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Effect of Bio-Mos Utilization in Broiler Chick Diets on Performance, Microbial and Histological Alteration of Small Intestine and Economic Efficiency

M.M.E. Mostafa, H.A. Thabet and M.A.M. Abdelaziz
Department of Poultry Production, Faculty of Agriculture, Ain Shams University, Cairo 111241, Egypt

Corresponding Author: M.M.E. Mostafa, Department of Poultry Production, Faculty of Agriculture, Ain Shams University, Cairo 111241, Egypt

ABSTRACT

Two hundred and eight one-day broiler chicks (ROSS 500) were divided into 4 treatments till 35 days old, each group fed on corn-soybean starter diet (S) from 1-21 days old and grower diet (G) from 22-35 days old. Control treatment received un-supplemented S and G diets, S1G0 group fed on S supplemented with 1 g Bio-Mos kg^{-1} then un-supplemented G, S1G0.5 group received S supplemented with 1 g Bio-Mos kg^{-1} then G supplemented with 0.5 g Bio-Mos kg^{-1}, while , S1G1 group received S supplemented with 1 g Bio-Mos kig^{-1} then G supplemented with 1 g Bio-Mos kg^{-1}. Each treatment included 52 chicks which reared on two batteries. During the 35 days of experimental period, a significant improvement in Body Weight Gain (BWG), Feed Conversion Ratio (FCR), microbial population counts and some histological alterations of small intestine, besides, a significant decreasing in feed cost per kilogram BWG (FCO) and higher Economic Efficiency Index (EEI) were showed with supplemented groups compared with un-supplemented treatment. Using of 1 g Bio-Mos kg^{-1} of starter diet in all supplemented diets and increasing of Bio-Mos in grower diet by 0, 0.5 or 1 g resulted in the followings: I-0.5 g kg^{-1} rate showed the highest BWG and FI and lowest ceacal *E. coli* count among treatments. II-1 g kg^{-1} rate recorded the best FCR, higher jejunal and ileal villus length, ceacal *Lactobacillus* and lower count of ceacal *Salmonella*. III-Linear reduction in FCO and increasing in EEI values up to 1 g kg^{-1} rate with Bio-Mos increasing but difference between treatments was not significant.

Key words: Bio-Mos, broilers, performance, bacteriology, histology, economic efficiency

INTRODUCTION

Mannan oligosaccharides (MOS) and its commercial product form (Bio-Mos, product of Alltech Inc., Nicholasville, KY, USA) is one of prebiotics that derived from the outer layer of yeast cell walls (*Saccharomyces cerevisiae*). The main idea to use yeast MOS in poultry feeds evolved from the following two concepts about involved mannose, which could be: (1) it is used largely to block the colonization of intestinal pathogenic bacteria, especially *E. coli* and *Salmonella* which are the most common pathogenic bacteria hosted in intestinal tract of poultry and enhance growth of beneficial bacteria such as *Lactobacillus* in intestinal gut, therefore, supporting growth performance of bird as reported by Cavazzoni *et al.* (1998), Brzoska *et al.* (1999), Joerger (2003) and Patterson and Burkholder (2003). (2) Some research workers including Spring (1996), Shane (2001) and Markovic *et al.* (2009), reported a beneficial alteration effect of Bio-Mos and yeast cell wall (as a source of MOS) inclusion in broiler diets on microvillus length and crypt depth of which are the basic absorbent elements of nutrients in intestinal mucosa.

Although, the important effects that mentioned above for Bio-Mos supplementation in diets of birds but most of those studies focused their regards on comparing between MOS and different antibiotic preparations as a tested safely replacer besides other feed additives like organic acids, organic salts, copper sulphate, probiotic preparations ,etc., but, there are a little researches that interested to the effect of changes MOS or Bio-Mos level during basic fattening stages of broiler, starter and grower, which represents 80-85% of fattening period of commercial broiler chicks, especially from the economic aspect, this point including Bio-Mos Manufacturers' Guide which revealed that the recommended levels of Bio-Mos supplementation in broiler diet are 1 g kg^{-1} in starter and 0.5 g kg^{-1} in grower diets, while levels of 1 and 0 kg^{-1} in starter and grower diets exhibited a moderate performance. Those recommended levels were raised only on basis the performance data. Another levels have been suggested by Savage and Zakrzewska (1997), which were 1-2 g kg^{-1} of starter and grower of poultry diets as general recommended levels but those levels logically may be vary according to poultry variety especially that; they performed their researches on turkey males. Additionally, most of those results concerning microbiological and histological effects and those interrelationships with obtained performance data were inconsistent. Accordingly, this study aimed to investigate the effect of Bio-Mos inclusion and using of three different supplementation programs of it in diets on broiler chick performance, microbial population and histological examination of small intestine and economic efficiency.

MATERIALS AND METHODS

Bird's management: This study was carried out, to investigate performance, counts of pathogenic and beneficial bacteria, histological measurement and economical efficiency of broiler chicks from 1-35 days old as affected by supplementation, as well as, inclusion of different levels of Bio-Mos (Alltech Inc., Nicholasville, KY, USA) as a commercial mannan oligosaccharides source in starter and grower diets. Bio-Mos, contains phosphorylated mannans, glucans and some proteins intermixed those characterized as safe compounds. Two hundred and eight one-day chicks (ROSS 500) divided into 4 groups, distributed on 4 treatments including 52 chicks each. The 4 treatments including, control, S1G0, S1G0.5 and S1G1 then reared on two batteries with 13 replicates each group and 4 chicks were specified for each cage till 35 days old. Feed by metallic feeders and drinking water by automatic nipples were offered to birds adlibitum. Birds subjected to 24 h daily light along the 35 days experimental period. In addition that, recommended vaccination program as showed in strain guide was followed for birds.

