ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 10 (11): 854-862, 2011
ISSN 1682-8356

The Effect of Single or Combined Dietary Supplementation of Mannan Oligosacharide and Probiotics on Performance and Slaughter Characteristics of Broilers

Sherief M. Abdel-Raheem[1] and Sherief M.S. Abd-Allah[2]
[1]Department of Nutrition and Clinical Nutrition, [2]Department of Food Hygiene (Meat Hygiene),
Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt

Abstract: A feeding trial was conducted to investigate the effects of dietary supplementation of prebiotic (mannan oligosaccharide, MOS), Probiotic (*Saccharomyces cerevisiae*) and their combination (synbiotic) on growth performance, some carcass traits and meat quality in broilers. One hundred, one day-old broiler chicks (Avian 48), were randomly assigned to 4 dietary treatments (25 birds/treatment) for 6 weeks. Treatment groups were as follow: 1. Basal diet (control); 2. Basal diet plus Mannan-Oligosaccharide (MOS) (2 g of MOS/kg of the starter diets and 0.5 g/kg of the grower diets); 3. Basal diet plus probiotic (*Saccharomyces cerevisiae*) 3 g/kg diet and 4.Basal diet plus the combination of pre and probiotics (synbiotic). The final BW, weight gain, carcass yield percentage and immune organ weights were significantly ($p<0.05$) increased in probiotic and synbiotic supplemented broilers in comparison with the control and prebiotic groups. Meat from prebiotics supplemented broilers was more tender and juicy. Serum total cholesterol and triglycerides were significantly decreased in all dietary treatments compared with the control birds. Supplementation of broiler diets with pre, pro and synbiotics significantly improved body weight, weight gain and feed conversion, some carcass traits and meat quality, compared with the un-supplemented control. The feed conversion rate was significantly lower in synbiotic supplemented group. The results of the present study demonstrated that synbiotic as growth promoters appeared to be superior compared to use pre or probiotic alone in optimizing digestion to convert feed into body mass more efficiently and improve broiler chickens growth performance.

Key words: Mannan oligosaccharides, prebiotic, probiotic, synbiotic, broilers, performance

INTRODUCTION

Increased bacterial resistance to antibiotics in humans has caused an increase in public and governmental interest in eliminating sub-therapeutic use of antibiotics in livestock. An alternative approach to sub-therapeutic antibiotics in livestock is the use of probiotic microorganisms, prebiotic substrates that enrich certain bacterial populations, or synbiotic combinations of prebiotics and probiotics. Prebiotics such as inulin, Fructo-oligosaccharides (FOS), Isomalto-oligosaccharides (IMO) and Mannan Oligosaccharides (MOS) have been defined by Gibson and Roberfroid (1995) as non-digestible food ingredients that selectively stimulate the growth and activity of one or a limited number of bacteria in the intestine that can improve the host health (Gibson and Roberfroid, 1995). These fermentable substrates are not hydrolyzed by the host digestive enzymes and pass intact in the lower digestive tract. Prebiotics have been reported to produce a beneficial effect upon the animal that receives them. This is due to the proliferation of certain beneficial bacteria such as *Bifidobacterium* sp. and *Lactobacillus* sp. or an increase in their metabolic activity (Gibson and Roberfroid, 1995). Inulin, FOS and IMO are reported to be substrates for certain species of beneficial bacteria (Chung and Day, 2004). MOS had the abilty to block the colonization of the pathogens as *E. coli* and *Salmonella* sp., by blocking the ability of these bacteria to connect via their fimbriae, with the intestinal epithelial cells and therefore facilitating their excretion (Spring *et al*., 2000; Duncan *et al*., 2005). Also, the MOS have a positive effect on the immunity preventing the infections (Shashidahara and Dewegowda, 2003).

Gong *et al*. (2002) define probiotics as health-promoting bacteria inhabiting the gastrointestinal tract of humans and animals. Research is focused on identifying beneficial bacterial strains and substrates along with the conditions (Patterson and Burkholder, 2003). The major probiotic strains include *Lactobacillus*, *Saccharomyces*, *Bacillus*, *Streptococcus* and *Aspergillus* (Tannock, 2001). Positive effects of probiotics on animals can result either from a direct nutritional effect of the probiotic, or a health effect, with probiotics acting as bioregulators of intestinal microflora and reinforcing the host's natural defenses. There have been numerous studies in humans and animals on the ability of probiotics to change the types

Corresponding Author: Sherief M. Abdel-Raheem, Department of Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt

and numbers of gut microflora (Endo *et al*., 1999). Exactly how dietary microbial products function in the digestive system is not known, but some suggested mechanisms are that they: 1) provide nutrients, 2) aid in digesting and 3) inhibit harmful bacteria (Owings *et al*., 1990). Moreover, *Saccharomyces cerevisiae* could act as bioregulator of the intestinal micro flora and reinforcing the host natural defenses, through the sanitary effect by increasing the colonization resistance and stimulation of the immune response (Line *et al*., 1998). Effects of yeast products on production and their mode of action in monogastrics have been reported in poultry (Stanley *et al*., 2004; Zhang *et al*., 2005). However, mode of action of yeast products in these animals is less clear. Some studies have confirmed the effects of Yeast Culture (YC) in increasing concentrations of commensal microbes or suppressing pathogenic bacteria (Stanley *et al*., 2004). Gao *et al*. (2008) hypothesized that there may be other mechanisms responsible for effects of YC in monogastrics other than modulation of microbial ecology. Mannan oligosaccharides and 1,3/1,6 β-glucan are components of the yeast cell wall that modulate immunity (Shashidahara and Dewegowda, 2003), promote growth of intestinal microflora (Spring *et al*., 2000) and increase growth (Parks *et al*., 2001). YC contains viable cells, cell wall components, metabolites and the media on which the yeast cells were grown (Miles and Bootwalla, 1991).

