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Mannan Oligosaccharides (MOS) from *Saccharomyces cerevisiae* in Broilers: Effects on Performance and Blood Biochemistry*

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Abstract: This study was conducted to investigate the effects of mannan oligosaccharides (MOSs), which are commonly used as alternatives to antibiotics, on the growth performance and some blood parameters in broiler chickens. The study included 120 Ross 308 male broiler chicks (1-day-old at the beginning of the study). There were 4 treatment groups, each consisting of 3 replicates. MOSs were added at the level of 0.05%, 0.10%, and 0.15% to the starter and finisher diets. The experiment lasted 42 days.

Body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR) were not significantly different ($P > 0.05$) between MOS treatment groups during the experimental period (0-6 weeks). Serum triglyceride level was not influenced by dietary treatment ($P > 0.05$). However, the addition of MOSs significantly decreased AST (the highest level, $P < 0.05$) and ALT (all levels, $P < 0.01$) activity in the blood. Mean total cholesterol was significantly lower in the 0.05% MOS-fed group ($P < 0.05$) when compared to the remaining MOS treatment groups.

Key Words: Mannanoligosaccharides, performance, broiler, blood biochemistry

Broylerlerde *Saccharomyces cerevisiae*'den Elde Edilen Mannanoligosakkarit (MOS): Performans ve Kan Parametrelerine Etkisi

Özet: Bu çalışma antibiyotiklere alternatif olarak kullanılan mannanoligosakkaritin (MOS) broylerlerde performans ve bazı kan parametreleri üzerine etkilerini belirlemek amacıyla yapılmıştır. Denemede 120 adet 1 günlük yaşta Ross 308 hattı broyler civciv kullanılmıştır. Hayvanlar her birinde 10 hayvan bulunan 3 alt gruptan oluşan 4 deneme grubuna ayrılmıştır. İlk gruba MOS ilave edilmemiş kontrol rasyonu diğer 3 deneme grubuna ise sırasıyla % 0,05, 0,10 ve 0,15 MOS ilave edilmiş kontrol rasyonu verilmiştir. Deneme 42 gün sürmüştür.

Deneme periyodu süresince canlı ağırlık artışı, yem tüketimi ve yemden yararlanma MOS ilavesi ile etkilenmemiştir ($P > 0,05$). MOS ilavesi serum trigliserid düzeylerini etkilememiştir ($P > 0,05$). Fakat kanda ALT (tüm düzeylerde, $P < 0,01$) ve AST (yüksek düzeyde, $P < 0,05$) düzeylerini önemli derecede azaltmıştır. Ortalama total kolesterol düzeyi % 0,05 MOS katılan grupta diğer gruplara göre önemli derecede azalmıştır ($P < 0,05$).

Anahtar Sözcükler: Mannanoligosakkarit, performans, broyler, kan biyokimyası

Introduction

Oligosaccharides, including fructo oligosaccharides, galacto oligosaccharides, transgalacto oligosaccharides, and mannan oligosaccharide (MOSs), are one of the most extensively investigated classes of antibiotic alternatives (1). MOSs, which are derived from the cell wall of *Saccharomyces cerevisiae*, have shown promising effects,

such as decreasing pathogenic microflora of the gut, stimulating a strong immune response, and elevating the strength of the intestinal mucosa in studies with poultry (1-5). By balancing the intestinal environment and stimulating the immune response, MOSs have been shown to increase growth in broilers (6), turkeys (7), and swine (8).