Experimental treatments: All groups received iso-caloric (starter = 3050, grower = 3100), iso-nitrogenous (starter = 23, grower = 21) yellow corn-soybean meal starter diet (S) from 1-21 days old then grower diet (G) from 22-35 days old. The composition and calculated analysis of basal diets are showed in Table 1 and the experimental design is described in Table 2.

Experimental measurements

Chick performance: For all groups, feed intake and body weight were weekly recorded and corrected to mortality rate. Then Body Weight Gain (BWG) g/chick, Feed Intake (FI) g/chick and Feed Conversion Rate (FCR) g FI/g BWG were mathematically calculated for overall period.

Bacterial counts and histological examination: At 35 days old, 8 chicks from each treatment group were slaughtered to determine some bacterial counts and histological examination. For

Table 1: Composition and calculated analysis of experimental basal diets

	Basal diet	
Ingredients (%)	Starter (1-21 days old)	Grower (22-35 days old)
Yellow corn	53.35	58.40
Soybean meal (44%)	33.14	28.90
Corn gluten meal (62%)	6.35	5.35
Soybean oil	3.00	3.10
Calcium carbonate	1.23	1.39
Di-calcium phosphate	1.93	1.96
Broiler premix*	0.35	0.35
Natural salt	0.45	0.45
DL-methionine	0.20	0.10
Total	100.00	100.00
Calculated chemical analysis		
Crude protein	23.00	21.00
ME (kcal kg^{-1})	3050.00	3100.00
Calcium	1.00	1.05
Av. phosphorus	0.48	0.48
Lysine	1.10	0.98
Meth.+Cystine	0.98	0.82

*Each 3 kilogram of the premix contains the followings: 12000000 I.U: VIT. A, 2000000 I.U: VIT. D3, 10000 mg: VIT. E, 2000 mg: VIT. K3, 1000 mg: VIT. B1, 5000 mg: VIT. B2, 1500 mg: VIT. B6, 10 mg: VIT. B12, 10000 mg: Ca D-Pantothenate, 30000 mg, Niacin 1000 mg: Folic acid, 50 mg: Biotin, 250000 g: Choline Chloride, 60000 mg: Mn, 50000 mg Zn: 30000 mg: Iron, 10000 mg: Cu, 1000 mg: Iodine, and 100 mg: Se, where, $CaCO_3$ taken as a carrier

Table 2: Experimental design of Bio-Mos inclusion in broiler diets

	Experimental treatment			
Parameters	Con	S1G 0	S1G 0.5	S1G 1
Bio- Mos addition g/kg starter diet (1-21 days old)	0.0	1.0	1.0	1.0
Bio- Mos addition g/kg grower diet (22-35 days old)	0.0	0.0	0.5	1.0

bacterial counts; the content of ceacum was collected and well mixed in a plastic tube and instantly send to microbiology lab to determine *Lactobacillus*, *E. coli* and *Salmonella* bacteria counts by plate method on MRS agar media, according to Fan *et al.* (2006). For preparing of MRS agar medium, 62 g of the MRS powder were suspended in 1 L of tap water, mixed thoroughly and then the suspension was heated with frequent agitation and boiled for 1 min to completely dissolve the powder. The medium was then autoclaved at 121°C for 15 min. To obtain direct counts of lactic acid bacteria, 15-20 mL of molten (45-50°C) sterilized MRS medium were poured sterile, into sterile Petri dishes containing 1 mL volume of different samples dilutions. The inoculums was distributed throughout the medium by rotating the plate in one direction and then in the reverse direction. The medium was allowed to solidify on a flat surface for 5-10 min. Simultaneously, specimens were previously collected in sterile plastic containers, stored at 5°C and sent to laboratory immediately. Then 1 g of each sample was homogenized in 1 mL dilution, serially diluted to 10^{-9}. One milliliter of dilutions of 10^{-8}, 10^{-7}, 10^{-6}, 10^{-5}, 10^{-3} and 10^{-1} were spread onto MRS plates. All plates were incubated in an anaerobic incubator (Hirayama Manufacturing Corp., Tokyo, Japan) at 37°C for 72 h. Total lactic acid bacterial counts were expressed as CFU per gram of wet contents weight. *Lactobacillus* bacteria count within the total lactic acid bacterial counts were performed by the microscopic examination of all plate colonies using simple staining. For *Salmonella* and *E. coil* determination in samples, 1 mL of the previously prepared dilutions was spread on XLD agar (Borsoi *et al*., 2011) and Mac-Conkey agar (Difco) (Jang *et al*., 2007), respectively. Colonies were counted after aerobic incubation at 37°C for 48 h. The results were expressed as CFU per gram of

wet contents weight. For *Salmonella* spp. and *E. coil* determination in samples on XLD agar (Borsoi *et al*., 2011) and Mac-Conkey agar (Difco) (Jang *et al*., 2007), respectively. Colonies were counted after aerobic incubation at 37°C for 48 h. The results were expressed as log CFU per gram of wet contents weight.

