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Research in Veterinary Science 80 (2006) 291–298
RVS
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Effects of supplementation of β-glucan on the growth performance and immunity in broilers ☆

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Accepted 25 July 2005

Abstract

Two experiments were conducted to evaluate the efficacy of β-glucan on commercial broilers. In experiment 1, one hundred and forty-four broiler chicks were employed in a 2×3 factorial design with cage and open floor housing with three levels of β-glucan viz. 0%, 0.02% and 0.04%. In experiment 2, ninety-six broilers were used with 4 treatments: No β-glucan and antibiotic (T1), β-glucan 0.03% (T2), antibiotic (T3), and β-glucan 0.03% + antibiotic (T4) for 34 d with 3 replicates of 8 chicks each in both studies. During experiment 1 there was no significant effect of the feeding system or the β-glucan levels on the performance from 0 to 17 d but during 18–34 days birds housed on the open floor had significantly ($p < 0.0001$) higher weight gain compared with those in cages. In experiment 2, no significant effect was noticed on the weight gains when the effect of β-glucan, antibiotic or their interaction were tested. The retention of dry matter increased in both experiments with β-glucan supplementation. The CD8 and TCR 1 cells were significantly higher in the 0.04% β-glucan group at 42 days as compared with the control. It could be concluded that β-glucan supplementation was beneficial for broilers.

Keywords: β-Glucans; Broilers; Growth; Immunity

1. Introduction

It is well known that antibiotic supplementation in the diet improves growth rate and feed efficiency in domestic animals and poultry. Because antibiotic supplementation may result in bacterial resistance to antibiotics and residues of antibiotics may be hazardous to human health, antibiotic supplementation should be limited and alternative sources of equal efficacy need to be evaluated. Glucans with β-1,3 and β-1,6 glycosidic linkages (β-glucans) are major structural components of yeast and fungal cell walls (Jorgensen and Robertsen, 1995). β-Glucan is known to possess antitumor and antimicrobial activities by enhancing the host immune function. It has a beneficial effect on weaned pigs' growth as it elicits specific immune reactions, increases non-specific immunity and tolerance to oral antigens (Mowat, 1987; Stokes et al., 1987). Supplementing nursery pigs' diets with 0.025% β-glucan increased growth performance but also increased the susceptibility to *Streptococcus suis* infection as reported by Dritz et al. (1995).

Schoenherr et al. (1994) reported that a β-glucan (Macrogard™-S) supplementation improved growth performance and feed efficiency in nursery pigs. Immunopotentiation effected by binding of a $(1 \rightarrow 3)$-β-glucan molecule or particle probably includes activation of cyto-

☆ The project underwent proper ethical standards and approved by Kangwon National University animal care and use committee.

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doi:10.1016/j.rvsc.2005.07.008

toxic macrophages, helper T-cells and natural killer (NK) cells, promotion of T cell differentiation and activation of the alternative complement pathway (Bohn and BeMiller, 1995). Stimulatory effects of β-glucan on both specific and non-specific immune responses have been demonstrated in mice (Suzuki et al., 1990), in fish (Robertsen et al., 1990; Jeney and Anderson, 1993) and beneficial effects on growth performances in pigs (Schoenherr et al., 1994; Dritz et al., 1995). But there are no reports about the effects of β-glucan in poultry. The following study was conducted to evaluate the effective dose of β-glucan on the performance of broilers and its immuno-modulating effects, and compare it with antibiotics.

2. Materials and methods

2.1. Design, animals and sample preparation

Two experiments were conducted to evaluate the efficacy of β-glucan.

2.1.1. Experiment 1

For a six-week feeding trial, a total of 144 broiler chicks (Ross, 3-day old, average 49.30 ± 2.89 g body weight) either caged or on rice hull litter material were allotted to three dietary treatments of β-glucan at 0%, 0.02% and 0.04% of diet. Thus, a 2 × 3 factorial study was conducted with 3 replicates consisting of 8 chicks each. From 4 days of age the birds were fed a starter (until 21 days of age) and finisher diet (from 22 to 38 days of age) containing β-glucan levels as stated.

