JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
ISSN Print: 1813–2235; ISSN Online: 1814–960X
07–303/ZIP/2008/04–1–13–17
http://www.fspublishers.org

Full Length Article

Effect of Mannan Oligosaccharide on Performance and Carcass Characteristics of Broiler Chicks

M.A. MOHAMED[1], H.M.A. HASSAN AND E.M.A. EL-BARKOUKY†
Department of Animal Production, National Research Center, 12311 Dokki Egypt
†Biological Applications Department, Nuclear Research Center, Anshas, Egypt
[1]Corresponding author's e-mail: modamin_m@yahoo.com

ABSTRACT

A natural growth promoter (mannan oligosaccharide (Mos)) was compared with an antibiotic growth promoter (enramycin) on performance and carcass characteristics of broiler chicks. Mos, derived from the cell wall of the yeast *Saccharomyces cerevisiae*, were added at 1 g kg^{-1} from 1 to 28 days of age and at 0.5 g kg^{-1} from 29 to 42 days of age. Enramycin was added at 0.35 g kg^{-1} to 28 days of age followed by 0.20 g kg^{-1} to 42 days of age. A diet of no supplement served as a control while another diet was supplemented with both Mos and enramycin. The dietary treatments were fed to four replicates of 15 chicks each. The results indicated that addition of Mos, enramycin or the combination of both did slightly improve ($P>0.05$) body weight gain during the finishing (29 - 42 days of age) and the overall experimental period (1- 42 days of age) by about 2% compared to the control diet. Feed conversion ratio at 14 and 28 days were significantly ($P<0.05$) improved by the addition of Mos, enramycin or the combination of both. The addition of Mos, enramycin, or the combination significantly ($P<0.05$) reduced the percentage of abdominal fat in the carcass. No significant effects on dressing percentage, liver, heart, gizzard and bursa weight were detected. It is concluded, that Mos might be used as an alternative to growth-promoting enramycin in broiler diets.

Key Wards: Mannan oligosaccharide; Enramycin; Performance; Boilers; Carcass

INTRODUCTION

Antibiotics have been widely used in poultry feeds to control diseases and to promote growth and improve feed conversion. Recently, the non-prescription use of antibiotics in poultry feeds has been eliminated. The European Union banned the use of subtherapeutic levels of antibiotics to prevent disease or promote growth, starting with a ban on avoparcin in 1997 and a ban on virginiamycin, bacitracin, spiromycin and tylosin in 1999. Antimicrobials banned by January 2006 include avilamycin, bambermycin, salinomycin and monensin. Therefore, alternatives to antibiotics are of great interest to the poultry industry (Waldroup *et al.,* 2003a). These alternatives include acidifiers, prebiotics, probiotics, enzymes, herbal products, microflora enhancers and immuno-modulators.

Mannan oligosaccharide exerts a significant growth-promoting effect by enhancing the animal's resistance to enteric pathogens. Mos, a mannan oligosaccharide derived from the cell wall of the yeast *Saccharomyces cerevisiae* is commercially available as a feed supplement and regarded as safe compound (Ferket, 2004). Based on the scientific literature, Mos enhances resistance to enteric disease and promotes growth by: (1) inhibits colonization of enteric pathogens by blocking bacterial adhesion to gut lining (Oyofo *et al*., 1989; Spring *et al*., 2000; Duval-Iflah, 2001; Valancony *et al*., 2001), (2) enhances immunity (Ferket, 2002; Humphrey *et al.,* 2002), (3), brush border mucin barrier (Iji *et al*., 2001; Loddi *et al*., 2002), (4) and integrity of the gut lining (Sonmez & Eren, 1999; Ferket, 2002) and (5) and reduces enterocyte turnover rate (Spring *et al*., 2000). These properties have the potential to enhance growth rate, feed conversion efficiency and livability in commercial broilers and turkeys and to increase egg production (Hooge, 2004).