Histological examinations for jejunum and ileum segments of small intestine were carried out according to the method of Iji *et al.* (2001). Intestinal samples of 5 slaughtered birds from each treatment group were immersed in formaldehyde, before fixation in Bouin's solution and paraffin embedding. Paraffin sections at 6 μm thickness were made from each sample, stained with haematoxylin and eosin. Villus length was measured from the top of the villus to the top of the lamina propria and the crypt depth was measured from the base up to the region of transition between the crypt and villus according to Aptekmann *et al*. (2001). Then, the microscopic examination was carried out using advanced light microscope (Leica®, DM 2500, Germany). Villus length and crypt depth (μm) were analyzed and measured from each preparation using linear scaled graticule (10x) and combined LEICA, 2500 computerized software.

Economic parameters: The economic parameters of the dietary inclusion of different levels of Bio-Mos was firstly assessed by calculating feed cost per kilogram of body weight gain (Fco), as proposed by Bellaver *et al.* (1985) as follow:

$$FCO_i = \frac{PF_i \times FI_i}{WG_i}$$

where, FCO_i, is the feed cost per kilogram of body weight gain in the ith treatment, PF_i is price per kilogram of feed used in the ith treatment, FI_i is feed intake amount in the nth treatment and WGi is weight gain of the ith treatment. Then, the Economic Efficiency Index (EEI) proposed by Fialho *et al.* (1992) was calculated as follow:

$$EEI = \left(\frac{MC}{CT_i}\right) \times 100$$

where, MC is the lowest feed cost per kilogram of weight gain observed among treatments and CT_i is the cost of the i treatment. All costs were calculated with Egyptian L.E.

Statistical analysis: Data of chick performance, microbial counts (CFU log g^{-1}), microvillus length, crypt depth and economic parameters were statistically analyzed using SAS software (SAS., 1995) with one way analysis procedure and differences between means were separated using Duncan's multiple range test (Duncan, 1955) at significance levels 0.01 and 0.05. The statistical model performed as follow:

$$Y_{ij} = \mu + T_i + E_{ij}$$

where, Y_{ij} is the experimental observation, μ is overall mean, T_i is the effect of ith dietary treatment and E_{ij} is random error.

RESULTS AND DISCUSSION

Regarding to present study, it has been fixed the Bio-Mos level at starter diet for the three supplemented groups, S1G 0, S1G 0.5 and S1G 1 at one level which is 1 g kg^{-1} diet and graded it in grower diet with 0, 0.5 and 1 g kg^{-1}, on basis, what reported by Tucker *et al.* (2003), Jamroz *et al.* (2004) and Yang *et al.* (2007a), where chicks gave a significant greater response to Bio-Mos during the early life of chicks. Besides, that the newly chicks needs to any supporter compounds those may help it for more digestion and absorption of nutrients due to that the digestive system of newly chick through the first 3 weeks of age is anatomically complete but its functional digestion and absorption capacities are still immature, with low secretion of endogenous enzymes especially pancreatic enzymes and lower quantitative and qualitative forms of intestinal bacteria populations which rise as feed consumption and bird age increase (Van Leeuwen *et al*., 2004; Tavernari *et al*., 2008). Therefore, our study designed to be making the tested variation between the three supplemented groups in experimental Bio-Mos level was only in grower diets.

Effect of experimental treatments on chick performance

Comparison between un-supplemented and supplemented treatments: Chick performance represented in Body Weight Gain g (BWG), Feed Intake g (FI) and Feed Conversion Ratio g feed/g gain (FCR) resulted from different experimental treatments from 1-35 days old are presented in Table 3, which indicated that both of Bio-Mos supplementation and forms of its inclusion in starter and grower diets were significantly affected chick performance. The BWG was higher in all supplemented groups compared with chicks fed on un-supplemented diets. Those differences in values as a percent of BWG of Control were 3.58, 8.52 and 7.17% for S1G 0, S1G 0.5 and S1G 1, respectively. The marked improvement in BWG of chicks fed on supplemented diets in this study is in accordance with Denev *et al.* (2006), Brzoska *et al.* (2007) and Kamran *et al.* (2013). But disagreed with Baurhoo *et al.* (2007), who reported evident lower BWG for chicks fed on diets supplemented with Bio-Mos compared with un-supplemented ones. On the other hand, Yang *et al.* (2007b), Bozkurt *et al.* (2008) and Markovic *et al.* (2009) reported a non significant difference in BWG between chick groups received diets supplemented or un-supplemented with Bio-Mos.

No significant trend was noted for the effect of Bio-Mos inclusion in diets on FI of chicks. This result is in agreement with many research workers including Yang *et al.* (2007b), Baurhoo *et al.* (2007), Brzoska *et al.* (2007), Markovic *et al.* (2009) and Kamran *et al.* (2013), except Bozkurt *et al.* (2008), who recorded a significant increase in FI associated with dietary Bio-Mos inclusion in diet compared with the negative control treatment.

Table 3: Effect of experimental treatments on chick performance from 1 to 35 days old

	Experimental treatments[#]				
Item	Control	S1G 0	S1G 0.5	S1G 1	Sig.[##]
IBW[1]	46	44	43	45	NS
Performance trait[2]					
BWG	1701[c]	1762[b]	1846[a]	1823[a]	*
FI	3203[a]	3126[b]	3219[a]	3085[b]	*
FCR	1.882[a]	1.777[b]	1.745[b]	1.692[c]	*
Mortality rate (%)	1.76	1.76	2.46	1.06	NS

