Abstract

This study was conducted to investigate the effects of prebiotic and organic zinc alone and in combination in broiler diets on the live weight gain (LWG), feed consumption (FC), feed conversion ratio (FCR), carcass yield, some relative organ weights and blood parameters. A total of 160 Ross 308 one-day-old male chicks were assigned to 4 treatment groups with 4 replicates of 10 birds each. Treatment for each group consisted of: first group (control group) received basal diet without supplementation; second group received 1 g/kg Mannanoligosaccharide (MOS); third group received 80 mg/kg organic zinc (OZn); and fourth group received 80 mg/kg organic zinc + 1 g/kg Mannanoligosaccharide (MOS+OZn). The study lasted 42 days. The supplementation of MOS and OZn had no effect on the LWG, FC, FCR, carcass yield, serum aspartate aminotransferase, (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and triglyceride levels during the experiment (P>0.05). Relative organ weights (liver, spleen, pancreas) were significantly higher in OZn group than those in the other groups (P<0.001). There was a significant difference in serum total cholesterol and glucose levels between treatment groups and control group (P<0.001). Serum Zn and Fe levels were significantly lower in control group than those in OZn and MOS+OZn groups (P<0.001). The highest and the lowest Cu levels were in the MOS+OZn and control groups, respectively (P<0.001). These data suggest that OZn with MOS combination may have a beneficial effect on serum mineral level in broilers.

Materials and methods

Animal and diets

A total of 160 Ross 308 one-day-old male chicks were used. Chicks were weighed and assigned to 4 treatment groups with 4 replicates of 10 birds each. Treatment for each group consisted of: first group (control group) received basal diet without supplementation; second group received 1 g/kg Mannanoligosaccharide (MOS); third group received 80 mg/kg organic zinc (OZn); and fourth group received 80 mg/kg organic zinc + 1 g/kg Mannanoligosaccharide (MOS+OZn). The basal diet was presented in Table 1. First group (control group) received a basal diet with no supplementation during the experiment. Second group received 1 g/kg mannanoligosaccharide (MOS), 3rd group received 80 mg/kg organic zinc (OZn) and 4th group received 80 mg/kg organic zinc + 1 g/kg mannanoligosaccharide (MOS+OZn) in basal diet. Zinc, Fe and Cu levels were detected in liver and pancreas samples by Inductively coupled plasma atomic emission spectrometer; AES Varion Vista Model, Sydney, Australia).
organs. Carcass yield was calculated as carcass weight/live weight x 100 at slaughter and expressed as percentage.

The liver, spleen and pancreas were removed, weighed and expressed as relative organ weights (gram of per 100 of live-weights).

Blood sample collection
At the end of the 42 d, 3 birds from each replicate of each treatment group (12 birds/group) were randomly selected, and blood samples were individually collected into serum test tubes from brachial vein for biochemical analysis during slaughter. Sera were separated by centrifugation for 10 min at 1600×g after 1 h incubation at room temperature and stored at -20°C until the analysis. Aspartate aminotransferase (AST) (EC 2.6.1.1), alanine aminotransferase (ALT) (EC 2.6.1.2), alkaline phosphatase (ALP) (EC 3.1.3.1) activities, triglyceride, glucose (Biolabo, Maizy, France), total protein (TP), total cholesterol (DDS, Dusseldorf, Germany) concentration were determined by a Shimadzu UV 1700 spectrophotometer (Kyoto, Japan) with diagnostic kits. Concentrations of Zn, Fe and Cu in serum were determined by ICP (Inductively coupled plasma atomic emission spectrometer; AES Varion Vistra Model, Sydney, Australia).

Statistical analyses
The data were analyzed using SPSS 10 for Windows (SPSS Inc., Chicago, IL, USA). Statistically significant differences between group means were determined by analysis of variance (ANOVA). Duncan’s multiple range test was performed when the differences were significant. Mean values were considered significantly different at P<0.05. The data were expressed as mean values ±SE.