The combination of a pre- and probiotic in 1 product has been shown to confer benefits beyond those of either on its own (Gallaher and Khil, 1999). Synbiotics is defined as a mixture of probiotics and prebiotics that beneficially affects the host by activating the metabolism of one or a limited number of health promoting bacteria and/or by selectively stimulating their growth improving the host's welfare (Gibson and Roberfroid, 1995). Zhang *et al*. (2006) found that some probiotics or synbiotics were effective in increasing the body weight of chickens. In addition, Mohnl *et al*. (2007) found that the synbiotic product (Biomin® PoultryStar) had a comparable potential to improve broiler performance as Avilamycin (an antibiotic growth promoter). It seems that synergistic effects of prebiotics and probiotics can be useful in stimulating beneficial bacteria and improving the health of the gut. However, there is scarce information available to date on synbiotics and its possible mechanisms in broiler chickens. Synbiotics include both beneficial micro-organisms and substrates, which may have synergetic effects on the intestinal tract of animals. Thus it may offer a considerable promise for growth promotion in poultry production and a new alternative to antibiotic growth promoters (Patterson and Burkholder, 2003; Awad *et al*., 2008; 2009).

Therefore, the objective of this study was to evaluate effects of dietary supplementation of prebiotics (Bio-MOS), probiotic *(Saccharomyces cerevisiae*) and their combination on growth performance, carcass traits and meat quality in broilers.

MATERIALS AND METHODS

Birds and housing: The experiment was conducted in the experimental poultry house of the Department of Nutrition and Clinical Nutrition, Fac. of Vet. Med., Assiut University, Assiut, Egypt. A total number of 100 One day-chicks (Avian 48) were randomly divided into 4 groups (25 birds/group) and housed in pens of identical size (2 m^2) in a deep litter system with a wood shaving floor and equipped with feeders and drinkers. Each group had 3 replicates (8 birds/pen) one pen contain 9 birds in each group. The birds had free access to water and feed. The climatic conditions and lighting program followed the commercial recommendations. Environmental temperature in the first week of life was 32°C and decreased to 25°C until the end of the experiment. During the first week, 22 h of light was provided with a reduction to 20 h afterward.

Dietary treatments: Two basal diets, starter and grower-finisher were formulated. The starter diet was fed for the first 3 weeks, while the grower finisher one was fed for the last 3 weeks of the experimental period. The physical and the calculated chemical composition of the basal diets are illustrated in Table 1. The dietary treatments were: 1 Basal diet (control); 2. Basal diet + 0.2% prebiotic (2 g prebiotic/kg) in the starter phase and 0.05% (0.5 g prebiotic/kg) in the grower phase; 3. Basal diet plus 0.3% (3 g probiotic/kg) 4. Basal Diet + 0.2% prebiotics and 0.3% probiotics in the starter pahse or 0.05% Bio-mos and 0.3 Probiotic in the grower phase. The chicks were fed with the starter diets from d 1 to d 21 of age and grower feed from d 22 to d 42 (Table 1) in mash form. Diets were formulated according to NRC (1994) recommendations. A commercial prebiotic source Bio-Mos® (Alltech Inc., Nicholasville, KY, USA) and commercial probiotics source (Yeast culture probiotics (Bro-bio-fair, Vitality Co., Egypt), which contained *Saccharomyces Servisia* (labelled as each kg contains: 100 gram *Saccharomyces servisia* (10^{10} cell/gram) and 900 gram carrier (90% soy meal, 5% molt, 5% *Fenu* Greek). The birds were fasted for 10-12 h prior to determination of the final body weight at slaughter.

Growth performance traits: All birds were weighed individually after their arrival from the hatchery to the experimental farm (initial weight) and every week tell the end of the experiment the BW was recorded. Weight gain for each dietary treatment was calculated. Feed consumption was recorded in the course of the whole experiment for each treatment and the feed conversion

Table 1: Inclusion rates for mannan oligosaccharide (Bio-MOS) and probiotic products in broiler chicken diets by treatment

Item	Additives	Starter (d 0 to 21)	Grower and finisher (d 21 to 42)
		Inclusion rate (g/kg)	
T1 (control)	-	-	-
T2	Prebiotic (Bio-Mos)	2	0.5
T3	Probiotic	3	3
T4	Bio-Mos + probiotic (synbiotic)	2 + 3	0.5 + 3

Table 2: Composition and nutrient content of starter (d 1 to 21) and grower (d 22 to 42) basal diets for broiler chicks (%, as fed-basis)

Ingredients (%)	Starter	Grower
Yellow corn	55.45	64.00
Soybean meal	32.70	25.00
Fish meal (60%)	4.00	4.00
Sunflower oil	4.50	3.70
Dicalcium phosphate	1.50	1.50
Limestone	1.00	1.00
Salt (NaCl)	0.40	0.35
Lysine	0.10	0.10
DL-Methionine	0.10	0.10
Premix[1]	0.25	0.25
Antioxidant	0.04	0.04
Total	100.00	100.00
Calculated analysis		
ME (kcal/kg)	3202.91	3224.18
CP (%)	23.03	20.03
Met and Cys (%)	0.93	0.67
Lysine (%)	1.39	1.19
Ca (%)	1.01	1.00
Av. P (%)	0.49	0.49
Na (%)	0.19	0.18
CF (%)	2.97	2.92

[1]Mineral and vitamin premix Heromix broilers (Heropharma Co., Egypt).
Each 2.5 kg contain: 12,000000 IU Vit. A, 2,000000 Vit D3, 10 g vit. E, 2 g Vit K3, 1 g Vit. B1, 5 g vit B2, 1.5 g Vit. B6, 10 mg Vit B12, 30 g nicotinic acid, 10 g pantothenic acid, 1 g folic acid, 50 g biotin, 250 g choline chloride 50%, 30 g iron, 10 g copper, 50 g zinc, 60 g manganese, 1 g iodine, 0.1 g selenium, 0.1 g cobalt and carrier $CaCO_3$ to 2.5 kg

rates were calculated subsequently. Mortality was recorded as it occurred and feed per gain values were corrected for mortality (regarding feed intake).