[#]Control group received un-supplemented S (starter) then G (grower) diets, S1G0 group fed on S contained 1 g Bio-Mos kg^{-1} diet then un-supplemented G diet, S1G0.5 group received S contained 1g Bio-Mos kg^{-1} diet then G contained 0.5 g Bio-Mos kg^{-1} diet, S1G1 group received S contained 1 g Bio-Mos kg^{-1} diet then G contained 1 g Bio-Mos kg^{-1} diet, [a,b,c]: Means within the same row with different superscripts are significant1y differed. Sig. = Significance, *: $p \leq 0.05$, NS: Non significant, [1]IBW: Initial body weight g/chick at one day old. [2]BWG: Body weight gain g/chick, FI: Feed intake g/chick, FCR: Feed conversion ratio g FI/g BWG

The FCR significantly improved with Bio-Mos supplementation to diets. Compared to control group (FCR = 1.882), the improvement values of FCR as a percent of group were 5.57, 7.27 and 10.09% for S1G0, S1G0.5 and S1G1, respectively. The significant better FCR accompanied with Bio-Mos inclusion in diet is in accordance with that reported by Hooge (2003), Denev *et al.* (2006), Fathi *et al.* (2012) and Kamran *et al.* (2013). A large part of this improvement in FCR value may be attributed to the significant effect on BWG not to FI. Many research workers including Yang *et al.* (2007b), Baurhoo *et al.* (2007), Brzoska *et al.* (2007), Bozkurt *et al.* (2008) and Corrigan *et al.* (2011) documented a non significant effect of Bio-Mos inclusion in broiler diets on FCR, this may resulted from the non significant differences between un-supplemented and supplemented groups in both BWG and FI in their studies but all those recognized that Bio-Mos inclusion in broiler diets potentially improved immunity and overall health of experimental birds.

Comparison between different Bio-Mos supplementation programs: The S1G0.5 and S1G1 treatments recorded a significant higher BWG of chicks than S1G0 but the difference between both treatments failed to be significant. This meaning that the continuous supplementation of Bio-Mos in grower diet resulted in a considerable improvement in BWG, while increasing its level in grower diet above 0.5 g had a little effect on BWG. This result is agreement with Fathi *et al.* (2012), who didn't showed any significant difference in BWG between different chick groups fed on graded levels in broiler diets ranging between 1 and 1.5 g kg^{-1}. A similar result reported by Iji *et al.* (2001) and Yang *et al.* (2007a,b) using a range between 1-5 and 0.5-2 g Bio-Mos kg^{-1} of broiler diets, respectively. More recent study of Corrigan *et al.* (2011) reported the same result using 1-2 g Bio-Mos inclusion per kilogram of starter and grower broiler diets through 42 days experimental period. Different levels of Bio-Mos in grower diet exhibited significant lower values in FI with 0 and 1 g kg^{-1} levels (3126 and 3085 g, respectively) compared with 0.5 g level which recorded 3219 g FI. This result causing unclear trend concerning the effect of increasing level of Bio-Mos in broiler diet on FI, hence, causing, somewhat, difficulty in its explanation. However, no significant effect of increasing of Bio-Mos levels in broiler diets on FI was reported by Iji *et al.* (2001), Yang *et al.* (2007a) and Brummer *et al.* (2010).

Continuous increasing of Bio-Mos in grower diets causing a significant efficiency in feed converted to weight gain by chicks, where FCR values were linearly decreased alongside with increasing level of Bio-Mos in grower diets. However, this improvement showed between S1G 0 (1.777) and S1G0.5 (1.745) failed to be significant while S1G 1 chick group was recorded a significant better FCR value (1.692) than both groups. A linear improvement in FCR associated with Bio-Mos increasing in starter and grower diets was reported by Denev *et al.* (2006).

General concepts related to chick performance of current study: As general concepts of our study including the effect of dietary supplementation and increasing of Bio-Mos in broiler diets on the three parameters of chick performance could be summarized as follow: Bio-Mos supplementation in broiler diet resulted in significant increasing in BWG, improvement in FCR and unclear trend in FI of chicks compared with those fed un-supplemented treatment. Those results are in agreement with Denev *et al.* (2006) and Kamran *et al.* (2013).

Using of 1 g Bio-Mos kg^{-1} starter diet in all the three supplemented diets, as well as, the gradual increasing of this level in grower diet with 0, 0.5 and 1 g resulted in significant higher BWG only up to 0.5 level, while 1 g didn't significantly differed. In addition that, it showed that S1G 0.5 exhibited the higher value of FI compared with S1G 0 and S1G 1 treatments. Beside a

significant improvement in FCR up to 1 g kg^{-1} Bio-Mos level in grower diet. Those results are in accordance with Santin *et al.* (2001), Zhang *et al. (*2005), Hosseini (2011) and Fathi *et al.* (2012) using graded levels of yeast (*Saccharomyces cerevisiae*) cell components as a source of mannan oligosaccharides in diets and Hooge (2003) and Kamran *et al.* (2013) using different levels of Bio-Mos in experimental diets. It is clear that feed conversion ratio is more sensitive for Bio-Mos inclusion in broiler diets and its level in grower diet up to 1 g kg^{-1}, followed by BWG of chicks, while FI take unclear trend in its response.