Results and discussion
The results of broiler performance are given in Table 2. Live weight gain, FC, FCR were not influenced by addition dietary MOS and OZn (P>0.05). Similar results were obtained in broiler fed with 1 g/kg MOS (Bozkurt et al., 2008). Also Yang et al. (2007) reported that 0.5-2 g/kg MOS supplementation had no effect on FC and FCR but tended to improve BW as compared to control group. Waldroup et al. (2003) demonstrated that supplementation of MOS (1 g/kg) in broiler diet did not improve BW and FCR. Khalaji et al. (2011) showed that MOS (0.5, 1 and 1.5 g/kg) had no significant effect on growth performance and FCR. Mohanna and Nys (1999) reported that LWG, FC and FCR in broilers were not influenced by 40 mg/kg Zn sulfate or Zn-Met. Rossi et al. (2007) reported that LWG, FC and FCR were not statistically influenced by addition of organic Zn supplemental (0, 15, 30, 60 ppm) in diet. These results are also consistent with our study. On the contrary, some investigators, who added organic zinc to broiler diets, observed an improvement in growth performance (Ao et al., 2006; Bao et al., 2007). This difference can be attributed to the varying protocols and dose regimens of the experiments. In Bao et al. (2007) study, not only 80 mg/kg Zn but also other minerals like Fe, Cu and Mn were used, and the study lasted 29 d, in our study we used only Zn and the study lasted 42 d. In Ao et al. (2006) study, it was concluded that feed intake and weight gain were linearly increased by dietary supplementing Bioplex Zn until 10 mg/kg after which no further increase occurred.

Carcass yield and relative organ weights were shown in Table 3. In this study carcass yield was not influenced by addition of MOS and OZn (P>0.05). Similarly some researchers (Eren et al., 1999; Waldroup et al., 2003; Yalcinkaya et al., 2008) reported no significant improvement in carcass yield of broilers when fed with 1 g/kg Bio-Mos. In addition, Rossi et al. (2007) reported that carcass yield was not significantly different at P<0.05. This difference can be attributed to the varying protocols and dose regimens of the experiments. In Bao et al. (2007) study, not only 80 mg/kg Zn but also other minerals like Fe, Cu and Mn were used, and the study lasted 29 d, in our study we used only Zn and the study lasted 42 d. In Ao et al. (2006) study, it was concluded that feed intake and weight gain were linearly increased by dietary supplementing Bioplex Zn until 10 mg/kg after which no further increase occurred.

Table 1. Composition of the basal diets.

| Ingredient, % | Starter, 0-21 days | Finisher, 22-42 days |
|---------------|--------------------|---------------------|
| Corn          | 48.50              | 56.00               |
| Soybean meal  | 42.40              | 34.40               |
| Vegetable oil | 5.50               | 6.00                |
| Limestone     | 1.30               | 1.30                |
| Dicalcium phosphate | 1.50 | 1.50 |
| Salt          | 0.25               | 0.25                |
| Vitamin+mineral premix<sup>a</sup> | 0.25 | 0.25 |
| DL-Methionine | 0.30               | 0.30                |

<sup>a</sup>Vitamin-mineral premix: vit. A, 12,000 U; vit. D3, 1500 U; vit. E, 30 mg; vit. K3, 5 mg; vit. B1, 3 mg; vit. B2, 6 mg; vit. B6, 5 mg; vit. B12, 0.03 mg; Cu, 25 mg; Zn, 40 mg; Fe, 100 mg; Mn, 10 mg; I, 0.2 mg; NaCl, 40 mg; MgSO<sub>4</sub>, 160 mg; CaCO<sub>3</sub>, 150 mg; DL-Methionine, 0.5 mg; Choline chloride, 150 mg; CDP-choline, 15 mg; BHT, 0.1 mg; BHA, 0.1 mg; vitamin K3, 1 mg; vitamin B3, 1 mg; vitamin B5, 1 mg; vitamin B12, 0.03 mg; vitamin B6, 0.5 mg. Metabolizable energy, kcal/kg: 3090, 3209. Crude protein, %: 23.00, 20.10. DL-Methionine: 0.30.

