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Comparison of Bio-Mos® and Antibiotic Feeding Programs in Broiler Diets Containing Copper Sulfate[1]

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Abstract: A study was conducted to evaluate the response of broilers to diets containing a mannan oligosaccharide, antibiotics, or a combination of antibiotics and mannan oligosaccharide. All diets were supplemented with copper sulfate to provide 250 mg/kg Cu in diets fed to 42 d and 62.5 mg/kg Cu in diets from 42 to 56 d, in addition to the 10 mg/kg provided in the trace mineral mix. Bio-Mos®, a mannan oligosaccharide derived from the cell wall of the yeast *Saccharomyces cerevisiae*, was added at 1 g/kg in diets fed to 42 d and at 0.75 g/kg in diets fed 42 to 56 d. The antibiotic program consisted of 55 mg/kg of bacitracin methylene disalicylate[2] to 42 d of age followed by 16.5 mg/kg virginiamycin[3] to 56 d of age. When the Bio-Mos® and antibiotics were fed in combination, half the levels indicated above were fed. Twelve pens of 50 male broilers were fed each of the dietary treatments. Results of the study indicate that body weight of broilers was not significantly influenced by the antibiotic treatment, addition of Bio-Mos®, or the combination of antibiotics and Bio-Mos®. Feed conversion at 42 d was significantly improved by both the antibiotic treatment and by the addition of Bio-Mos®. At 56 d the feed conversion of birds fed the antibiotics or the combination of antibiotics and Bio-Mos® was improved compared to that of birds fed the negative control ($P = 0.10$). No significant effects on mortality, dressing percentage, or parts yield were observed. Possible interference of copper sulfate with the activity of the antibiotics and Bio-Mos® is discussed.

Key words: Mannan oligosaccharide, broilers, antibiotics, copper sulfate, growth promotion

Introduction

Since the early 1950's antibiotics have been widely used in poultry feeds, at first primarily to control disease and more recently to promote growth and improve feed conversion. Use of antibiotics has been severely limited or eliminated in many countries and legislative action to limit their use is probable in many others. Therefore, alternatives to antibiotics are of great interest to the poultry industry. Bio-Mos®, a mannan oligosaccharide derived from the cell wall of the yeast *Saccharomyces cerevisiae*, has shown promise in suppressing enteric pathogens, modulating the immune response, and improving the integrity of the intestinal mucosa in studies with chickens and turkeys (Spring, 1999a, 1999b; Iji *et al.*, 2001; Sonmez and Eren, 1999; Spring *et al.*, 2000; Savage and Zakrzewska, 1997; Valancony *et al.*, 2001).

Copper has been added to poultry diets as an antimicrobial and growth promoter for many years (Aldinger, 1967; Smith, 1969; Jenkins *et al.*, 1970; Fisher, 1973; Fisher *et al.*, 1973; Doerr *et al.*, 1980; Pesti and Bakali, 1996). Copper sulfate may interfere with the use of antibiotics, arsenicals, and histomoniastats in poultry diets (Carlson *et al.*, 1979; Bowen and Sullivan, 1971; Bowen *et al.*, 1971a, 1971 b).

The following study was conducted to evaluate the use of Bio-Mos® in copper-supplemented diets for growing broilers in comparison to commonly used growth-promoting antibiotics. In addition, combinations of Bio-Mos® and antibiotics were evaluated.

Materials and Methods

Diets were formulated for starter (0 to 21 d), grower (21 to 42 d), and finisher (42 to 56 d) periods that provided a minimum of 110% of the amino acids recommended by NRC (1994). Starter diets contained minimal added fat with reduced energy levels as an attempt to reduce the incidence of ascites (Dale and Villacres, 1986; Arce *et al.*, 1992). A blended animal protein product[4] was added to all diets at 5%, as most poultry diets in the U.S. contain some form of animal protein. The diets were supplemented with complete vitamin and trace mineral mixes obtained from a commercial poultry integrator. Composition of the diets is shown in Table 1. The trace mineral mix provided 10 mg/kg of copper in the form of copper sulfate, sufficient to meet the nutrient requirements for this mineral (NRC, 1994). In addition,

[1]Published with approval of the Director, Arkansas Agricultural Experiment Station, Fayetteville AR 72701. Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the University of Arkansas and does not imply its approval to the exclusion of other products that may be suitable. [2]BMD-50; Alpharma, Inc., Ft. Lee, NJ 07024. [3]Stafac-10; Pfizer Animal Health, Exton PA 19341. [4]Pro-Pak; H.J. Baker & Bro., Stamford CT 06901.