Effect of experimental treatments on *Escherichia coil, Salmonella* and *Lactobacillus bacteria* counts of ceacum: Table 4 documented the *E. coil, Salmonella* and *Lactobacillus* bacteria counts of ceacum of experimental broiler chicks at 35 days old. It is obvious that, inclusion of Bio-Mos in supplemented diets resulted in significant lower counts of ceacal *E. coli* and *Salmonella* and higher count of *Lactobacillus* colonization compared with un-supplemented group. Research papers those handled the effect of Bio-Mos supplementation in diet compared with negative control diets on ceacal *Lactobacillus* bacteria counts as a common hosted beneficial in different poultry types reported inconsistent results. For instance, Fernandez *et al.* (2002) and Denev *et al.* (2006) reported increases in *Lactobacillus* population in the ceacum of broilers fed MOS diet compared with un-supplemented group, while Sims *et al.* (2004) observed a non significant effect on ceacal *Lactobacillus* colonies in turkeys fed MOS compared with negative control treatment, Spring *et al.* (2000) also reported a non significant effect of dietary supplementation with MOS on ceacal *Lactobacillus* in broiler. Fairchild *et al.* (2001) reported in their studies with turkeys, that intestinal populations of *Lactobacillus* bacteria did not differ among chick groups fed Bio-Mos supplemented and those fed free diets. Regarding to the lower counts of ceacal *E. coli* and *Salmonella* in our study, is in agreement with Brzoska *et al.* (2005).

Continuous and increasing of Bio-Mos inclusion in experimental diets especially in grower diet linearly caused a significant reduction in *Salmonella* count till 1 g Bio-Mos level in grower diet, as well as *E. coli* count up to 0.5 g Bio-Mos level in grower diet, where 0.5 and 1 g levels didn't significantly differ. Whereas, *Lactobacillus* count of intestinal ceacum increased linearly with continuous and increasing of Bio-Mos inclusion in supplemented diets up to 1 g level in grower diet. This result agreed with Baurhoo *et al.* (2007) using 1 and 2 g Bio-Mos kg^{-1} of starter and grower diets, respectively, compared with negative control group. The same result was somewhat reported at 42 days old by Brzoska *et al*. (2007) for ceacal *E. coli* count while *Lactobacillus* count showed a non significant increasing, while *Salmonella* count wasn't determined. On other side, Yang *et al.* (2007a) didn't showed any significant effect of Bio-Mos included in diets on counts of the three types of intestinal bacteria.

Table 4: Effect of different dietary treatments on ceacal *Salmonella*, *Escherichia coil* and *Lactobacillus* counts (log CFU g^{-1}) of broiler chicks at 35 days old

	Experimental treatments[#]				
Items	Control	S1G 0	S1G 0.5	S1G 1	Sig.[##]
Salmonella count (log CFU g^{-1})	2.694[b]	5.132[a]	1.622[c]	0.584[d]	**
Escherichia coil count (log CFU g^{-1})	3.268[a]	0.992[c]	2.586[b]	2.584[b]	*
Lactobacillus count (log CFU g^{-1})	1.848[d]	4.825[a]	2.746[b]	2.218[c]	**

[#]Control group received un-supplemented S (starter) then G (grower) diets, S1G0 group fed on S contained 1g Bio-Mos kg^{-1} diet then un-supplemented G diet, S1G0.5 group received S contained 1g Bio-Mos kg^{-1} diet then G contained 0.5 g Bio-Mos kg^{-1} diet, S1G1 group received S contained 1 g Bio-Mos kg^{-1} diet then G contained 1 g Bio-Mos kg^{-1} diet, [## a,b,c,d]: Means within the same row with different superscripts are significant1y differed, Sig: Significance *: $p \leq 0.05$, **: $p \leq 0.01$

However, according to our study, the significant effects of Bio-Mos supplemented representing in lowering counts of the main pathogenic bacteria in intestine, *E. coli* and *Salmonella* and increasing of *Lactobacillus* count (beneficial bacteria), moreover that, the best overall health of experimental chicks and low mortality rate (ranged between 1.06 to 2.46% as showed in Table 3, let us suggested to the same concept of Sharon and Lis (1993) and Spring *et al*. (2000), where they documented that *E. coli* and *Salmonella* species contains type 1 fimbriae with mannose-seeking lectins. When they bind to the MOS product, the pathogens are prevented from attaching to intestinal mannose, proliferating and producing toxins, causing enhancement of bird immunity and overall health. Besides that, Savage and Zakrzewska (1997) and Brzoska *et al.* (2007) postulated that Bio-Mos may raising the population of lactic acid bacteria in intestinal gut of birds, this bacteria living in the digestive tract of birds and found to be promote the immunity of birds against pathogenic bacteria such as *E. coil* and *Salmonella* by two ways which are: (1) It have adhesive properties that can colonize different parts of digestive tract (Jin *et al.,* 1996). (2) By producing lactic acid and acetic acid molecules from glucose fermentation, hence, acidifies the digestive medium and bacteriocins that inhibit the growth of those pathogenic bacteria (Joerger, 2003; Patterson and Burkholder, 2003) causing high immunity and growth performance of tested birds. This improvement effect in intestinal microbial population are positively reflected on BWG up to 0.5 g Bio-Mos and FCR up to 1 g Bio-Mos kg^{-1} of grower diets.

Effect of experimental diets on villus length and crypt depth of intestinal jejunum and ileum: The length of villus and depth of crypt of intestinal jejunum and ileum of chicks resulted of Bio-Mos inclusion and its different levels in diets through the 35 days experimental period are summarized in Table 5. It showed that, comparing between supplemented and un-supplemented groups as well as between the 3 feeding programs, villus length of both jejunum and ileum was significantly increased with inclusion and also increasing of Bio-Mos in diets up to 1 g kg^{-1} level in grower diet. While, inclusion or different levels of Bio-Mos didn't significantly affect crypt depth of jejunum or ileum. This result agreed with Yang *et al.* (2007a), when they reported that Bio-Mos supplementation in broiler diet significantly increased villus length of jejunum but didn't affect crypt depth of both ileum and jejunum compared with un-supplemented control group. The same result was documented in Yang *et al.* (2007b) where they reported that both medium (1 g kg^{-1}) and high (2 g kg^{-1}). Mos treatments increased the villus length of small intestine at 42 days old. Some research workers including Baurhoo *et al.* (2007), Markovic *et al.* (2009) and Brummer *et al.* (2010) showed a non significant effect of Bio-Mos inclusion or different levels of it in broiler diet on villus length and crypt depth of different segments of small intestine.