Table 2. Effects of mannanoligosaccharide and organic zinc supplementation on feed consumption, live weight gain and feed consumption ratio of broilers.

| Parameter     | Period, days | Control | MOS | OZn | MOS+OZn | P   |
|---------------|--------------|---------|-----|-----|---------|-----|
| FC, g/bird/d  | 1-21         | 1211.18±24.72 | 1249.07±26.55 | 1291.42±10.93 | 1254.91±15.45 | ns  |
|               | 21-42        | 3098.32±49.19 | 3175.33±64.77 | 3143.62±77.69 | 3182.69±88.72 | ns  |
|               | 1-42         | 4319.49±51.71 | 4424.40±82.54 | 4435.04±76.21 | 4437.11±81.80 | ns  |
| LWG, g/bird/d | 1-21         | 902.68±22.04 | 942.59±25.85 | 944.18±20.40 | 937.40±14.70 | ns  |
|               | 21-42        | 1640.12±22.17 | 1694.43±39.43 | 1681.96±19.43 | 1711.78±46.35 | ns  |
|               | 1-42         | 2540.70±27.64 | 2636.04±21.93 | 2622.61±15.88 | 2646.38±49.66 | ns  |
| FCR           | 1-21         | 1.35±0.02    | 1.33±0.03    | 1.37±0.02    | 1.34±0.01    | ns  |
|               | 21-42        | 1.89±0.04    | 1.87±0.01    | 1.87±0.04    | 1.86±0.01    | ns  |
|               | 1-42         | 1.70±0.02    | 1.68±0.03    | 1.69±0.02    | 1.68±0.01    | ns  |

MOS, mannanoligosaccharide; OZn, organic zinc; MOS+OZn, mannanoligosaccharide + organic zinc; FC, feed consumption; LWG, live weight gain; FCR, feed consumption ratio; ns, not significant.
influenced by supplementation of increasing levels of dietary organic zinc. But relative organ weights (liver, spleen, pancreas) were significantly higher in OZn group than those in other treatment groups (P<0.001). Also, Jahanian et al. (2008) fed chicks on increasing levels of OZn, (40-80-120 mg/kg) and demonstrated that dietary zinc source affect liver weight. The heaviest livers were found in chicks fed on 80 mg/kg ZnMet supplemented diets. In our study the combined supplementation of MOS and OZn reduced the increase found in the liver of OZn group.

Blood parameters were presented in Table 4. In the present study, serum glucose concentration decreased in OZn and MOS+OZn groups (P<0.001) compared with control group. Our results were similar to those of Uyanık et al. (2001) who found that Zn supplementation decreased serum glucose concentration in broilers. This decrease might have been resulted from a possible relationship between Zn and insulin. Salgueiro et al. (2001) suggested a close relation among zinc, glucose metabolism and insulin physiology. Zinc induced pancreatic islet cells to produce and secrete insulin by playing crucial role in the synthesis, storage, and secretion of insulin. The zinc deficient rats had an impaired glucose metabolism. The deficiency of zinc increased the level of glucose in rats (Sandergaard et al. 2006).

In this study, the concentration of serum cholesterol was increased in MOS+OZn group as compared to MOS and control group (P=0.004). This result was consistent with the results of studies in goat (Keskin et al., 1999), rat (Allen and Klevay, 1980; Samman and Roberts, 1988) pig (Eiseman et al., 1979) and human (Hooper et al., 1980; Samman and Roberts, 1988) which showed an increased serum cholesterol concentration due to Zn supplementation (<300 mg/kg diet) to the diet. The relationship between dietary zinc and plasma cholesterol is not well understood (Uyanık et al., 2001). Zinc supplementation did not influence serum cholesterol in chicks (Lu and Combs, 1988). Uyanık et al. (2001) indicated that inorganic zinc decreased serum cholesterol concentration. In contrast, Kaya et al. (2001) reported that adding 50 and 200 mg/kg Zn to the diet increased plasma total cholesterol level in laying hens.