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Results of many trials indicated that MOSs can be one of the best alternatives to antibiotic growth promoters (9), and even trace amounts of MOSs (0.1%-0.4%) added to a ration were quite effective in increasing the health status and production of poultry (5). Other studies have shown that trace amounts of MOSs in the diet had no significant effects on short chain fatty acid production or pH level in the GI tract of broilers (4) or turkey poults (10,11). Stanczuk et al. (12) reported that supplementation of rations with MOSs and inulin (0.1% and 0.4% MOS in diet) did not significantly affect live body weight (BW), feed intake (FI), or feed conversion ratio (FCR) in turkeys in an 8-week trial. On the other hand, it has been reported that 0.1% MOSs in the diet improved the performance of turkeys (8). In a study on broilers by Waldroup et al. (13,14), the addition of Bio-Mos[®] (trademark of Alltech) produced from *Saccharomyces cerevisiae* cell surfaces (1 g/kg from day 0 to 42 and 0.75 g/kg to day 63) had no significant effect on growth, but improved feed conversion in birds. The authors postulated that the level of MOSs used in the study might not have been sufficient to elicit a positive response. In another study conducted on turkeys by Fritts and Waldroup (10), the supplementation of rations with MOSs (0.05% and 0.10%) did not affect the BW of turkeys; however, it significantly increased the FCR from 0 to 20 weeks of age. Rosen (15) evaluated 124 published papers on Bio-Mos[®] and found that its effects on performance ranged widely; however, the mean values showed that Bio-Mos[®] depressed feed intake by 0.46% (including mortality), increased body weight gain (BWG) by 1.48%, and decreased the FCR by 2.43%.

With a high level of fermentable oligosaccharides in an animal feeding system, an increase in digesta weight is the natural outcome of a physiological response and nontoxic effect (15). Additionally, it was often associated with some beneficial changes in the gut (lower pH, ammonia reduction, and increased amount of short chain fatty acids).

Most recently, considerable attention has been paid to growth promoters' abilities to alter lipid metabolism to protect the human body from fatal diseases like arteriosclerosis. This has led animal nutritionists to search for a method of producing lean and low-lipid content poultry meat. Supporting this, some researchers (16,17) reported that feeding prebiotics reduced serum cholesterol, triglyceride concentration, and abdominal fat content in broilers.

Experiments conducted with MOSs have to date revealed contradictory performance results in broilers. Moreover, the effects of MOSs on metabolism have not been extensively investigated. Therefore, the aim of the present study was to determine the effects of MOSs on the performance and some blood parameters in broilers.

Materials and Methods

The study included 120 male Ross PM3 broiler chicks (1-day-old at the beginning of the study). They were divided randomly into 1 control group and 3 treatment groups, each of which had 3 replicates of 10 broiler chicks. Twelve stainless steel cages 40 × 65 × 98 cm were used to accommodate 10 chicks per m². Plastic holed flooring was used as bedding. The chicks were fed a starter diet from 1 to 14 days of age, and then a grower diet for the period of 15 to 42 days. Experimental diets were formulated as recommended by the NRC (18) (Table 1). Continuous lighting was provided

Table 1. Composition of the basal experimental broiler diets (%).

Ingredients	Starter	Grower
Corn	36.00	49.00
Wheat	15.35	8.00
Soybean meal	25.00	20.00
Full fat soy bean	14.15	15.00
Fish meal	3.15	1.65
Vegetable oil	3.00	3.00
Limestone	1.50	1.50
Dicalcium phosphate	1.00	1.00
Salt	0.25	0.25
Vitamin pre-mix ¹	0.25	0.25
Mineral pre-mix ²	0.15	0.15
DL- Methionine	0.20	0.20
Analyzed		
Crude protein	23.40	20.30
Ether extract	8.66	10.17
Calculated		
ME (kcal/kg)	3110	3215

¹ The pre-mix (Rovimix 124-F) supplemented to 2.5 kg of feed had the following vitamin content: vitamin A: 15,000,000 IU; vitamin D3: 1,500,000 IU; vitamin E: 50,000 mg; vitamin K3: 5000 mg; vitamin B1: 3000 mg; vitamin B2: 6000 mg; niacin: 25,000 mg; calcium-D pantothenate: 12,000 mg; vitamin B6: 5000 mg; vitamin B12: 30 mg; folic acid: 1000 mg D-biotin: 125 mg; L-lysine: 300,000 mg.