Table 5: Effect of experimental treatments on villus length and crypt of Lieberkühn depth of intestinal jejunum and ileal segments of broiler chicks at 35 days old

	Experimental treatments[#]				
Intestinal segments	Control	S1G 0	S1G 0.5	S1G 1	Sig.[##]
Jejunum:					
Microvillus length (μm)	848[c]	905[c]	1179[b]	1421[a]	*
Crypt of Lieberkühn depth (μm)	134.4	140.5	135.6	132.3	NS
Ileum:					
Microvillus length (μm)	924[d]	1096[c]	1360[b]	1535[a]	*
Crypt of Lieberkühn depth (μm)	242.6	229.1	261.5	229.4	NS

[#]Control group received un-supplemented S (starter) then G (grower) diets, S1G0 group fed on S contained 1g Bio-Mos kg^{-1} diet then un-supplemented G diet, S1G0.5 group received S contained 1g Bio-Mos kg^{-1} diet then G contained 0.5 g Bio-Mos kg^{-1} diet, S1G1 group received S contained 1 g Bio-Mos kg^{-1} diet then G contained 1 g Bio-Mos kg^{-1} diet. [## a,b,c,d]: Means within the same row with different superscripts are significant1y differed, Sig: Significance *: $p \leq 0.01$, NS: Non Significant

Table 6: Effect of experimental treatments on feed cost per kilogram body weight gram (FCO) and economic efficiency of Bio-Mos inclusion in broiler chicks through 1 to 35 days old

	Experimental treatments[#]			
Items	Control	S1G 0	S1G 0.5	S1G 1
FCO[##]	7.53	7.26	7.22	7.07
EEI[###]	93.88[b]	97.55[a]	98.48[a]	100.00[a]

[#]Control group received un-supplemented S(starter) then G (grower) diets, S1G0 group fed on S contained 1 g Bio-Mos kg^{-1} diet then un-supplemented G diet, S1G0.5 group received S contained 1g Bio-Mos kg^{-1} diet then G contained 0.5 g Bio-Mos kg^{-1} diet, S1G1 group received S contained 1 g Bio-Mos kg^{-1} diet then G contained 1 g Bio-Mos kg^{-1} diet. [##] FCO: Feed cost (L.E.) per kilogram of body weight gain. [###]EEI: Economic Efficiency Index (FCO value of lower treatment in FCO value/Fco per each treatment)*100

However, according to this study, it is obvious that villus high is may be more sensitive to Bio-Mos inclusion and its levels up to 1 g kg^{-1} in broiler diet than crypt depth. As well as, this significant high length caused a significant improvement in nutrient absorption, BWG up to 0.5 g kg^{-1} and FCR up to 1 g kg^{-1} Bio-Mos levels in grower diet with a constant level of 1 g kg^{-1} in starter diets for both treatments. This notation is somewhat in accordance with Choi *et al.* (1994), Bradley *et al.* (1994), Spring (1996) and Shane (2001), where they postulated that MOS supplementation in broiler diet was enhanced the absorptive properties of intestinal mucosa by increasing micro villus length and reducing crypt depth, causing improvement of body weight and feed conversion ratio.

Effect of experimental treatments on feed cost per kilogram body weight gram (FCO) and Economic Efficiency Index (EEI): Table 6 documented the effect of experimental treatments on economic efficiency. It indicated that feed cost per kilogram BWG (FCO) was lowered (ranged between 7.07-7.26) and EEI increased (ranged between 97.55-100 as a percents of FCO of S1G1 group) with supplemented Bio-Mos diets compared with un-supplemented diets which recorded 7.53 for FCO and 93.88% for EEI.

Supplementation of Bio-Mos with 1 g kg^{-1} of starter diets of the three supplemented groups and using levels of 0, 0.5 and 1 g kg^{-1} in their grower diets resulted in a linear reduction in FCO up to S1G1 treatment, when it taken as a standard for EEI measurement, the economic efficiency values were increased with Bio-Mos increasing in grower diets as shown of EEI values of S1G0 and S1G0.5 groups which recorded 97.55 and 98.48%, respectively.

Very little research workers interested to the economic aspect of Bio-Mos inclusion in poultry diets. However, Eseceli *et al.* (2010), didn't show any significant differences in feed cost kg^{-1} BWG between three broiler chick groups fed on diets supplemented with 0.5, 1 or 1.5 g Bio-Mos kg^{-1} diet. The same result was confirmed by Hooge (2003) using 0 (negative control), 0.5 and 1 g Bio-Mos kg^{-1} in different periodical diets of broiler chicks till 49 days-old.