Published reports on the use of Mos in broiler diets are sparse and inconsistent, perhaps due to variability in the levels used in the diets. Jamroz *et al*. (1997) reported no improvement on performance of broilers when 2 g kg^{-1} of Mos was included in the feed. Kumprecht and Zobac (1997) incorporated Mos at levels up to 3 g kg^{-1} in broiler finisher diets and observed significant improvements in body weight and feed conversion. Eren *et al*. (1999) fed chicks diets containing 1 g kg^{-1} of Mos to 35 days and reported no significant improvements in body weight gain, feed conversion, or carcass dressing percentage. A level of 2 g kg^{-1} was said to be the most effective level. Iji *et al*. (2001) reported that feeding broilers diets containing 5 g kg^{-1} Mos led to minor improvements in body weight but no improvement in feed conversion. Waldroup *et al*. (2003b)

To cite this paper: Mohamed, M.A., H.M.A. Hassan and E.M.A. El-Barkouky, 2008. Effect of mannan oligosaccharide on performance and carcass characteristics of broiler chicks. *J. Agri. Soc. Sci.,* 4: 13–7

were unable to detect improvements in body weight when 1 g kg^{-1} Mos was fed to broilers, but did note improved feed utilization.

Recently, promising results and remarkable positive effects on using Mos as an alternative antibiotic growth promoter had been reported (Blake *et al.,* 2006; Podmaniczky *et al*., 2006; Zakeri & Mahdavi, 2006). The objective of this study was to further determine the effects of Mos supplementation to broiler diets compared to a growth promoting antibiotic, enramycin. A combination of Mos and enramycin was also evaluated.

MATERIALS AND METHODS

Nutritionally complete diets were formulated for starter (0 to 14 days), grower (15 to 28 days) and finisher (29 to 42 days) periods (Table I). The diets were formulated to cover the nutrient requirements of ROSS broilers. Mos, a commercial product of mannan oligosaccharide derived from the cell wall of the yeast *Saccharomyces cerevisiae*, was provided by Alltech under the trademark of Bio-Mos. Enramycin is a polypeptide antibiotic produced by streptomyces fungicidus and provided by Schering-plough Animal Health. Four experimental diets were used. The first served as a control with no addition of Mos or enramycin. The second and third contained either Mos or enramycin, respectively. Both Mos and enramycin, were added in the forth. Mos was used at 1 g kg^{-1} in starter and grower diets from 1 to 28 days of age and at 0.5 g kg^{-1} in finisher diets from 29 to 42 days of age. Enramycin was used at 0.35 g kg^{-1} to 28 days of age followed by 0.20 g kg^{-1} to 42 days of age.

Two hundreds and forty a day old Ross broiler chicks were used in this experiment. Birds were brooded in the warmed fumigated brooder house and fed on the experimental diets. The experimental diets were fed to four replicates of 15 chicks each. The average initial live body weight of all replicates was similar. Replicates were randomly allocated in batteries of three-tier system divided into 16 compartments (4 replicates X 4 dietary treatments). Gas heaters were used during the first two weeks of age to keep the required temperature for the brooding period and light was provided 23 h daily during the experiment. Feed and water were allowed for *ad libitum* consumption. After fasting overnight, birds were weighed and feed consumption was recorded per replicate at 14, 28 and 42 days of age. Body weight gain and feed conversion ratio were calculated.

Birds were vaccinated against avian influenza, New Castle, IB and IBD throughout the experimental period. After such medical treatments, a dose of vitamins (AD_3E) was offered in the drinking water for the successive 3 days. At day 42, six birds per treatment were randomly taken to study carcass characteristics. Chicks were fasted for approximately 12 h and then individually weighed, slaughtered, feathered and eviscerated. Weights of carcass, heart, liver, spleen, bursa and gizzard were recorded. The abdominal fat surrounding the gizzard and the leaf fat attached to the abdominal wall around the vent area were removed and weighed. The percentage of carcass, organs and abdominal fat (% of live body weight) was calculated.