Organ weights and carcass yield percentages: At the end of experiment, after weighing, 4 birds per treatment were randomly selected and weighed live, slaughtered by neck cut and allowed to bleed. Afterward, the birds were scalded, de-feathered and carcasses were eviscerated. The gizzard, heart, liver, were excised and weighed. The weight of carcass refers to the weight of the eviscerated carcass plus giblet (liver, heart, skinned empty gizzard). Carcass yield (dressing percentage) was obtained by expressing the dressed carcass weight (with giblet) as percentage of live body weight.

Sensory analysis: Three consumer-based sensory panel were conducted to evaluate the acceptability of chicken breast and thigh meat from broilers that were fed the dietary treatments. Chicken breasts and thighs, which were previously frozen (-20°C), were thawed at 2°C for 24 h before sensory testing. Thawed samples were boiled till complete cooking, cooled at room temperature for 10 min, cut into parts and kept worm (60-70°C) in Petri dishes until panelists evaluated them. Sample order was randomized to account for sampling order bias. Water was provided and panelists were asked to expectorate and rinse their mouths between each sample. Each panelist was asked to evaluate cooked chicken breast and thigh samples for flavor, tenderness and juiciness using a 9-point Hedonic Scale, in which 1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely (Meilgaard *et al*., 2007).

Serum biochemistry: Four broilers were randomly selected from each treatment group for blood sample collections from the brachial vein during at day 21 and from the bronchial vein during slaughter at day 42. The collected blood samples were centrifuged at 2000 rpm for 10 min and the sera were collected, stored at -20°C until further analysis. Serum samples were assayed for estimation of total protein, triglycerides, cholesterol, calcium, phosphorus, ALT and AST enzymes by spectrophotometer using commercial test kits (Spectrum, Cairo, Egypt).

Statistics: The data were subjected to statistical analysis with one way ANOVA of (SPSS for Windows Version 13; SPSS GmbH, Munich, Germany) to determine if variables differed between groups. The Kolmogorov-Smirnov test was used to test the normal distribution of the data before statistical analysis was performed. The BW, weight gain, feed intake, feed conversion and organ weights, were compared between groups by one way ANOVA and subsequent Duncan's multiple range test. Probability values of less than 0.05 ($p<0.05$) were considered significant. Results are expressed as means ± pooled SEM.

RESULTS

The initial BW of chicks did not differ ($p>0.05$) between the dietary treatments (Table 3). Birds supplemented with prebiotic (BIO-MOS), probiotic and those supplemented with synbiotic had a greater ($p<0.05$) BW compared with controls at d 21 of age. Moreover, MOS supplemented birds had a greater BW (706.00) ($p<0.01$) than birds supplemented with the synbiotic (632.32) at d 21. However, at the end of the experiment (d 42), birds

Table 3: Body weight, feed intake, feed conversion ratio and mortality of broilers given MOS, probiotcs and their combination

Item	Control	MOS	Probiotic	Synbiotic	SEM	P
Body weight (g)						
1 d	49.44	48.20	49.12	48.28	0.42	0.660
21 d	564.76^{a}	706.00^{b}	668.48^{bc}	632.32^{c}	8.69	0.000
42 d	2058.10^{a}	2175.05^{ab}	2247.14^{b}	2299.19^{b}	29.51	0.020
Weight gain (g)						
0-21	515.32^{a}	657.80^{b}	619.36^{bc}	584.04^{c}	8.70	0.000
22-42	147.86	1465.95	1577.76	1667.33	30.76	0.090
0-42	2009.72^{a}	2127.38^{ab}	2198.87^{b}	2252.23^{b}	29.50	0.020
Feed intake (g/bird)						
0-21	974.37^{a}	1110.29^{b}	1006.71^{a}	1041.29^{c}	15.83	0.000
22-42	3117.29^{a}	3346.33^{b}	3213.00^{c}	3211.90^{c}	24.76	0.000
0-42	4091.66^{a}	4456.63^{b}	4219.71^{c}	4253.20^{d}	39.71	0.000
FCR						
0-21	1.89^{a}	1.69^{b}	1.63^{c}	1.78^{d}	0.03	0.000
22-42	2.08^{a}	2.28^{b}	2.03^{c}	1.92^{d}	0.1	0.000
0-42	2.04^{a}	2.09^{b}	1.92^{c}	1.88^{d}	0.03	0.000
Mortality (%)						
0-21	4.11	1.33	1.33	1.33	0.79	0.580
22-42	1.45	1.38	1.38	1.38	0.59	0.970
0-42	4.13	1.33	2.66	1.33	1.15	0.860

MOS = Mannan oligosaccharide prebiotic (Bio-Mos). Means with different superscript in the same row are significantly different ($p<0.05$). SEM (pooled standard errors of means)

Table 4: Carcass traits and absolute organ weights (g) of broilers given Bio-Mos, probiotcs and synbiotic