CONCLUSION

Our study suggested the followings:

- Inclusion of Bio-Mos in starter and grower diets of broiler chicks till 35 days old have desirable effects on body weight gain, feed conversion, microbial counts and mucosal histology of small intestine as well as, it was more efficient from economic aspect
- Using of 1 g Bio-Mos kg^{-1} starter diet in all supplemented diets and increasing of Bio-Mos in grower diet by 0, 0.5 or 1 g resulted in that the 0.5 g kg^{-1} rate showed the highest BWG and FI and lowest ceacal *E. coli* count among treatments. In addition that, 1 g kg^{-1} rate recorded the best FCR, higher jejunal and ileal villus length, ceacal *Lactobacillus* and lower count of ceacal *Salmonella.* Although, the economic efficiency values between the three treatments were not statistically differed but there were linearly increased with Bio-Mos increasing in grower diet

REFERENCES

Aptekmann, K.P., S.M.B. Arton, M.A. Stefanini and M.A. Orsi, 2001. Morphometric analysis of the intestine of domestic quails (*Coturnix coturnix japonica*) treated with different levels of dietary calcium. Anatomia Histologia Embryologia, 30: 277-280.

Baurhoo, B., A. Letellier, X. Zhao and C.A. Ruiz-Feria, 2007. Cecal populations of lactobacilli and bifidobacteria and *Escherichia coli* populations after *in vivo Escherichia coli* challenge in birds fed diets with purified lignin or mannanoligosaccharides. Poult. Sci., 86: 2509-2516.

Bellaver, C., E.T. Fialho, J.F. da Silva Protas and P.C. Gomes, 1985. [Malt rootlets as ration ingredients for swine on growing and finishing stages]. Pesquisa Agropecuaria Brasileira, 20: 969-974, (In Portuguese).

Borsoi, A., L.R. do Santos, L.B. Rodrigues, H.L. de Souza Moraes, C.T.P. Salle and V.P. do Nascimento, 2011. Behavior of *Salmonella* heidelberg and *Salmonella* enteritidis strains following broiler chick inoculation: Evaluation of cecal morphometry, liver and cecum bacterial counts and fecal excretion patterns. Braz. J. Microbiol., 42: 266-273.

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

Bradley, G.L., T.F. Savage and K.I. Timm, 1994. The effects of supplementing diets with *Saccharomyces cerevisiae* var. *boulardii* on male poult performance and ileal morphology. Poult. Sci., 73: 1766-1770.

Brummer, M., C.J. van Rensburg and C.A. Moran, 2010. *Saccharomyces cerevisiae* cell wall products: The effects on gut morphology and performance of broiler chickens. South Afr. J. Anim. Sci., 40: 14-21.

Brzoska, F., R. Grzybowki, K. Stecka and M. Pieszka, 1999. Effect of probiotic microorganisms vs. antibiotics on chicken broiler body weight, carcass yield and carcass quality. Ann. Anim. Sci., 26: 303-315.

Brzoska, F., S.B. Buluchevskij, B. Sliwinski and K. Stecka, 2005. Preliminary study of the microbial spectrum of the digestive tract in broilers fed diets with and without antibiotic supplementation. J. Anim. Feed Sci., 14: 451-454.

Brzoska, F., S. Buluchevskij, K. Stecka and B. Sliwinski, 2007. The effects of lactic acid bacteria and mannan oligosaccharide, with or without fumaric acid, on chicken performance, slaughter yield and digestive tract microflora. J. Anim. Feed Sci., 16: 241-251.

Cavazzoni, V., A. Adami and C. Castrovilli, 1998. Performance of broiler chickens supplemented with *Bacillus coagulans* as probiotic. Br. Poult. Sci., 39: 526-529.

Choi, K.H., N. Namkung and I.H. Paik, 1994. Effets of dietary fructooligosaccharides on the suppression of intestinal colonization of *Salmonella typhimurium* in broiler chicks. Korean J. Anim. Sci., 36: 271-284.

Corrigan, A., K. Horgan, N. Clipson and R.A. Murphy, 2011. Effect of dietary supplementation with a *Saccharomyces cerevisiae* mannan oligosaccharide on the bacterial community structure of broiler cecal contents. Applied Environ. Microbiol., 77: 6653-6662.

Denev, S., I. Dinev, I. Nikiforov and V. Koinarski, 2006. Effect of mannanoligosaccharide on composition of the cecal microflora and performance of broiler chickens. Bulghar J. Econ. Sci., 5: 10-16.

Duncan, D.B., 1955. Multiple range and multiple *F* tests. Biometrics, 11: 1-42.

Eseceli, H., E. Demir, N. Degirmencioglu and M. Bilgic, 2010. The effects of Bio-Mos® mannan oligosaccharide and antibiotic growth promoter performance of broilers. J. Anim. Vet. Adv., 9: 392-395.

Fairchild, A.S., J.L. Grimes, F.T. Jones, M.J. Wineland, F.W. Edens and A.E. Sefton, 2001. Effects of hen age, Bio-Mos and Flavomycin on poult susceptibility to oral *Escherichia coli* challenge. Poult. Sci., 80: 562-571.

Fan, Y.J., S.J. Chen, Y.C. Yu, J.M. Si and B. Liu, 2006. A probiotic treatment containing Lactobacillus, Bifidobacterium and Enterococcus improves IBS symptoms in an open label trial. J. Zhejiang Univ. Sci. B, 7: 987-991.

Fathi, M.M., S. Al-Mansour, A. Al-Homidan, A. Al-Khalaf and M. Al-Damegh, 2012. Effect of yeast culture supplementation on carcass yield and humoral immune response of broiler chicks. Vet. World, 5: 651-657.

Fernandez, F., M. Hinton and B. van Gils, 2002. Dietary mannan-oligosaccharides and their effect on chicken caecal microflora in relation to *Salmonella* Enteritidis colonization. Avian Pathol., 31: 49-58.