Data were statistically analyzed for analysis of variance using the General Liner Model of SAS Institute (1990). Significant differences among treatment means were separated by Duncan's new multiple rang test (Duncan, 1955) with a 5% level of probability.

RESULTS

Effects of dietary Mos and enramycin supplementation on body weight gain and feed conversion ratio during the different growing phases are shown in Table II. Body weight gain was not significantly influenced by the addition of either Mos, enramycin or the combination of both. However, such addition did not significant body weight gain during the finishing (29-42 days of age) and the overall experimental period (1-42 days of age) by about 2% compared to the control diet.

Addition of either Mos or enramycin and both Mos and enramycin together resulted in significant ($P<0.05$) improvement in feed conversion ratio (feed: gain) during the starting (1-14 days of age) and growing period (15-28 days of age). During the starting and growing period birds fed the control diet recorded FCR values being 1.46 and 1.70, respectively. The corresponding values recorded for birds fed Mos with enramycin diet were 1.39 and 1.63. During the finishing period, all the dietary treatments gave almost the same value of FCR being 1.99. Regarding the overall experimental period, supplementation of Mos or enramycin did not significantly affect FCR. An improvement on values of FCR by 0.02 or 0.03 was observed when the control diet was supplemented with Mos, enramycin or both. No significant statistical interaction effects were detected between Mos and enramycin on body weight gain and feed conversion ratio during the different phase of the growing period or the overall experimental period.

The effects of Mos and enramycin supplementation on carcass characteristics of chicks fed the different dietary treatments are shown in Table III. The results on carcass characteristics indicated that addition of Mos or enramycin significantly ($P<0.05$) decreased abdominal fat percentage. Significant ($P<0.05$) statistical interaction between Mos and enramycin on abdominal fat was detected. The highest abdominal fat percentage value was recorded for birds fed the control, un-supplemented, diet (2.21%) while the lowest value was recorded for birds fed the Mos supplemented diet (1.78%). The different supplementation did not significantly affect dressing percentage and liver, heart, gizzard and bursa weights relative weight. Supplementation of enramycin showed significant ($P<0.05$) decrease in spleen weight as percentage of body weight.

DISCUSSION

The results of using Mos as natural growth promoters

Table I. Formulation and nutrient composition of the experimental diets

Ingredients %	Starter	Grower	Finisher
Yellow corn	52.05	53.95	57.25
Soybean meal (44%)	32.00	30.00	28.00
Corn gluten meal (60%)	9.00	7.00	5.00
Vegetable oil	2.50	5.00	6.00
Limestone	1.10	1.10	1.10
Dicalcium phosphate	2.10	1.80	1.70
Vitamin and Mineral mix[(1)]	0.30	0.30	0.30
Salt	0.35	0.35	0.35
L-Lysine HCl	0.35	0.25	0.15
DL-Methionine	0.25	0.25	0.15
Total	**100**	**100**	**100**
Calculated Composition[(2)] %			
Crude protein	24.20	22.15	20.15
ME (kcal kg^{-1})	3030	3190	3260
Lysine	1.43	1.27	1.10
Methionine	0.67	0.64	0.50
Methionine + Cystine	1.07	1.02	0.84
Calcium	0.99	0.91	0.88
Nonphytate P	0.55	0.47	0.44

[(1)] Vitamin - mineral mixture supplied per Kg of diet: Vit A, 12000 I.U; Vit D_3, 2200 I.U; Vit E, 10 mg; Vit K_3, 2 mg; Vit B_1, 1mg; Vit B_2, 4mg; Vit B_6, 1.5mg; Vit B_{12}, 10μg; Niacin, 20 mg; Pantothenic acid, 10 mg; Folic acid, 1 mg; Biotin, 50 μg; Choline chloride, 500mg; Copper, 10 mg; Iodine, 1mg; Iron, 30 mg; Manganese, 55 mg; Zinc, 50 Mg and Selenium, 0.1 mg.
[(2)] Calculated values based on feed composition Tables of NRC (1994)