	Control	MOS	Probiotic	Synbiotic	SEM	P
Live weight	2133.40	2093.30	2013.20	2286.67	44.88	0.17
Carcass weight	1450.66^{ab}	1347.00^{b}	1393.33^{a}	1616.66^{a}	39.44	0.04
Carcass yield (%)	67.96^{ab}	64.45^{b}	69.17^{a}	70.68^{a}	0.90	0.04
Left breast	301.33^{ab}	269.20^{a}	239.60^{a}	388.33^{b}	20.73	0.02
Left thigh	127.66	133.03	130.33	151.00	4.14	0.18
Abdominal fat	17.00	10.66	16.33	13.80	1.31	0.34
Head	64.17	56.87	57.00	76.00	3.78	0.25
Legs	84.50	73.66	74.83	97.08	4.16	0.15
Liver	43.33	46.83	43.33	49.66	1.08	0.08
Gizzard	40.83	42.17	44.50	44.66	1.11	0.62
Heart	8.90	10.43	10.90	11.53	0.59	0.49
Proventriculus	12.70^{ab}	11.53^{a}	10.33^{a}	17.00^{b}	0.94	0.03
Pancreas	7.20^{ab}	6.23^{a}	6.36^{a}	9.66^{b}	0.53	0.04
Spleen	3.60	3.70	2.30	3.83	0.36	0.45
Bursa	1.43^{a}	1.43^{ab}	2.33^{b}	2.30^{b}	0.15	0.008
Thymus	8.03^{a}	6.83^{a}	8.56^{ab}	13.5^{b}	0.91	0.02

MOS = Mannan oligosaccharide prebiotic (Bio-Mos)

supplemented with synbiotic exhibited a greatest ($p<0.05$) BW (2299.19) compared to probiotic group (2247.14) and control group (2009.72), however the prebiotic supplemented group had an intermediate (2127.38) values.

The cumulative feed intake from d 1 to 21, from d 22 to d 42 and during the whole experiment was increased ($p<0.01$) for birds supplemented with MOS compared with the other dietary treatments and the control groups.

Feed Conversion Rate (FCR): Feed Conversion Rate (FCR) was lower ($p<0.01$) for birds supplemented with probiotic (1.63) in comparison with control (1.89) and prebiotic (1.69) or synbiotic (1.78) supplemented birds at d 21 of age. However, synbiotic supplemented birds had a lower FCR in comparison with either the control or the pre or probiotic alone supplemented birds at the last 3 week of the experiment from d 22 to 42 and from day 1 to d 42 (Table 3).

Mortality rate: The mortality rate was numerically lower (Table 3) for all the dietary treated groups in comparison with the control group at day 21 and at the last 3 weeks from the experiment (d 22 to 42 day). Moreover, at the end of the experiment the mortality rate was lower numerically not statistically in prebiotic and synbiotic supplemented groups.

Carcass traits and absolute organ weights: The data in Table 4 showed that there is a significant increase ($p<0.05$) in the carcass weight and dressing % in synbiotic supplemented broilers compared with either pre or probiotic alone supplemented group. There is also a significant increase in the absolute weight of the immune organs (bursa and thymus) and numerical increase in the spleen in synbiotic supplemented broilers. However, the liver also tended to be higher ($p<0.1$) in synbiotic supplemented broilers.

Table 5: Consumer acceptability of chicken breast meat from broilers given Bio-mos, probiotcs and synbiotic

	Control	MOS	Probiotic	Synbiotic	SEM	P
Flavour	6.94	8.37	6.68	6.62	0.29	0.110
Tenderness	6.56^{b}	8.37^{a}	6.56^{b}	6.31^{b}	0.27	0.005
Juciness	6.75^{b}	8.12^{a}	6.94^{b}	6.87^{b}	0.18	0.006

1Hedonic scale was based on a 9-point scale: 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely. MOS = Mannan oligosaccharide prebiotic (Bio-Mos)

Table 6: Effect of prebiotic and probiotic and their combination on blood metabolites of broilers

	At day 21						At day 42					
Item	Control	MOS	Pro.	Synbiotic	SEM	P	Control	MOS	Pro.	Synbiotic	SEM	P
Total protein (g/dl)	2.5^{a}	3.56^{b}	3.03^{c}	3.36^{bc}	0.13	0.002	3.26	3.90	3.43	3.70	0.09	0.080
T-cholesterol (mg/dl)	148.3	140.60	144.50	135.70	2.14	0.180	160.70^{a}	103.00^{b}	108.30^{b}	93.00^{b}	8.22	0.000
Triglyceride (mg/dl)	124.4	109.00	123.00	118.70	2.40	0.080	125.00^{a}	88.00^{b}	96.00^{bc}	101.67^{c}	4.40	0.001
ALT (u/l)	16.3	13.70	14.30	12.00	0.67	0.110	16.40	16.00	14.20	12.10	0.75	0.220
AST (u/l)	50.3	43.40	45.00	40.60	1.20	0.060	50.30	45.70	42.60	43.00	1.25	0.080
Ca (mg/dl)	12.0	13.40	13.30	13.70	0.54	0.750	13.00	14.00	13.50	14.10	0.47	0.870
P (mg/dl)	5.4	5.80	5.70	6.10	0.14	0.430	5.10	5.86	5.83	5.50	0.20	0.230

MOS = Mannan oligosaccharide prebiotic (Bio-Mos)

Sensory characteristics: Sensory analysis data (Table 5) declared the presence of significant difference ($p<0.05$) between control samples and those from chicken fed Bio-MOS concerning tenderness and juiciness. Where samples from chicken fed Bio-mos were rated higher. Like wise, there were a significant difference in the tenderness and juiciness between samples from chicken fed Bio-Mos and those from the other two treatments, where Bio-Mos fed chicken had more tender and juicy meat. However, there were no significant difference between the control sample and those from chicken fed probiotic or synbiotic concerning tenderness and juiciness. As well, no significant difference was found between control samples and all the other treatments or between the three different treatments concerning the flavor of the chicken meat samples.

Blood metabolites: The data at Table 6 showed that at day 21 serum total protein increased ($p<0.01$) in MOS supplemented group in comparison with the control and probiotic supplemented groups. Moreover, serum calcium and phosphorus level was numerically higher in all dietary supplemented groups in comparison with the control one.