Table 1: Composition (g/kg) of experimental diets

Ingredient	0-21 d	21-42 d	42-56 d
Yellow corn	653.76	715.73	754.995
Soybean meal (48%)	253.93	181.41	147.48
Pro-Pak[1]	50.00	50.00	50.00
Poultry oil	12.61	22.70	23.28
Ground limestone	7.94	11.23	10.26
Dicalcium phosphate	9.07	5.17	2.96
DL-Methionine (99%)	2.29	1.58	0.76
Lysine HCl (98%)	1.55	2.20	1.57
L-Threonine	0.02	0.96	0.98
Iodized salt	3.73	3.92	2.69
Choline Cl (60%)	2.00	2.00	2.00
Copper sulfate	0.10	0.10	0.025
Trace mineral mix[2]	1.00	1.00	1.00
Vitamin premix[3]	2.00	2.00	2.00
TOTAL	1000.00	1000.00	1000.00
Calculated analysis[4]ME, kcal/kg	3080.00	3200.00	3250.00
Crude protein, %	21.18	18.22	16.77
Crude protein, % (A)	20.83	18.27	17.27
Methionine, %	0.62	0.50	0.40
Lysine, %	1.27	1.10	0.95
TSAA, %	0.95	0.79	0.67
Threonine, %	0.85	0.81	0.76
Copper, mg/kg (A)	263	285	71

[1]H. J. Baker & Bro., 595 Summer Street, Stamford, CT 06901-1407. [2] Provides per kg of diet: Mn (from $MnSO_4 \bullet H_2O$) 100 mg; Zn (from $ZnSO_4 \bullet 7H_2O$) 100 mg; Fe (from $FeSO_4 \bullet 7H_2O$) 50 mg; Cu (from $CuSO_4 \bullet 5H_2O$) 10 mg; I from $Ca(IO_3)_2 \bullet H_2O$), 1 mg. [3]Provides per kg of diet: vitamin A (from vitamin A acetate) 7714 IU; cholecalciferol 2204 IU; vitamin E (from dl-alpha tocopheryl acetate) 16.53 IU; vitamin B_{12} 0.013 mg; riboflavin 6.6 mg; niacin 39 mg; pantothenic acid 10 mg; menadione (from menadione dimethylpyrimidinol) 1.5 mg; folic acid 0.9 mg; thiamin (from thiamine mononitrate) 1.54 mg; pyridoxine (from pyridoxine hydrochloride) 2.76 mg; d-biotin 0.066 mg; ethoxyquin 125 mg; Se 0.1 mg. [4]From NRC (1994). Values marked by (A) are analyzed values.

Table 2: Effects of antibiotics and Bio-Mos mannan oligosaccharide on live performance and carcass parameters of broilers (means of 12 pens of 50 male broilers)

Parameter	Negative control	Antibiotic Program[1]	Bio-Mos Program[2]	Bio-Mos + Antibiotics[3]	P diff[4]	SEM
21 d BW (kg)	0.653	0.638	0.643	0.638	0.286	0.006
42 d BW (kg)	2.072	2.078	2.031	2.053	0.213	0.017
56 d BW (kg)	2.887	2.906	2.872	2.915	0.837	0.035
0-21 d feed:gain (kg:kg)	1.376	1.378	1.362	1.369	0.662	0.009
0-42 d feed:gain (kg:kg)	1.773[a]	1.741[b]	1.751[b]	1.755[ab]	0.029	0.008
0-56 d feed:gain (kg:kg)	2.036	2.009	2.053	2.009	0.108	0.015
0-21 d mortality (%)	1.70	1.50	3.00	1.50	0.139	0.05
0-42 d mortality (%)	6.70	7.20	7.10	4.30	0.395	1.4
0-56 d mortality (%)	7.70	10.50	7.20	8.60	0.638	2.0
Dressing percentage (%)	73.15	73.62	73.36	73.20	0.767	0.35
Breast yield, % of carcass	24.48	24.32	23.64	24.54	0.152	0.27
Leg quarters, % of carcass	33.16	33.19	32.78	33.26	0.678	0.30
Wing yield, % of carcass	11.20	11.53	11.53	11.55	0.085	0.12
Fat pad, % of carcass	2.79	2.74	2.75	2.75	0.98	0.10

[1]The antibiotic program consisted of 55 mg/kg of bacitracin methylene disalicylate to 42 d of age followed by 16.5 mg/kg virginiamycin to 56 d of age. [2]The Bio-Mos program consisted of 0.1% to 42 d followed by 0.075% to 56 d. [3]When the Bio-Mos and antibiotics were fed in combination, half the levels of each described above were used. [4]Probability of difference among treatment means. [ab]Means in row with common superscript do not differ significantly ($P \leq 0.05$).

Table 3: Mean weekly high and low house temperature (F°) during the study

Week[1]	High	Low
1	89.8	84.1
2	86.2	79.3
3	89.8	78.8
4	91.4	78.0
5	80.2	70.8
6	76.4	69.2
7	85.4	76.5
8	89.6	77.1

[1]Study began on June 20 and terminated August 14.

copper sulfate was added to all diets to provide 250 mg/kg Cu to 42 d and 62.5 mg/kg Cu from 42 to 56 d. A large lot of the basal diet was mixed for each age period and aliquots used to mix the test diets.