Table 3. Effects of mannanoligosaccharide and organic zinc supplementation on carcass yield* and some relative organ weights’ for broilers.

| Parameters          | Control    | MOS        | OZn        | MOS+OZn    | P       |
|---------------------|------------|------------|------------|------------|---------|
| Carcass yield, %    | 79.21±0.50 | 80.35±0.95 | 78.45±1.21 | 80.32±0.43 | ns      |
| Liver, %            | 1.81±0.09  | 1.83±0.08  | 2.28±0.04  | 1.86±0.06  | 0.000** |
| Spleen, %           | 0.12±0.01  | 0.25±0.05  | 0.43±0.01  | 0.27±0.05  | 0.000** |
| Pancreas, %         | 0.24±0.01  | 0.36±0.05  | 0.53±0.01  | 0.42±0.05  | 0.000** |

*Carcass yield was calculated as carcass weight / liveweight x 100 at slaughter and expressed as percentage.

Table 4. Effects of mannanoligosaccharide and organic zinc supplementation to diet on some blood parameters of broilers.

| Parameters          | Control    | MOS        | OZn        | MOS+OZn    | P       |
|---------------------|------------|------------|------------|------------|---------|
| AST, U/L            | 213.03±10.62 | 236.69±7.08 | 238.18±12.55 | 231.38±8.55 | ns      |
| ALT, U/L            | 8.36±1.17  | 7.33±1.39  | 5.97±0.95  | 5.93±0.70  | ns      |
| ALP, U/L            | 2632.48±140.14 | 2577.38±183.49 | 2637.10±120.46 | 2555.68±73.92 | ns      |
| Glucose, mg/dL      | 261.74±8.59 | 205.89±4.05 | 208.55±8.24 | 208.55±8.24 | ns      |
| Triglyceride, mg/dL | 48.79±1.70  | 45.43±2.44  | 45.34±2.11  | 45.87±2.08  | ns      |
| Total cholesterol, mg/dL | 126.53±2.98  | 121.14±5.42  | 128.84±3.29  | 139.99±3.15  | 0.004** |
| Total protein, g/dL | 3.49±0.10  | 3.42±0.12  | 3.96±0.17  | 3.73±0.17  | 0.043   |
| Zinc, ppm           | 1.83±0.11  | 2.12±0.11  | 2.24±0.12  | 2.38±0.13  | 0.034*  |
| Iron, ppm           | 3.38±0.50  | 4.82±0.79  | 5.84±0.49  | 5.97±0.59  | 0.017*  |
| Copper, ppm         | 0.28±0.03  | 0.68±0.09  | 0.71±0.09  | 0.96±0.09  | 0.000** |

Mannanoligosaccharide and organic zinc had no significant effect on growth performance but changed some biochemical parameters in broilers, and Cu level in MOS+OZn group was higher than those in the other groups whereas Fe level in MOS+OZn group was only higher than that of control group. These data suggest that using organic zinc might reduce Cu-Zn antagonism and MOS supplementation improved Fe and Cu absorption.

Conclusions

Mannanoligosaccharide and organic zinc had no significant effect on growth performance but changed some biochemical parameters in broilers, and Cu level in MOS+OZn group was higher than those in the other groups whereas Fe level in MOS+OZn group was only higher than that of control group. These data suggest that OZn with MOS combination facilitated the Fe and Zn absorption and aid in the retention of Cu. MOS and OZn combination exhibited synergistic effect on blood mineral level, which would provide more alternative choice to broiler producers for preparation of environment-friendly feed.

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