At day 42 there was a significant decrease in serum total cholesterol and triglycerides in all dietary supplemented groups in comparison with the control one. There is a numerical decrease in serum AST and ALT in all dietary supplemented groups in comparison with the control one.

DISCUSSION

The alternatives to in feed antibiotics possibly can improve the health and performance of birds by increasing the growth of beneficial microbes or by reduction and removal of potential pathogens. Probiotics, prebiotics and synbiotics are either beneficial microorganisms or substrates that facilitate the growth of these microorganisms, which can be suitably used by the food manufacturers and hold considerable promise for the health care industry.

At day 21 BW, weight gain and feed conversion efficiency was significantly improved in all dietary treatments in comparison with the control group. Prebiotic (MOS) supplemnted broilers are superior to probiotic and synbiotic birds at day 21 in BW and weight gain and feed intake. These results were in agreement with several studies, which have reported that prebiotics can improve performance in broilers (Olsen, 1995; Parks *et al*., 2001; Ferket *et al*., 2002; Ferket, 2004; Hooge, 2004; Benites *et al*., 2008). Three major modes of action by which broiler performance is improved by MOS are proposed: 1) control of pathogenic or potential pathogenic bacteria which possess type-1 fimbriae (mannosesensitive lectin), 2) immune modulation and 3) modulation of intestinal morphology and expression of mucin and brush border enzymes (Ferket, 2004). A unique character of MOS in immune modulation is that it enhances the protective antibody response to enhance disease resistance while at the same time suppress the acute phase (fever) response (Ferket *et al*., 2002). Mannanoligosaccharides, specifically Bio-MOS, were shown to alter mucosal architecture and longer villi were noticed in birds fed MOS-supplemented diets (Loddi *et al*., 2002; Yang *et al*., 2007). Further, Bio-MOS consistently reduced the crypt depth of the mucosa of the small intestine where its growth-promoting effects were observed.

At day 42 body weights, the cumulative weight gains and feed conversion rate were significantly ($p<0.05$) increased by the dietary inclusion of the probiotics and synbiotic as compared to the control fed broilers. Furthermore, the mortality % was numerically decreased by dietary supplementation of prebiotic and synbiotic. These results are fully consistent with the results of Kim

et al., 1988; Awad *et al*., 2008; Bozkurt *et al*., 2008; El-Banna *et al*., 2010; Falaki *et al*., 2011. Improvement in growth performance and feed efficiency in broilers chickens fed probiotic and synbiotic may be attributed to the total effect of probiotic action including the maintenance of beneficial microbial population (Fuller, 1989), improving feed intake and digestion (Nahanshon *et al*., 1992) and altering bacterial metabolism. The results of our study are supported by other studies (Kim *et al*., 1988; Jin *et al*., 1998; Jamroz and Kamel, 2002; Mitsch *et al*., 2004; Li *et al*., 2007; Mountzouris *et al*., 2007; Awad *et al*., 2008, 2009). These studies reported that probiotics, prebiotics, synbiotics could enhance the performance of broilers by (1) improving intestinal morphology and microbial balance associated with suppressing intestinal pathogens, by competitive exclusion and antagonism, such as Salmonella, Camphylobacter and *E. coli* (Fuller, 1989; Jin *et al*., 1998; Kabir *et al*., 2005; Line *et al*., 1998), (2) increasing digestive enzyme activity and decreasing bacterial enzyme activity and ammonia production (Chiang and Hsieh, 1995; Jin *et al*., 2000), (3) also by an increase in feed intake and the uptake of nutrients (fatty acids and glucose), (4) fixation of nitrogen and reduction of excretion of fat in feces and microbial urea (Willis *et al*., 2007). (5) Stimulating the immune system and reducing mortality (Huang *et al*., 2004, Kabir, 2009). Therefore, beneficial effects of these supplements in the gastrointestinal tract could result in an improvement of overall health and performance of animals. However, Karaoglu and Durdag (2005) used *Saccharomyces cerevisiae* as a dietary probiotic to assess performance and found no overall weight gain difference. Variations among reports of researches could be related to environmental conditions that be exist in various experiments.

In poultry industry, one of the major concerns is to obtain a higher percentage yield of saleable products and consequently, to increase the edible portions. The significant increase in the carcass weight and dressing % in synbiotic supplemented broilers was totally coincided with the observations of (Awad *et al*., 2009) who reported that carcass yield percentage was significantly increased in the synbiotic-fed broilers compared with the control and probiotic-fed broilers. In consistent with that prediction, there are significant increases in the absolute weight of breast, proventriculus and pancreas in synbiotic supplemented group. Kabir *et al*. (2004) reported the occurrence of a significantly ($p<0.01$) higher carcass yield in broiler chicks fed with the probiotics on the 2nd, 4th and 6th week of age both in vaccinated and non-vaccinated birds. Although Mahajan *et al*. (1999) recorded in their study that mean values of giblets, hot dress weight, cold dress weight and dressing percentage were significantly ($p<0.05$) higher for probiotic (Lacto-Sacc) fed broilers. Dietary treatments had no significant effect on abdominal fat pad accumulation in the present study. These results are in harmony with results of (Waldroup *et al*., 2003; Alcicek *et al*., 2004; Bozkurt *et al*., 2005).

The significant increases in the absolute weight of the immune organs (thymus and bursa) were in harmony with the results of previous studies (Gao *et al*., 2001; Wang *et al*., 2003; Huang *et al*., 2007). Measurement of immune organ weight is a common method for evaluation of immune status in chickens (Heckert *et al*., 2002). Such related organs include bursa of Fabricius, liver and spleen. Good development of these organs is crucial for optimal Ig synthesis (Glick, 1977).

