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Effects of rare earth elements-enriched yeast on growth performance, nutrient digestibility, meat quality, relative organ weight, and excreta microflora in broiler chickens

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ABSTRACT

The objective of this study was to evaluate the effects of rare earth elements-enriched yeast (RY) on growth performance, nutrient digestibility, meat quality, relative organ weight, and excreta microflora in broiler chickens. A total of 765 ROSS 308 one-day-old broilers with an average initial body weight of 49.0 ± 0.1 g were used in this 4-wk feeding study containing the starter period (d 1 to 14) and the grower period (d 15 to 28). Dietary treatments include: (1) basal diet, free of antibiotics [negative control(NC)], (2) NC+500 mg/kg of RY (RY500), (3) NC+1000 mg/kg of RY (RY1000), (4) NC+1500 mg/kg of RY (RY1500), and (5) antibiotics diet, NC+1000 mg/kg of tiamulin [positive control (PC)]. Broiler chickens were allotted to 5 treatments with 9 replicates (17 broiler chickens/replicate) in a completely randomized design. At the end of the experiment, digestibility of dry matter was increased in broiler chickens fed RY1500 (linear, $P=0.011$) and PC ($P=0.035$) diets by 3.7 and 3.9%, respectively, compared with NC diet. The digestibility of gross energy was increased (linear, $P=0.019$) by 4.4% when broiler chickens were fed RY1500 diet compared with those fed NC diet. Yellowness of breast muscle (linear, $P=0.003$) was increased by 10.7% in broiler chickens fed RY1500 diet compared with the NC group. However, there was no significant influence on growth performance, relative organ weight, and excreta microflora. In conclusion, the results from this study demonstrated that nutrient digestibility and meat quality were improved slightly in the broiler chickens supplemented with RY.

1. Introduction

Antibiotics not only inhibit pathogen growth in the intestine but also promote growth in livestock. Because of residues, microbial resistance, and environment problems, the use of antibiotics as growth promoters on farm was first banned and enacted in 1986 in Sweden and 2006 in European Union, and may be banned worldwide (Castanon, 2007). Therefore, seeking different alternatives to antibiotics is a very important task in the livestock industry, which can provide more choices for animal husbandry.

Rare earth elements (REE) compounds were considered as a safe alternative to antibiotics and literatures reported that REE compounds may enhance performance in agricultural production (He and Rambeck, 2000). Rare earth elements contain scandium, yttrium, as well as La, and another 14 elements following La. Researchers have studied La and Ce, because previous reports showed that they could increase nutrient digestibility and modulate the balance of gut micro-organism (Yang et al., 2009; Han and Thacker, 2010). Redling (2006) stated that REE compounds improved meat quality of non-ruminant.

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Table 1
Feed composition of control diet (as-fed basis)[a].

Item	Starter	Grower
Ingredients (g/kg)		
Corn	553.4	629.2
Soybean meal, 480 g/kg of CP	282.5	246.1
Corn gluten meal, 600 g/kg of CP	65.0	35.0
Soybean oil	55.0	48.9
Dicalcium phosphate	24.6	22.9
Limestone	8.9	7.5
Salt	2.0	2.0
DL-Met, 980 g/kg	1.7	1.7
L-Lys-HCl, 780 g/kg	2.1	2.1
Vitamin premix[b]	2.0	2.0
Trace mineral premix[c]	2.0	2.0
Choline chloride	0.8	0.6
Calculated composition		
ME (MJ/kg)	13.14	12.93
Analytical composition (g/kg)		
CP	221.0	198.0
Met+Cys	9.0	7.4
Ca	10.0	9.0
Total P	7.9	7.6

[a] Starting diets provided during wk 0 to 2; finishing diet provided during wk 3 to 4.

[b] Provided per kg of diet: 15,000 IU of vitamin A (vitamin A acetate), 3750 IU of vitamin D_3, 37.5 IU of vitamin E (α-tocopheryl acetate), 2.55 mg of vitamin K_3, 3 mg of thiamin, 7.5 mg of riboflavin, 4.5 mg of vitamin B_6, 24 μg of vitamin B_{12}, 51 mg of niacin, 1.5 mg of folic acid, 0.2 mg of biotin and 13.5 mg of pantothenic acid.

[c] Provided per kg of diet: 37.5 mg Zn (as $ZnSO_4$), 37.5 mg of Mn (MnO_2), 37.5 mg of Fe (as $FeSO_4 \cdot 7H_2O$), 3.75 mg of Cu (as $CuSO_4 \cdot 5H_2O$), 0.83 mg of I (as KI), and 0.23 mg of Se (as $Na_2SeO_3 \cdot 5H_2O$).