in poultry diets are inconsistent. Kumprecht and Zobac (1997) reported that inclusion of Mos at levels up to 3 g kg^{-1} in broiler finisher diets resulted in a significant improvement in body weight and feed conversion. Eren *et al.* (1999) fed chick diets with 1 g kg^{-1} of Mos to 35 days and reported no significant differences in body weight gain, feed conversion ratio, or carcass dressing percentage compared to a negative control. Iji *et al.* (2001) found that feeding broilers diets with 5 g kg^{-1} of Mos led to minor improvements in body weight but no improvement in feed conversion. Shafey *et al.* (2001) reported that supplementation of broiler diets with 3 g kg^{-1} of Mos did not influence body weight gain or feed utilization.

Valancony *et al.* (2001) compared the antibiotic avilamycin and Mos in diets fed to turkeys grown to slaughter weights and observed no difference in slaughter weight or carcass yield. Waldroup *et al.* (2003b) did not detect any improvement in body weight when 1 g kg^{-1} Mos was fed to broilers, but did note improvement in efficiency of feed utilization. Waldroup *et al.* (2003a) found that feed conversion at 14 and 21 days of age was significantly improved by addition of the antibiotics but did not prove to be significantly improved at later ages. Addition of Mos had no effect on body weight at any age. Carcass characteristics were not improved by any of the factors tested.

In some studies (Mathis, 2000; Sefton *et al*., 2002); in which certain antibiotics were used in combination with Mos, additive or synergistic beneficial effects on broiler live performance were observed compared to antibiotic alone. Virginiamycin + Mos, gave significant improvement in feed conversion (Mathis, 2000); bacitracin-MD and virginiamycin shuttle program + Mos, improved feed conversion (Sefton *et al*., 2002).

Decreased abdominal fat by the addition of antibiotics or Mos are in agreement with previous studies (Kumprecht *et al*., 1997; Clementino Dos Santos *et al.*, 2002; Fritts & Waldroup, 2003). Fritts and Waldroup (2003) used Mos as a potential replacement for growth promoting antibiotics in the diet of growing turkeys. Mos was added to nutritionally complete turkey diets at the rate of 0.05 and 0.10%. The growth-promoting antibiotics bambermycins and bacitracin methylene disalicylate (BMD) were added at 2.2 and 55 mg kg^{-1}, respectively. The addition of BMD significantly reduced the percentage of abdominal fat in the carcass.

In a cage broiler study, using 0 to 0.3% Mos at 0.05% increments of addition to the diets, 0 to 21 days fiber digestibility significantly improved with diets containing each level of Mos compared to the negative control diets (Kumprecht *et al*., 1997). It is conceivable that better health of the intestinal mucosa due to feeding Mos diets improves carcass and breast meat yield. Dietary Mos (0.1%) significantly increased breast yield as a percentage of dressed carcass compared to the negative control treatment (Clementino Dos Santos *et al.*, 2002).

Recently, more remarkable positive effects of using Mos were reported. Blake *et al.* (2006) indicated that the addition of Mos to broiler diets had an influence in promoting body weight increases over the control diet in the early growing period (0-14 days). The combination of Mos and Bacitracin Methylene Disalycilate resulted in highly significant ($P<0.001$) improvements in body weight over the control diet at 14 days. Podmaniczky *et al.* (2006) showed that Mos addition to challenged broiler diets had significantly ($P<0.05$) improved body weight gain and feed conversion ratio compared to challenge chickens without Mos (FCR, 1.84 vs 2.11, respectively). The authors concluded that Mos could be a useful tool to maintain intestinal health and growth performance under challenged or sub-optimal production system.

Zakeri and Mahdavi (2006) found that supplementation of Mos to broiler diets (g kg^{-1}) significantly improved feed conversion ratio by 12% ($P<0.05$), a considerable rise of 350 g in average of final weight ($P<0.05$) and tended to decrease mortality rate (-0.7%). The authors indicated that Mos can also enhance immunity system with beneficial actions such as prevention of intestinal colonization by diseases-producing bacteria, induces macrophages activation and toxin binding.