The improvement of sensory characteristics of meat samples from broilers supplemented with prebiotics was observed. Kabir *et al*. (2005) evaluated the effects of probiotics on the sensory characteristics and microbiological quality of dressed broiler meat and reported that supplementation of probiotics in broiler ration improved the meat quality both at pre-freezing and post-freezing storage. Likewise, Zhang *et al*. (2005) conducted an experiment with 240, day-old, male broilers to investigate the effects of *Saccharomyces cerevisiae* (SC) cell components on the meat quality and they reported that meat tenderness could be improved by the whole yeast or *Saccharomyces cerevisiae* extract. On the other hand, Loddi *et al*. (2000) reported that neither probiotic nor antibiotic affected sensory characteristics (intensity of aroma, strange aroma, flavour, strange flavour, tenderness, juiciness, acceptability, characteristic colour and overall aspects) of breast and leg meats.

The effects of probiotics and prebiotics on serum cholesterol and triglycerides concentrations are consistent among previous studies. These studies have shown that probiotics and prebiotics exhibited lipid-lowering properties which might be related to the changes in the intestinal bacterial flora composition, which ferments prebiotics to produce short-chain fatty acids in the gut and then causes a decrease in the systemic levels of blood lipids and cholesterol. Furthermore, some probiotic bacteria may interfere with cholesterol absorption in the gut by de-conjugating bile salts or by directly assimilating cholesterol (Mohan *et al*., 1996; Jin *et al*., 1998; Zhao and Yang, 2005; Liong and Shah, 2006; Li *et al*., 2007).

In conclusion, The BW, weight gain, carcass yield percentage and feed conversion rate were significantly ($p<0.05$) increased by the dietary inclusion of the synbiotic and probiotic compared with the control. The results of the present study revealed that supplementation of broiler diets with pre, pro and synbiotics increased body weight gain and feed conversion, some carcass traits and meat quality,

compared with the un-supplemented control. The combination of pre and probiotic (synbiotic) induced additive benefit in growth performance, feed conversion and carcass traits than that of individual use of these additives. Under present experimental condition, synbiotic as a growth promoter appeared to be superior compared to use pre or probiotic alone in optimizing digestion to convert feed into body mass more efficiently and improve broiler chickens growth performance.

REFERENCES

Alcicek, A., M. Bozkurt and M.C. Abuk, 2004. The effect of a mixture of herbal essential oils, an organic acid or a probiotic on broiler performance. South African J. Anim. Sci., 34: 217-222.

Awad, W.A., K. Ghareeb and J. Bohm, 2008. Intestinal structure and function of broiler chickens on diets supplemented with a synbiotic containing Enterococcus faecium and oligosaccharides. Int. J. Mol. Sci., 9: 2205-2216.

Awad, W.A., K. Ghareeb, S. Abdel-Raheem and J. Bohm, 2009. Effects of dietary inclusion of probiotic and synbiotic on growth performance, organ weights and intestinal histomorphology of broiler chickens. Poult. Sci., 88: 49-56.

Benites, V., R. Gilharry, A.G. Gernat and J.G. Murillo, 2008. Effect of dietary mannan oligosaccharide from bio-mos or SAF-mannan on live Performance of broiler chickens. J. Appl. Poult. Res., 17: 471-475.

Bozkurt, M., K. Kucukyilmaz, A.U. Catli and M. Cinar, 2005. Growth performance and carcass yield of broiler chickens given antibiotic, mannan oligosaccharide and dextran oligosaccharide supplemented diets. Nutritional Biotechnology in the Feed and Food Industries. Proc. 21st Annual Symp. May 22-25, 2005 Lexington, Kentucky, USA. (Suppl. 1). pp: 69.

Bozkurt, M., K. Kucukyilmaz, A.U. Katil and M. Cinar, 2008. Growth performance and slaughter characteristics of broiler chickens fed with antibiotics, mannan oligosaccharide ad dextran oligosaccharide supplemented diet. Int. J. Poult. Sci., 7: 969-977.

Chiang, S.H. and W.M. Hsieh, 1995. Effect of direct feed microorganisms on broiler growth performance and litter ammonia level. Asian Aust. J. Anim. Sci., 8: 159-162.

Chung, C.H. and D.F. Day, 2004. Efficacy of *Leuconostoc mesenteroides* (ATCC 13146) isomalto-ologosacharides as a poultry prebiotic. Poult. Sci., 83: 1302-1306.

Duncan, M.J., E.L. Mann, M.S. Cohen, I. Ofek, N. Sharon and S.N. Abraham, 2005. The distinct binding specificities exhibited by enterobacterial type 1 fimbriae are determined by their fimbrial shafts. J. Biol. Chem., 280: 37707-37716.

El-Banna, H.A., H.Y. El-Zorba, T.A. Attia and A. Abd Elatif, 2010. Effect of probiotic, prebiotic and synbiotic on broiler performance. World Applied Sci. J., 11: 388-393.

Endo, T., M. Nakano, S. Shimizu, M. Fukushima and S. Miyoshi, 1999. Effect of a probiotic on the lipid metabolism of cocks fed on cholesterol-enriched diet. Biosci. Biotech. Biochem., 63: 1569-1575.

Falaki, M., M. Shams Shargh, B. Dastar and S. Zerehdaran, 2011. Effect of different levels of probiotic and prebiotic on performance and carcass characteristics of broiler chickens. J. Anim. Vet. Adv., 10: 378-384.

Ferket, P.R., 2004. Alternatives to antibiotics in poultry production: Responses, practical experience and recommendations. Nutritional biotechnology in the feed and food industries: Proceedings of Alltech's 20th Annual Symposium, Kentucky, USA, pp: 56-67.