According to the previous studies, there are two kinds of REE: inorganic REE and organic REE (ORE). Inorganic REE (REE-chlorides) is connected with inorganic elements and ORE (REE-chitosan) comprises a central trivalent REE ion with organic ligands attached to it (Suzuki et al., 2003). Organic and biological mineral sources are much more efficient for bioavailability, than inorganic ones (Case and Carlson, 2002; Dlouhá et al., 2008). In the previous study, researchers added La or Ce no more than 100 mg/kg to diets as their study levels and REE residues were not observed in animal tissues (Wang and Xu, 2003; He et al., 2010; Eleraky and Rambeck, 2011). Yuangsaard et al. (2013) demonstrated that during fermentation, yeast can absorb REE and form new organic REE compounds. To the best of our knowledge, no study has been conducted to evaluate the effect of REE-enriched yeast (RY) in livestock. The objective of this study was to evaluate the effect of RY on growth performance, nutrient digestibility, meat quality, and excreta microflora in broiler chickens.

2. Material and methods

2.1. Preparation of RY

The RY (Biotopia Co., Ltd., Chuncheon-city, Gangwon-do, Korea) product used in this study was obtained through a fermentation process. *Pichia kudriavzevii* LA30 (KCCM 11262P) was inoculated into a YM broth (YM medium, Difco Laboratories, Detroit, MI, USA) at 30 °C for 2 d in a shaking incubator (250 × *g*). Then, 2% (v/v) of the culture was inoculated into an YM broth containing 320 mg/kg of La and 480 mg/kg of Ce at 30 °C for 5 d in the fermenter. The culture broth was continuously centrifuged at 15,800 × *g* (25 ± 5 °C, flow rate: 1.3 L/min) using KS type super-high speed centrifugal separator (Open Type Centrifugal Separators, Kansai Centrifugal Separator Manufacturing, Japan) to separate the cultured cells and supernatant. The collected cells were washed 2 or 3 times with distilled water. The washed cells were crushed using a pulverizer (Avestin, Inc., model n.: EmusiFlex-C160B, Canada) and then mixed with distillers dried grains (DDGS) as an excipient. The resulting mixture was air-dried. The final product of RY containing 2.82% La, 4.71% Ce, 40.3% DDGS, and 52.17% yeast was used in this study.

2.2. Experimental design, animals, and housing

A total of 765 one-day-old Ross 308 broiler chickens, weighing 49.0 ± 0.1 g were purchased from a commercial hatchery. The experiment was conducted in 2 phases consisting of a starter phase (1 to 14 d) and a grower phase (15 to 28 d). Broilers were randomly allotted to 5 dietary treatments containing: (1) basal diet, free of antibiotics [negative control (NC)], (2) NC+500 mg/kg of RY (La, 14.1 mg/kg; Ce, 23.6 mg/kg) (RY500), (3) NC+1000 mg/kg of RY (La, 28.2 mg/kg; Ce, 47.1 mg/kg) (RY1000), (4) NC+1500 mg/kg of RY (La, 42.3 mg/kg; Ce, 70.65 mg/kg) (RY1500), and (5) antibiotics diet, NC+1000 mg/kg of tiamulin [positive control (PC)]. There were 9 replicated cages per treatment with 17 broiler chickens per cage. Broiler chickens were housed in the animal building of Dankook University and practiced an all-in and all-out production system. The room was cleaned every week during the experiment and it was sterilized regularly by using a disinfectant. The temperature of the room was maintained at 33 ± 1 °C for the first 3 d, and then gradually decreased by 3 °C per week to 24 °C until the end of the experiment and the humidity was kept around 60% through the whole experiment. Artificial light was provided 24 h per d by fluorescent lights. All diets were formulated to meet or exceed the NRC (1994) requirements for broiler chickens (Table 1). Feed samples were ground to pass through a 1-mm screen, after which they were analyzed for dry matter (DM) (method 934.01; AOAC, 2000), nitrogen (method 968.06; AOAC, 2000), gross energy (GE), Ca (method 984.01; AOAC, 1995), and P (method 965.17; AOAC, 1995). Individual amino acid composition was measured using an amino acid analyzer (Beckman 6300; Beckman Coulter Inc., Fullerton, CA) after a 24-h hydrolysis in HCl (Spackman et al., 1958). For the determination of Cys and Met, the samples were oxidized with performic acid overnight to convert Cys quantitatively to cysteic acid and Met to Met sulfone (Moore, 1963). Nitrogen was determined (Kjectec 2300 Nitrogen Analyzer; Foss Tecator AB, Hoeganaes, Sweden), and crude protein (CP) was calculated as nitrogen × 6.25. Gross energy in the feed was determined using a calorimeter (Mode 1241, Parr Instrument Co., USA).

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