The Mos is reported to have at least three probable modes of action by which broiler performance may be improved: (1) adsorption of pathogenic bacteria containing type 1 fimbriae with mannose-sensitive lectins, sometimes referred to as the "receptor analog" mechanism (strongly binding to & decoying pathogens away from the "sugar coated" intestinal lining), or stated another way, different bacterial strains can agglutinate Mos (Oyofo *et al*., 1989;

Table II. Effect of Mos and enramycin supplementation on body weight gain and feed conversion ratio of broiler chicks

Item		1-14 day		15-28 day		29-42 day		1-42 day	
Dietary treatments		BWG	FCR	BWG	FCR	BWG	FCR	BWG	FCR
Mos	Enramycin								
-	-	262	1.46[a]	693	1.70[a]	890	1.99	1844	1.81
+	-	263	1.40[ab]	700	1.67[ab]	920	1.99	1883	1.79
-	+	264	1.40[ab]	703	1.67[ab]	916	1.98	1882	1.78
+	+	263	1.39 [b]	704	1.63[b]	916	1.99	1883	1.78
SE of means		2.47	0.01	6.60	0.01	7.80	0.01	11.3	0.01
Main effects									
Mos									
-		263	1.43 [a]	697	1.69[a]	903	1.99	1863	1.79
+		263	1.40 [b]	702	1.65[b]	918	1.99	1883	1.78
Enramycin									
-		262	1.43 [a]	697	1.69[a]	905	1.99	1863	1.80
+		263	1.40 [b]	703	1.65[b]	916	1.99	1882	1.78
Significances									
Source of variation									
Mos effect (A)		NS	*	NS	*	NS	NS	NS	NS
Enramycin effect (B)		NS	*	NS	*	NS	NS	NS	NS
A X B		NS	NS	NS	NS	NS	NS	NS	NS

[a-b] Means within each column for each effect with no common superscript are significantly different (P< 0.05).
* P<0.05 NS: not significant (P>0.05)

Table III. Effect of Mos and enramycin supplementation on dressing percent, abdominal fat and giblets weight as percent of live body weight of 42-day old broiler chicks

		Dres-sing%	Abdo-minal fat %	Giblets % (of LBW)				
Item				Liver	Heart	Gizzard	Spleen	Bursa
Dietary treatments								
Mos	Enramycin							
-	-	71	2.21[a]	2.38	0.53	1.43	0.19[a]	0.13
+	-	71	1. 78 [c]	2.45	0.52	1.40	0.19[a]	0.11
-	+	71	1. 96 [b]	2.44	0.49	1.36	0.14[b]	0.11
+	+	72	1.80 [c]	2.40	0.49	1.45	0.17[ab]	0.11
SE of means		0.22	0.07	0.01	0.01	0.01	0.01	0.01
Main effects								
Mos								
-		71	2.08 [a]	2.41	0.51	1.40	0.17	0.12
+		72	1.79 [b]	2.42	0.50	1.43	0.18	0.11
Enramycin								
-		71	2.00 [a]	2.41	0.52	1.42	0.19[a]	0.12
+		72	1.88 [b]	2.42	0.49	1.41	0.16[b]	0.11
Significances								
Source of variation								
Mos effect (A)		NS	*	NS	NS	NS	NS	NS
Enramycin effect (B)		NS	**	NS	NS	NS	*	NS
(A) X (B)		NS	*	NS	NS	NS	NS	NS

[a–c] Means within each column for each effect with no common superscript are significantly different (P< 0.05). * P<0.05 ** P<0.01 NS: not significant (P>0.05)

Spring *et al*., 2000); (2) improved intestinal function or "gut health" (for example: increases villi height, uniformity & integrity, Loddi *et al*., 2002) and (3) immune modulation simulates gut associated and systemic immunity by acting as a non-pathogenic microbial antigen, giving an adjuvant-like effect (Ferket *et al*., 2002).