Fialho, E.T., H.P. Barbosa, A.S. Ferreira, P.C. Gomes and A.F. Girotto, 1992. [Utilization of barley in diets supplemented with soybean oil for growing and finishing pigs]. Pesquisa Agropecuaria Brasileira, 27: 1467-1475, (In Portuguese).

Hooge, D.M., 2003. Dietary mannan oligosaccharides improve broiler and turkey performance: Metaanalysis of pen trials around the world. Proceedings of the Alltech's 19th Annual Symposium on Nutritional Biotechnology in the Feed and Food Industries, May 12-14, 2003, Lexington, KY., pp: 113-124.

Hosseini, S., 2011. The effect of utilization of different levels of saccharomysec cerevisiae on broiler chicken's performance. Global Veterinaria, 6: 233-236.

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: 1186-1192.

Jamroz, D., A. Wiliczkiewicz, J. Orda, T. Wertelecki and J. Skorupinska, 2004. Response of broiler chickens to the diets supplemented with feeding antibiotic or mannanoligosaccharides. Electron. J. Polish Agric. Univ. Ser. Anim. Husb., Vol. 7.

Jang, I.S., Y.H. Ko, S.Y. Kang and C.Y. Lee, 2007. Effect of a commercial essential oil on growth performance, digestive enzyme activity and intestinal microflora population in broiler chickens. Anim. Feed Sci. Technol., 134: 304-315.

Jin, L.Z., Y.W. Ho, M.A. Ali, N. Abdullah, K.B. Ong and S. Jalaludin, 1996. Adhesion of *Lactobacillus* isolates to intestinal epithelial cells of chicken. Lett. Applied Microbiol., 22: 229-232.

Joerger, R.D., 2003. Alternatives to antibiotics: Bacteriocins, antimicrobial peptides and bacteriophages. Poult. Sci., 82: 640-647.

Kamran, Z., M.A. Mirzaa, S. Ahmad, H.A. Samad, M.U. Sohail and M. Saadullahb, 2013. Performance of broiler chickens fed mannan oligosaccharides as alternatives to antibiotics from one to twenty-two days of age. J. Anim. Plant Sci., 23: 1482-1485.

Markovic, R., D. Sefera, M. Krstic and B. Petrujkic, 2009. Effect of different growth promoters on broiler performance and gut morphology. Arch. Med. Vet., 41: 163-169.

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

SAS., 1995. JMP Statistics and Graphics Guide, Version 3.1. SAS Institute, Cary, NC., USA.

Santin, E., A. Maiorka, M. Macari, M. Grecco, J.C. Sanchez, T.M. Okada and A.M. Myasaka, 2001. Performance and intestinal mucosa development of broiler chickens fed diets containing *Saccharomyces cerevisiae* cell wall. J. Applied Poult. Res., 10: 236-244.

Savage, T.F. and E.I. Zakrzewska, 1997. The performance of male turkeys fed a starter diet containing a mannan oligosaccharide. Zootech. Int., 20: 30-32.

Shane, M.S., 2001. Mannan Oligosaccharides in Poultry Nutrition: Mechanism and Benefits. In: Science and Technology in the Feed Industry: Proceedings of Alltech's 17th Annual Symposium, Lyons, T.P. and K.A. Jacques (Eds.). Nottingham University Press, Nottingham, UK., pp: 65-77.

Sharon, N. and H. Lis, 1993. Carbohydrates in cell recognition. Sci. Am., 268: 82-89.

Sims, M.D., K.A. Dawson, K.E. Newman, P. Spring and D.M. Hoogell, 2004. Effects of dietary mannan oligosaccharide, bacitracin methylene disalicylate, or both on the live performance and intestinal microbiology of Turkeys. Poult. Sci., 83: 1148-1154.

Spring, P., 1996. Effects of mannanoligosaccharide on different cecal parameters and on cecal concentrations of enteric pathogens in poultry. Ph.D. Thesis, Swiss Federal Institute of Technology, Zurich, Switzerland.

Spring, P., C. Wenk, K.A. Dawson and K.E. Newman, 2000. The effects of dietary mannaoligosaccharides on cecal parameters and the concentrations of enteric bacteria in the ceca of salmonella-challenged broiler chicks. Poult. Sci., 79: 205-211.

Tavernari, F.C., L.F.T. Albino , R.L. Morata, W.M. Dutra Jr., H.S. Rostagno and M.T.S Viana, 2008. Inclusion of sunflower meal, with or without enzyme supplementation, in broiler diets. Revista Brasileira Ciencia Avicola, 10: 233-238.

Tucker, L.A., E. Esteve-Garcia and A. Connolly, 2003. Dose response of commercial mannan oligosaccharides in broiler chickens. Proceedings of the 14th European Symposium on Poultry Nutrition, August 10-14, 2003, Lillehammer, Norway.

Van Leeuwen, P., J.M.V.M. Mouwen J.D. Van Der Klis and M.W.A. Verstegen, 2004. Morphology of the small intestinal mucosal surface of broilers in relation to age, diet formulation, small intestinal microflora and performance. Br. Poult. Sci., 45: 41-48.

Yang, Y., P.A. Iji and M. Choct, 2007a. Effects of different dietary levels of mannanoligosaccharide on growth performance and gut development of broiler chickens. Asian-Australasian J. Anim. Sci., 7: 1084-1091.

Yang, Y., P.A. Iji, A. Kocher, L.L. Mikkelsen and M. Choct, 2007b. Effects of mannanoligosaccharide on growth performance, the development of gut microflora and gut function of broiler chickens raised on new litter. J. Applied Poult. Res., 16: 280-288.

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. J. Poult. Sci., 84: 1015-1021.