² The pre-mix (Remineral 1) supplemented to 1 kg of feed had the following mineral content: Mn: 80,000 mg; Fe: 30,000 mg; Zn: 60,000 mg; Cu: 5000 mg; Co: 500 mg; I: 2000 mg; CaCO₃: 235,680 mg.

during the experimental period. Room temperature was gradually decreased from 32 °C on day 0 to 25 °C on day 14, and remained constant thereafter. The chicks were allowed ad libitum access to feed and water.

The experimental design consisted of 4 levels of MOSs in the diet (0%, 0.05%, 0.10%, and 0.15%). MOSs were added to the basal diets in the mixer as the last step in mixing, as would occur commercially. The experimental lasted 42 days.

Chemical analyses of the experimental rations were determined by AOAC (19). The metabolizable energy value of the rations was calculated according to TSE (20).

The chickens were weighed weekly to determine growth performance. BW, BWG, FI, and FCR were recorded weekly throughout the experiment.

At the end of the study period (day 42), 12 broilers were randomly selected from each replicate of each treatment group and blood samples were collected from the bronchial vein during slaughter. The collected blood samples were centrifuged at 2000 rpm for 10 min and the sera were decanted into aseptically treated vials and stored at -20 °C until further analysis. Serum samples were analyzed for total cholesterol, triglycerides, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) using an automatic analyzer (XL 600, Erba, India).

Data were analyzed using SPSS v.10 for Windows (SPSS Inc., Chicago, IL, USA). Statistically significant differences between group means were determined by analysis of variance (ANOVA). When the differences were significant, Duncan's multiple range test was performed. Mean values were considered significantly different at $P < 0.05$. Data are expressed as mean values \pm SEM.

Results

The results of MOSs on the growth performance of male broiler chicks are shown in Table 2. BWG, FI, and FCR of the broilers in this study were not significantly influenced ($P > 0.05$) by the addition of MOSs. Although it was not significant, a numerical increase in BWG in the 0.15% MOS-fed group was detected as compared to the control diet group. Blood parameters are presented in Table 3. While serum total cholesterol concentration was significantly lower in broilers fed 0.05% MOSs than in the broilers in the other groups, it was higher in broilers fed the 0.10% and 0.15% MOS treatment diets ($P < 0.05$). ALT level was significantly higher in the control group than in all the treatment groups. Although AST level in the control group was numerically higher than that in all the other groups, it was only significantly different from that in the 0.15% MOS-fed group.

Discussion

In agreement with our study, Waldroup et al. (14) fed chicks diets supplemented with antibiotic, Bio-Mos[®], or a combination of antibiotic and Bio-Mos[®] until 42 days of age and reported no significant differences in BW as compared to a negative control. Jamroz et al. (21) reported that MOSs or antibiotic supplementation of diets had no significant effects on BW. Several studies have reported that prebiotics (16,22) can improve BW in broilers. The results obtained in the present study are in agreement with the findings published by Sarica et al. (23), who reported that BWG, FI, and FCR were not significantly affected by the addition of MOSs or an

Table 2. Growth performance of male broiler chicks affected by MOS supplementation at the end of the experiment.

Variable Parameter	Control	Treatment Groups		
		0.05% MOSs	0.10% MOSs	0.15% MOSs
BWG (g)	2536.8 \pm 32.2	2573.9 \pm 43.6	2557.8 \pm 36.3	2623.1 \pm 34.6
FI (g)	3994.7 \pm 117.1	4058.9 \pm 130.7	4162.9 \pm 40.3	4221.0 \pm 60.5
FCR (FI/BWG)	1.58 \pm 0.08	1.58 \pm 0.04	1.63 \pm 0.03	1.61 \pm 0.06

FI: feed intake.

BWG: body weight gain.

FCR: feed conversion ratio.

Table 3. The effect of MOSs on serum biochemical values for broiler chicks.