The results of the present study suggest that Mos might be considered as an alternative to growth promoting antibiotics. It is also possible that the levels of Mos used in this study were not sufficient to elicit a pronounced response. This warrants further study with higher levels of inclusion in the diet.

REFERENCES

Blake, J.P., J.B. Hess, K.S. Maklin, S.F. Bilgili, A.E. Sefton and A. Kocher, 2006. Mannan oligosaccharide supplementation of wheat-based diets for broilers. *In: Proceedings 12th European Poultry Conference, Supplement of World's Poultry Science J.,* Vol. 62, p: 342

Clementino Dos Santos, E., A. Soares Teixeira, A. Gilberto Bertechini, R. Tadeu Fonseca De Freitas, P. Borges Rodregues, E. Souza Dias, D.M. Torres, A. Vieira Santos and R.A. Giacometi, 2002. Effect of growth beneficial additives on broiler carcass yield. *In: Proc. Braz. Soc. Anim. Prod.,* p: 5

Duncan, D.B., 1955. Multiple Range and Multiple F Tests. *Biometric.*, 11: 1–42

Duval-Iflah, Y.S., 2001. Comparison of yogurt, heat treated yogurt, milk and lactose effects on plasmid dissemination in antibiotic mice. *Ant. Van Leeu. Int. J. Gen. and Mol. Microbial.,* 79: 199

Eren, M., G. Deniz, H. Birickik, S.S. Gezen, I.I. Turkemen and H.M. Yavuz, 1999. Effects of supplementation of zinc bacitracin, mannan oligosaccharide and probiotic in broiler feeds on fattening performance. *Vet. Fak. Derg. Ulu. University,* 18: 73–84

Ferket, P.R., 2002. Use of oligosaccharides and gut modifiers as replacements for dietary antibiotics. *Proc. 63rd Minnesota Nutrition Conference, September 17-18,* pp: 169–82. Eagan, MN

Ferket, P.R., C.W. Parks and J.L. Grimes, 2002. Benefits of dietary antibiotic and mannan oligosaccharide supplementation for poultry. *In: Proc. Multi-State Poult. Feeding and Nutr. Conf., Indianapolis, Indiana USA. May 14-16,* p: 22

Ferket, P.R., 2004. Alternatives to antibiotics in poultry production: response, practical experience and recommendations. *In*: Lyons, T.P. and K.A. Jacques (eds.), *Biotechnology in the Feed and Food Industry, Proceedings of Alltech's 20th Annual Symposium*, pp: 57–66. Nottingham University Press, UK

Fritts, C.A. and P.W. Waldroup, 2003. Evaluation of mannan oligosaccharide as a replacement for growth promoting antibiotics in diets for turkeys. *Int. J. Poultry Sci.,* 2: 19–22

Hooge, D.M., 2004. Meta-analysis of broiler chicken pen trials evaluating dietary mannan oligosaccharide, 1993-2003. *Int. J. Poultry Sci*., 3: 163–74

Humphrey, B.D., E.A. Koutsos and K.C. Klasing, 2002. Requirements and priorities of the immune system for nutrients. *In*: Jacques, K.A. and T.P. Lyons (eds.), *Biotechnology in the Feed and Food Industry, Proceedings of Alltech's 18th Annual Symposium*, pp: 69–77. Nottingham University Press, UK

Iji, P.A., A.A. Saki and D.R. Tivey, 2001. Intestinal structure and function of broiler chickens on diets supplemented with a mannan oligosaccharide. *J. Sci. Food Agric.,* 81: 1186–92

Jamroz, D., A. Wiliczkiewicz, J. Skorupinska and J. Orda, 1997. Using enzymatic additive Endofeed and mannan oligosaccharide BIO-MOS in mixtures for slaughter chickens. *Roczniki-Naukowe-Zootech*., 24: 251–63