The following treatments were compared:

1. No additives (Negative control); 2. Antibiotic program; 3. Bio-Mos®[5] program; 4. Bio-Mos® + Antibiotics.

The antibiotic program consisted of 55 mg/kg of bacitracin methylene disalicylate[6] to 42 d of age followed by 16.5 mg/kg virginiamycin[7] to 56 d of age. This is currently the most popular antibiotic program used in the U.S. poultry industry. The Bio-Mos® program consisted of 1 mg/kg to 42 d followed by 0.75 mg/kg to 56 d. When the Bio-Mos® and antibiotics were fed in combination, half the levels of each described above were used. Starter diets were fed as crumbles; diets fed from 21 to 56 d were pelleted with steam. Samples of each diet were analyzed in duplicate for crude protein and copper content and were found to be within expected range (Table 1).

Male chicks of a commercial broiler strain cross (Ross[8] x Cobb[9]) were obtained from a local hatchery where they had been vaccinated *in ovo* for Marek's virus and had received vaccinations for Newcastle Disease and Infectious Bronchitis post hatch via a coarse spray. Coccivac®[10] was administered in the hatchery. Fifty birds were placed in each of 48 pens at a density of 11.2 birds/m^2. Previously used softwood shavings top-dressed with new litter served as bedding. No copper sulfate had previously been fed to chicks on this litter, other than that provided in the trace mineral mix. Each pen was equipped with one automatic water fount and two tube-type feeders. Twelve pens were assigned to each dietary treatment. Bird management and care followed approved guidelines (FASS, 1999).

Birds were group weighed by pen at 21, 42, and 56 days of age and feed consumption for the same ages determined. Samples of birds (5 per pen) were processed at 56 days as described by Izat *et al.* (1990) to determine dressing percentage and parts yield. The data were analyzed using single-degree comparisons of each of the various test diets to the negative control group using the General Linear Models procedure of SAS (SAS Institute, 1991). Mortality data were transformed to $\sqrt{n+1}$ prior to analysis; data are presented as natural numbers. Feed conversion was corrected for mortality by weighing all birds that died. Statements of statistical significance are based upon a probability of $P \leq 0.05$ unless stated otherwise.

Results and Discussion

The effects of antibiotic treatment and Bio-Mos supplementation on various live performance and carcass factors are shown in Table 2. Body weight of broilers in this study was not significantly influenced by the antibiotic treatment, addition of Bio-Mos®, or the combination of antibiotics and Bio-Mos®. Feed conversion (kg feed:kg gain) at 42 d was significantly improved by both the antibiotic treatment and by the addition of Bio-Mos®. The feed conversion of birds fed the combination of antibiotics and Bio-Mos® did not differ from that of birds fed the negative control. At 56 d the feed conversion of birds fed the antibiotics and the combination of antibiotics and Bio-Mos® was improved compared to that of birds fed the negative control ($P = 0.10$). No significant effects on mortality, dressing percentage, or parts yield were observed.

High temperatures were observed during much of the study (Table 3), influencing body weight. Much of the mortality appeared to be related to heat stress. However, there did not appear to be any relationship of dietary treatments to mortality.

Published reports on the use of Bio-Mos® in broiler diets are sparse and show inconsistent response. This may be due in part to differences in level of incorporation into the diets. Kumprecht and Zobac (1997) reported that inclusion of Bio-Mos® in broiler finisher diets resulted in a significant improvement in body weight and feed conversion with a level of 2 g/kg being most effective. Iji *et al.* (2001) reported that feeding broilers diets with 5 g/kg of Bio-Mos® led to minor improvements in body weight but no improvement in feed conversion. Eren *et al.* (1999) fed chicks diets with 1 g/kg of Bio-Mos® to 35 d and reported no significant differences in body weight gain, feed conversion ratio, or carcass dressing percentage compared to a negative control. Shafey *et al.* (2001) reported that supplementation of broiler diets with 3 g/kg did not influence body weight gain, feed utilization, or nutrient utilization.

Copper sulfate has been shown to interfere with the use of antibiotics in diets for turkeys (Bowen and Sullivan, 1971). While no reports have been found relating response of poultry to Bio-Mos® in the presence of copper sulfate,

[5]Alltech Inc., Nicholasville KY 40356. [6]BMD-50; Alpharma, Inc., Ft. Lee, NJ 07024. [7] Stafac-10; Pfizer Animal Health, Exton PA 19341. [8] Ross Breeders, Huntsville AL 35805. [9]Cobb-Vantress, Inc., Siloam Springs, AR 72761.[10]Schering Plough Animal Health, Union NJ 07083.

work reported by Davis *et al.* (2000) indicated that high levels of copper in the diet of weanling barrows interfered with the ability of Bio-Mos® to enhance growth and feed conversion. Further studies are suggested to determine if the levels of copper sulfate employed in the present trial may interfere with the response of broilers to antibiotics or to Bio-Mos®.

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