Ferket, P.R., C.W. Parks and J.L. Grimes, 2002. Mannan oligosaccharides versus antibiotics for turkeys. Nutritional biotechnology in the feed and food industries: Proceedings of Alltech's 18th Annual Symposium, Kentucky, USA, pp: 43-64.

Fuller, R., 1989. Probiotic in man and animal. J. App. Bacteriol., 66: 365-378.

Gallaher, D. D. and J. Khil, 1999. The effect of synbiotics on colon carcinogenesis in rats. J. Nutr., 129 (Suppl. 7): 1483S-1487S.

Gao, F., G.H. Zhou and Z.K. Han, 2001. The effect of fructooligosaccharides on broiler performance and immune function. Acta Zoonutrim Sin, 13: 51-55.

Gao, J., H.J. Zhang, S.H. Yu, S.G. Wu, I. Yoon, J. Quigley, Y.P. Gao and G.H. Qi, 2008. Effects of yeast culture in broiler diets on performance and immuno-modulatory functions. Poult. Sci., 87: 1377-1384.

Gibson, R.G. and M.B. Roberfroid, 1995. Dietary modulation of the human colonic microbiota: Introducing the concept of prebiotics. J. Nutr., 125: 1401-1412.

Glick, B., 1977. The bursa of Fabricius and immunoglobulin synthesis. Int. Rev. Cytol., 48: 345-402.

Gong, J., R.J. Forster, H. Yu, J.R. Chambers, R. Wheatcraft, P.M. Sabour and C. Shu, 2002. Molecular analysis of bacterial populations in the ileum of broiler chickens and comparison with bacteria in the cecum. FEMS Microbiol. Ecol., 41: 171-179.

Heckert, R.A., I. Estevez, E. Russek-Cohen and R. Pettit-Riley, 2002. Effects of density and perch availability on the immune status of broilers. Poult. Sci., 81: 451-457.

Hooge, D., 2004. Meta-analysis of broiler chicken pen trials evaluating dietary mannan oligosaccharide, 1993-2003. Int. J. Poult. Sci., 3: 163-174.

Huang, M.K., Y.J. Choi, R. Houde, J.W. Lee, B. Lee and X. Zhao, 2004. Effects of lactobacilli and an acidophilic fungus on the production performance and immune responses in broiler chickens. Poult. Sci., 83: 788-795.

Huang, R.L., Z.Y. Ding, C.B. Yang, Y.L. Yen, M.Y. Xie, G.Y. Wu, T.G. Li, L.L. Li, Z.R. Tang, P. Kang, Z.P. Hou, D. Ding, H. Xiang, X.F. Kong and Y.M. Guo, 2007. Dietary oligochitosan supplementation enhances immune status of broilers. J. Sci. Food Agric., 87: 153-159.

Jamroz, D. and C. Kamel, 2002. Plant extracts enhance broiler performance. J. Anim. Sci., 80 (Suppl. 1): 4 (abstract)..

Jin, L.Z., Y.W. Ho, N. Abdullah and S. Jalaludin, 1998. Growth performance, intestinal microbial populations and serum cholesterol of broilers fed diets containing *Lactobacillus* cultures. Poult. Sci., 77: 1259-1265.

Jin, L.Z., Y.W. Ho, N. Abdullah and S. Jalaludin, 2000 Digestive and bacterial enzyme activities in broilers fed diets supplemented with *Lactobacillus* cultures. Poult. Sci., 79: 886-891.

Kabir, S.M.L., 2009. The role of probiotics in the poultry industry. Int. J. Mol. Sci., 10: 3531-3546.

Kabir, S.M.L., M.M. Rahman, M.B. Rahman and S.U. Ahmed, 2004. The dynamics of probiotics growth performance and immune response in broilers. Int. J. Poult. Sci., 3: 361-364.

Kabir, S.M.L., M.M. Rahman and M.B. Rahman, 2005. Potentiation of probiotics in promoting microbiological meat quality of broilers. J. Bangladesh Soc. Agric. Sci. Technol., 2: 93-96.

Karaoglu, M. and H. Durdag, 2005. The influence of dietary probiotic (*Saccharomyes cerevisiae*) supplementation and different slaughter age on the performance, slaughter and carcass properties of broilers. Int. J. Poult. Sci., 4: 309-316.

Kim, C.J., H. Namkung, M.S. An and I.K. Paik, 1988. Supplementation of probiotics to the broiler diets containing moldy corn. Korean J. Anim. Sci., 30: 542-548.

Li, X.J., X.S. Piao, S.W. Kim, P. Liu, L. Wang, Y.B. Shen, S.C. Jung and H.S. Lee, 2007. Effects of chitooligosaccharide supplementation on performance, nutrient digestibility and serum composition in broiler chickens. Poult. Sci., 86: 1107-1114.

Line, E.J., J.S. Baily, N.A. Cox, N.J. Stern and T. Tompkins, 1998. Effect of yeast - supplemented feed on salmonella and Campylobacter populations in broilers. Poult. Sci., 77: 405-410.

Liong, M.T. and N.P. Shah, 2006. Effects of a Lactobacillus casei synbiotic on serum lipoprotein, intestinal microflora and organic acids in rats. J. Dairy Sci., 89: 1390-1399.

Loddi, M.M., E. Gonzalez, T.S. Takita, A.A. Mendes, R.O. Roca and R. Roca, 2000. Effect of the use of probiotic and antibiotic on the performance, yield and carcass quality of broilers. Rev. Bras. Zootec., 29: 1124-1131.

Loddi, M.M., V.M.B. Moraes, L.S.O. Nakaghi, F.M. Tucci, M.I. Hannas, J. Ariki and L.D.G. Bruno, 2002. Effect of mannanoligosaccharide and organic acids on intestinal morphology integrity of broilers evaluated by scanning electron microscopy. Proceeding 11th European Poultry Science Conference, Bremen, Germany, pp: 121.