Kumprecht, I. and F. Zobac, 1997. The effect of mannan oligosaccharides in feed mixtures on the performance of broilers. *Zivocisna Vyroba,* 42: 117–24

Kumprecht, I., P. Zobac, V. Siske and A.E. Sefton, 1997. Effects of dietary mannan oligosaccharide level on live weight and feed efficiency of broilers. *Poult. Sci.*, 76: 132

Loddi, M.M., L.S.O. Nakaghi, F. Edens, F.M. Tucci, M.I. Hannas, V.M.B. Moraes and J. Ariki, 2002. Mannan oligosaccharide and organic acids on intestinal morphology integrity of broilers evaluated by scanning electron microscopy. Page 121. *In: Proc. 11th European Poultry Sci. Conf., Bremen, Germany*. Sept. 6-10

Mathis, G.F., 2000. *Effect of MOS on Growth and Feed Efficiency in Commercial Broiler Chickens.* Southern Poultry Research, Inc., Athens, Georgia USA

Oyofo, B.A., J.R. DeLoach, D.E. Corrier, J.O. Norman, R.L. Ziprin and H.H. Mollenhauer, 1989. Prevention of Salmonella typhimurium colonization of broilers with D-mannose. *Poultry Sci*., 68: 1357–60

Podmaniczky, B., A. Kocher, Z.S. Szabo, B. Vegi, K. Horel, L. Korosi and A. Korosi Molnar, 2006. The effect of mannan oligosaccharides on growth performance of challenged broilers. *In: Proceedings 12th European Poultry Conference, Supplement of world's Poultry Science J.,* Vol. 62, p: 319

SAS Institute, 1990. *SAS® / STAT User's Guide: Statistics, Version 6*, 4th edition. SAS Institute Inc, Cary, NC

Sefton, A.E., M.D. Sims and S. Collett, 2002. Evaluation of Mos in commercial broiler chickens. *Poultry Sci.*, 81: 77

Shafey, T.M., S. Al-Mufarej, M.I. Shalaby and A.J. Jarlenabi, 2001. The effect of feeding mannan oligosaccharides (Bio-Mos) on the performance of meat chickens under two different vaccination programs. *Asian-Australian J. Anim. Sci*., 14: 559–63

Sonmez, G. and M. Eren, 1999. Effects of supplementation of zinc bacitracin, mannan oligosaccharide and probiotic into the broiler feeds on morphology of the small intestine. *Vet. Fac. Dergisi Uludag University*, 18: 125–38

Spring, P., C. Wenk, K.A. Dawson and K.E. Newman, 2000. The effects of dietary mannan oligosaccharides on cecal parameters and the concentrations of enteric bacteria in the ceca of salmonella-challenged broiler chicks. *Poultry Sci*., 79: 205–11

Valancony, H., F. Humbert, J. Rukelibuga, M. Bougon, L. Balaine and F. Lalande, 2001. Comparison of some substitutes for antibiotic additives in diets for turkey poults. Effects on production and on resistance to salmonella colonization. *Sci. Tech. Avicoles,* 35: 25–34

Waldroup, P.W., C.A. Fritts and F. Yan, 2003b. Utilization of Mos mannan oligosaccharide and Bioplex® copper in broiler diets. *Int. J. Poult. Sci.,* 2: 44–52

Waldroup, P.W., E.O. Oviedo-Rondon and C.A. Fritts, 2003a. Comparison of Mos and antibiotic feeding programs in broiler diets containing copper sulfate. *Int. J. Poult. Sci.*, 2: 28–31

Zakeri, A. and Mahdavi, 2006. The effect of Mos (mannan-oligosaccharide) on growth rate, productive parameters and amount of humoral immunity of broiler chickens. *In: Proceedings 12th European Poultry Conference, Supplement of world's Poultry Science J.*, Vol. 62, p: 304

(Received 04 September 2007; Accepted 21 December 2007)