosan, improved ($P<0.05$) growth performance during either the first, second, or for the entire feeding period, nutrient digestibility, and retention of N and Ca. Feed enzymes also increased ($P<0.05$) bone breaking strength, yielding load, and stiffness of femurs. The results of this study indicate that DDGS can be included at a level of 120 (starter) or 180 g (finisher)/kg in the diet of broiler chickens without any detrimental effect on performance, and feed additives such as enzymes (xylanase+phytase), probiotic, and chitosan can increase the nutritional efficacy of the diets with a high level of DDGS.

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http://dx.doi.org/10.1016/j.livsci.2014.03.001
1871-1413/

1. Introduction

Rapid development of the ethanol industry and increase of fuel ethanol production have been observed in the last decade and have resulted in an increased supply of distillers dried grains with solubles (DDGS), which entered the feed market in recent years. Corn DDGS, obtained previously mainly from brewing industry, has been used for decades as a good source of protein, vitamins, and minerals for poultry (Parsons et al., 1983; Waldroup et al., 1981), and it has been indicated in many experiments that DDGS is a useful feed material and can be used in properly balanced diets as a partial replacement for soybean meal and cereal grain in feed for broiler chickens (Choi et al., 2008; Łukasiewicz et al., 2012; Olukosi et al., 2010; Shim et al., 2011;) and laying hens (Krawczyk et al., 2012; Niemiec et al., 2012, 2013) without any harmful influences on performance indices.

During the production process, cereal starch is fermented to ethanol and CO_2, thus the concentration of remaining nutrients increases considerably and the non-starch polysaccharides (NSP) concentration in DDGS is approximately three times greater than that in the grain (Swiatkiewicz and Koreleski, 2008). Therefore the negative effect of high dietary level of DDGS on growth performance of broiler chickens observed in some previous studies can be associated with the reduced nutrient and energy utilization. For example, Lumpkins et al. (2004) found a decrease in body weight gain (BWG) and feed conversion of chicks during the starter period when a 180 g/kg of DDGS partially replaced corn and soybean meal in the diet. Similarly, the results of other experiments indicated that growth performance and carcass traits, as well as digestibility of amino acids, other nutrients, and energy decreased in broilers fed a diet with high level of DDGS (Abdel-Raheem et al., 2011; Leytem et al., 2008; Loar and Corzo, 2011; Thacker and Widyaratne, 2007; Wang et al., 2007).

Despite those findings, using a high level of DDGS in broiler diets, as a cost competitive source of protein, can still be economically justifiable because of increasing prices of soybean meal. Thus, the objective of this experiment with broiler chickens was to evaluate the possibility of improving the nutritional value of a diet with a high content of corn DDGS by using selected feed additives such as enzymes (xylanase and phytase), sodium butyrate, probiotic bacteria (*Lactobacillus salivarius*), mixture of herb extracts (*Taraxaci siccum*, *Urticae siccum*, and *Salviae siccum*), inulin, or chitosan.

2. Material and methods

2.1. Broiler chickens and experimental diets

A total of 480 one-day-old Ross 308 male broiler chickens, with an average initial weight of 40 g, obtained from a commercial hatchery were used. The birds were housed in electrically heated batteries in an environmentally controlled room in the poultry house at the Experimental Station of the National Research Institute of Animal Production (Balice, Poland). Broiler chickens were weighed and were randomly assigned to 1 of 8 treatments, each comprising 6 replicate cages, with 10 chickens per cage. From 0 to 42 d of age, all the chickens had *ad libitum* access to water and feed. The Local Krakow Ethics Committee for Experiments with Animals approved all the experimental procedures relating to the use of live animals.

Prior to formulating the experimental diets, it was determined that the DDGS contained (g/kg): crude protein, 269; crude fat, 110; crude fiber, 55.0; crude ash, 42.0; Lys, 7.40; Met, 6.20; Thr, 10.4; Trp, 2.95; Ca, 0.50; P, 8.26 and Na, 2.43. Ingredient and energy and nutrient composition of the basal diets used in the experiment is shown in Table 1. The diets contained 0 (control) or 120 g (starter phase) or 180 g (finisher phase) DDGS/kg, and were isocaloric and

Table 1
Composition, and energy and nutrient contents of experimental diets (as-fed).

Item	Starter (0–21 d)		Finisher (21–42 d)	
	Control diet	Experimental diets	Control diet	Experimental diets
Ingredient (g/kg)				
Corn	553.5	484.0	572.1	465.1
Soybean meal	375.0	322.0	337.5	260.0
Corn DDGS[a]	–	120.0	–	180.0
Rapeseed oil	29.0	31.0	48.0	52.0
Limestone	11.0	12.5	11.5	14.0
Dicalcium phosphate	21.0	19.0	20.0	16.5
NaCl	3.00	3.00	3.00	3.00
DL-Met	2.20	2.00	2.00	1.70
L-Lys ≅ HCl	0.30	1.50	0.90	2.70
Vitamin-mineral premix[b]	5.00	5.00	5.00	5.00
Chemical composition				
Metabolizable energy (MJ/kg)[c]	12.6	12.6	13.0	13.0
Crude protein (g/kg)	225	225	200	200
Lys (g/kg)	12	12	11.2	11.2
Met (g/kg)	5.4	5.4	5.1	5.1
Ca (g/kg)	9.4	8.3	9.2	8.1
Total P (g/kg)	6.9	6.4	6.5	6.1
Available P (g/kg)	4.3	3.7	4.0	3.5

[a] DDGS = distillers dried grains with solubles.

[b] Provided the following per kilogram of starter diet: vitamin A (retinol), 4.05 mg; vitamin D_3 (cholecalciferol), 0.0875 mg; vitamin E (alpha-tocopherol), 45 mg; vitamin K_3 (menadione), 3 mg; vitamin B_1 (thiamine), 3.25 mg; vitamin B_2 (riboflavin), 7.5 mg; vitamin B_6 (pyridoxine), 5 mg; vitamin B_{12} (cyanocobalamin), 0.0325 mg; biotin, 0.15 mg; Ca-pantotenate, 15 mg; niacin, 45 mg; folic acid, 1.5 mg; choline chloride, 600 mg; Mn ($MnSO_4$), 100 mg; Zn (ZnO), 75 mg; Fe ($FeSO_4$), 67.5 mg; Cu ($CuSO_4$), 17.5 mg; I (KI), 1 mg; and Se (Na_2SeO_3), 0.275 mg. Provided the following per kilogram of finisher diet: vitamin A (retinol), 3.6 mg; vitamin D_3 (cholecalciferol), 0.8125 mg; vitamin E (alpha-tocopherol), 40 mg; vitamin K_3 (menadione), 2.25 mg; vitamin B_1 (thiamine), 2 mg; vitamin B_2 (riboflavin), 7.25 mg; vitamin B_6 (pyridoxine), 4.25 mg; vitamin B_{12} (cyanocobalamin), 0.03 mg; biotin, 0.1 mg; Ca-pantotenate, 12 mg; niacin, 40 mg; folic acid, 1.0 mg; choline chloride, 450 mg; Mn ($MnSO_4$), 100 mg; Zn (ZnO), 65 mg; Fe ($FeSO_4$), 65 mg; Cu ($CuSO_4$), 15 mg; I (KI), 0.8 mg; and Se (Na_2SeO_3), 0.25 mg.

[c] Calculated according to European Table (Janssen, 1989) as a sum of the ME content of components.