Mahajan, P., J. Sahoo and P.C. Panda, 1999. Effects of probiotic feeding and seasons on the growth performance and carcass quality of broilers. In. J. Poult. Sci., 34: 167-176.

Meilgaard, M., G.V. Civille and B.T. Carr, 2007. Sensory Evaluation Techniques. 4th Edn., CRC Press, Boca Raton, FL.

Miles, R.D. and S.M. Bootwalla, 1991. Direct-fed microbials in animal production. In Direct-Fed Microbials in Animal Production-A Review of the literature. National Feed Ingredients Association, West Des Moines, IA., pp: 117-146.

Mitsch, P., K. Zitterl-Eglseer, B. Kohler, C. Gabler, R. Losa and I. Zimpernik, 2004. The effect of two different blends of essential oil components on the proliferation of *Clostridium perfringens* in the intestines of broiler chickens. Poult. Sci., 83: 669-675.

Mohan, B., R. Kadirvel, A. Natarajan and M. Bhaskaran, 1996. Effect of probiotic supplementation on growth, nitrogen utiliszation and serum cholestrol in broilers. Br. Poult. Sci., 37: 395-401.

Mohnl, M., Y. Acosta Aragon, A. Acosta Ojeda, B. Rodriguez Sanchez and S. Pasteiner, 2007. Effect of synbiotic feed additive in comparison to antibiotic growth promoter on performance and health status of broilers. Poult. Sci., 86 (suppl. 1): 217.

Mountzouris, K.C., P. Tsistsikos, E. Kalamara, S. Nitsch, G. Schatzmayr and K. Fegeros, 2007. Evaluation of the efficacy of a probiotic containing *Lactobacillus*, *Bifidobacterium*, *Enterococcus* and *Pediococcus* strains in promoting broiler performance and modulating cecal microflora composition and metabolic activity. Poult. Sci., 86: 309-317.

Nahanshon, S.N., H.S. Nakaue and L.W. Mirosh, 1992. Effects of direct fed microbials on nutrient retention and parameters of laying pullets. Poult. Sci., 71 (Suppl. 1): 111 (Abstrac.).

NRC (National Research Council), 1994. Nutrient Requirements of Poultry. 9th. Rev. (Edn.). National Academy Press, Washington, DC., USA.

Olsen, R., 1995. Mannanoligosaccharides: Experience in commercial turkey production. In: T.P. Lyons and K.A. Jacques, (Editors). Biotechnology in the Feed Industry. Proceedings of Alltech's 11th Annual Symposium. Nottingham University Press, Nottingham (UK), pp: 389-392.

Owings, W.J., D.L. Reynolds, R.J. Hasiak and P.R. Ferket, 1990. Influence of dietary supplementation with Streptococcus faecium M-74 on broiler body weight, feed conversion, carcass characteristics and intestinal microbial colonization. Poult. Sci., 69: 1257-1264.

Parks, C.W., J.L. Grimes, P.R. Ferket and A.S. Fairc, 2001. The effect of mannanoligosaccharides, bambermycins and virginiamycin on performance of large white male market Turkeys. Poult. Sci., 80: 718-723.

Patterson, J.A. and K.M. Burkholder, 2003. Application of Prebiotics and probiotics in poultry production. Poult. Sci., 82: 627-631.

Shashidahara, R.G. and G. Dewegowda, 2003. Effect of dietary mannan oligosaccharide on broiler breeder production traits and immunity. Poult. Sci., 82: 1319-1325.

Spring, P., C. Wenk, K.A. Dawson and K.E. Newman, 2000. The effects of dietary mannan-oligosaccahrides on cecal parameters and the concentration of enteric bacteria in the ceca of Salmonella-chalenged broiler chicks. Poult. Sci., 79: 205-211.

Stanley, V.G., C. Gray, M. Daley, W.F. Krueger and A.E. Sefton, 2004. An alternative to antibiotic-based drugs in feed for enhancing performance of broilers grown on *Eimeria* sp.-infected litter. Poult. Sci., 83: 39-44.

Tannock, G.W., 2001. Molecular assessment of intestinal microflora. Am. J. Clin. Nutr., 73: 410-414.

Waldroup, P.W., C.A. Fritts and Y. Fenglan, 2003. Utilization of Bio-Mos® mannan oligosaccharide and Bioplex® copper in broiler diets. Int. J. Poult. Sci., 2: 44-52.

Wang, X.W., Y.G. Du, X.F. Bai and S.G. Li, 2003. The effect of oligochitosan on broiler gut flora, microvilli density, immune function and growth performance. Acta Zoonutrim Sin, 15: 32-45.

Willis, W.L., O.S. Isikhuemhen and S.A. Ibrahim, 2007. Performance assessment of broiler chickens given mushroom extract alone or in combination with probiotics. Poult. Sci., 86: 1856-1860.

Yang, Y., P.A. Iji and M. Choct, 2007. Effects of different dietary levels of mannanoligosaccharide on growth performance and gut development of broiler chickens. Asian-Australasian J. Anim. Sci., 20: 1084-1091.

Zhang, A.W., B.D. Lee, S.K. Lee, K.W. Lee, G.H. An, K.B. Song and C.H. Lee, 2005. Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality and ileal mucosa development of broiler chicks. Poult. Sci., 84: 1015-1021.

Zhang, G., L. Ma and M.P. Doyle, 2006. Efficiency of probiotics, prebiotics and synbiotics on weight increase of chickens (*Gallus Domesticus*); http://www.ugacfs.org/research/pdfs/Poultry2006.pdf.

Zhao, J.R. and H. Yang, 2005. Progress in the effect of probiotics on cholesterol and its mechanism. Wei Sheng Wu Xue Bao (Acta Microbiologica Sinica), 45: 315-319.