Basal diets (mash) were formulated to contain 22.04% and 20.26% crude protein for starter and finisher diets, respectively (Table 1). β-Glucan was added in the vitamin premix and then mixed in the diet. The source of β-glucan was *Saccharomyces cerevisiae* IS 2 (KCTC 0959BP), IS 9 (KCTC 0960BP), IB 54 (KCTC 0961BP) and IB 56 (KCTC 0962BP) strains (GLUCAGEN; Enbiotec Company, Seoul, Korea). The product contains 10% moisture, 30% crude protein, 3% crude fiber, 10% crude ash and the concentration of β-1,3/1,6-glucan was more than 40% as stated by the company specifications. In a room (floor with rice hull bedding), 4 days old chicks were raised in pens of 1.0 × 1.5 meters on their respective diets with ad libitum access to feed and water. Room temperature was controlled until three weeks of age. The temperature during the first week was 34 ± 1 °C and was gradually reduced to 26 ± 1 °C by 21 days of age, after which the chicks were maintained at room temperature (15–34 °C). For the first three days the chicks were raised on a commercial starter diet. In the same room with the same environmental conditions and management another set of broilers were reared in cages of 1.0 m length and 0.5 m breadth with the same experimental diets.

Table 1
Formula and chemical composition of experimental diets (experiment 1)

	Starter (d 0–17)	Finisher (d 18–34)
Ingredients (g/kg)		
Maize	560.6	599.0
Soybean meal	224.4	207.6
Maize germ meal	70.0	80.0
Fish meal	61.6	30.0
Animal fat	60.0	57.0
Tri-calcium phosphate	9.2	11.2
Limestone	5.9	8.7
Vitamin premix[a]	1.0	1.0
Trace mineral premix[b]	2.0	2.0
Salt	2.5	2.5
L-Lysine	–	0.3
DL-Methionine (50%)	2.0	–
Choline chloride (25%)	0.8	0.7
Total	1000.0	1000.0
Chemical composition (g/kg)		
ME (MJ/kg)	13.4	13.4
Crude protein	220.4	202.6
Calcium	9.0	9.0
Available phosphorus	4.0	3.5
Lysine	11.4	10.0
Methionine	5.3	4.0
Met + Cys	9.0	7.5

[a] Supplied per kg diet: 9000 IU vitamin A, 1800 IU vitamin D_3, 10 IU vitamin E, 1 mg vitamin B_1, 10 mg vitamin B_2, 2 mg vitamin B_6, 0.02 mg vitamin B_{12}, 1 mg vitamin K_3, 12 mg pantothenic acid, 30 mg niacin, 0.03 mg biotin, 0.5 mg folic acid, 4 mg pyridoxine, 3 mg ethoxyquin.

[b] Supplied per kg diet: 80 mg Fe, 80 mg Cu, 100 mg Zn, 120 mg Mn, 2 mg I, 0.1 mg Co, 0.2 mg Se.

For nutrient retention studies, chicks in cages were fed finisher diets containing 0.25% chromic oxide as an indigestible marker at 38 days of age. Fecal samples were taken from each pen on the fourth day. Feces were dried in a forced-air drying oven at 60 °C for 3 days and stored.

To study the β-glucan effect on lymphocyte subpopulation, blood was collected from the wing vein of six chicks in each group (two per replicate) at 28 and 42 days of age only from birds reared in cages.

2.1.2. Experiment 2

For a six-week feeding trial, a total of ninety-six broiler chicks (Ross, 3-day old, average 53.51 ± 1.83 g body weight) in cages were allotted to four dietary treatments. Each treatment was assigned to 3 replicate cages containing 8 chicks each. The diets contained: T1 (No β-glucan or antibiotic), T2 (β-glucan 0.03%), T3 (antibiotic) and, T4 (β-glucan 0.03% + antibiotic). The antibiotic fed during the starter and finisher phase was flavomycin (5 mg/kg) as detailed in Tables 2 and 3, respectively. The source of β-glucan and the facilities and management were the same as in experiment 1. The experiment was conducted for 5 weeks during which the body weights