Item	Control	Treatment Groups			MOSs vs. Control
		0.05% MOSs	0.10% MOSs	0.15% MOSs	
Cholesterol (mg/dl)	86.9 ± 7.4ab	71.6 ± 12.1b	101.7 ± 4.6a	95.3 ± 3.8a	0.72
Triglyceride (mg/dl)	106.7 ± 13.6	85.3 ± 10.7	104.2 ± 8.6	112.6 ± 4.7	0.64
ALT (U/l)	15.8 ± 1.7A	10.9 ± 1.5B	8.0 ± 1.0B	8.9 ± 0.9B	0.00
AST (U/l)	42.1 ± 12.9a	23.8 ± 3.2ab	20.9 ± 2.9ab	19.4 ± 2.0b	0.01

a,b: Means within row with different superscripts are significantly different ($P < 0.05$).

A,B: Means within row with different superscripts are significantly different ($P < 0.01$).

organic acids mixture to broiler diets from 7 to 42 days of age. Eren et al. (24) fed chicks diets with 1 g/kg of Bio-Mos[®] until 35 days of age and reported no significant differences in BWG or FCR. Similarly, a study conducted by Shafey et al. (25) showed that supplementation of broiler diets with 3 g/kg of Bio-Mos[®] did not influence BWG, or feed and nutrient utilization. These results contradict the work by Kumprecht and Zobac (26), who reported that the inclusion of Bio-Mos[®] in broiler finisher diets resulted in a significant improvement in BW and FCR, with a level of 2 g/kg being the most effective. Iji et al. (3) reported that feeding broilers diets with 5 g/kg of Bio-Mos[®] led to minor improvements in BW, but no improvement in FCR. Waldroup et al. (14) reported that the addition of Bio-Mos[®], antibiotic, or the combination of antibiotic and Bio-Mos[®] did not significantly influence BW, but significantly improved FCR at 42 days of age. Published reports on the utilization of MOSs in broiler diets are rare and contradictory. This may be due, in part, to differences in the level of dietary supplementation.

Kannan et al. (17) reported that serum total cholesterol concentration was significantly lower in broilers fed a 0.05% MOS diet when compared to a control diet and 0.10% MOS diet. The results of the present study are in agreement with those reported by Raju and Devegowda (27). Kalavathy et al. (28) reported that serum total cholesterol concentration was significantly lower in broilers fed MOSs when compared to control broilers. The decrease in cholesterol level could be due to the assimilation by *Lactobacillus*, as prebiotic supplementation could have enhanced the *Lactobacillus* count (29) or *Lactobacillus*' ability to synthesize bile salt

hydrolase (BSH), which deconjugates bile salts (making them less absorbable), and since cholesterol is the precursor of bile salts more cholesterol is taken out of circulation (28). In contrast, Stanley et al. (30) reported that addition of MOSs to broiler diets did not significantly affect plasma cholesterol. Re-elevation of the cholesterol content in the groups fed higher levels MOSs suggested that this may be attributable to the inhibition of *Lactobacillus* populations by other factors in the intestinal environment.

Although no significant difference was observed in serum triglyceride levels between the groups in the present study, Kannan et al. (17) reported that serum triglycerides were lower in MOS-fed broilers than in control broilers.

While serum AST and ALT levels were significantly higher in our control group, AST level was significantly lower in broilers fed 0.15% MOSs than in those in the other groups ($P < 0.01$). These results contradict the work by Stanley et al. (30) and Sarica et al. (23), who reported that the addition of MOSs did not significantly affect AST level. Lower ALT and AST correlate with better health in animals. MOSs reduced both of those enzymes to the range of normal levels, which represent the non-pathological metabolism of the liver and heart.

In conclusion, although MOSs added to broiler diets seemed to depress BWG at earlier ages, BWG tended to be higher in broilers in the MOS-supplemented groups than in the control group. FI and FCR were not affected by dietary treatment. While serum triglyceride level was not influenced by dietary MOS treatment, low-level MOS

(0.05%) decreased cholesterol and higher levels of MOSs (0.10% and 0.15%) tended to increase the cholesterol concentration in blood. Additionally, AST and ALT levels in blood decreased in response to the dietary addition of MOSs. A wider MOS supplementation range and more

intestinal and biochemical data in future research will help to clarify our understanding of the optimal and marginal levels for broilers, with respect to performance and metabolism.

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