Influence of Some Dietary Organic Mineral Supplementations on Broiler Performance

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Abstract: A trial was set up to evaluate the influence of some dietary organic mineral supplementations on broiler performance. A total of 1,500 day-old Ross 308 broiler chicks was allotted into 10 groups with 3 replicates of 50 birds each. Two control diets (negative control with inorganic minerals and positive control with organic minerals) were formulated to meet nutrient requirements of chicks recommended for Ross 308. The premix was formulated to contain the requirements of trace elements in combination of either inorganic (sulphate form) or organic form (peptide chelate form). Diets were supplemented with the organic form of zinc, copper, manganese or iron (peptide chelate at the rate of 50% or 100% of the total requirements of the elements recommended for Ross broiler chicks). Production performance was measured during the 35 day trial period and mineral excretion was evaluated at 28 day of age. Results indicated that chicks fed diets containing 100% organic minerals (Zn, Cu, Mn and Fe) had significantly higher body weight, better feed conversion, higher % tibia ash and higher immunity compared with those of inorganic control minerals treatment. Also, when organic minerals were fed as a single element while the rest of minerals were inorganic forms at a level of 100% or 50%, the performance parameters were not significantly different from those resulted from all organic minerals together but were significantly better than those of inorganic control treatment. Fecal mineral excretions from broilers receiving the organic mineral diets were lower than those of inorganic control treatment. No significant effects were observed on muscle characteristics among the different treatments. However, organic mineral diets had a positive effect on economic efficiency. It is concluded that replacing inorganic minerals with organic sources improved bird’s performance and enhanced immune response of chicks.

Key words: Organic minerals, broiler performance, immune response, tibia ash

INTRODUCTION

Trace minerals, such as Cu, Fe, Mn and Zn, are essential for broiler growth and are involved in many digestive, physiological and biosynthetic processes within the body. They function primarily as catalysts in enzyme systems within cells or as parts of enzymes. They are constituents of hundreds of proteins involved in intermediary metabolism, hormone secretion pathways and immune defense systems (Dieck et al., 2003). Traditionally, these trace minerals are supplemented in the form of inorganic salts, such as sulfates, oxides and carbonates, to provide levels of minerals that prevent clinical deficiencies and allow the bird to reach its genetic growth potential (Bao et al., 2007).

In the 1990’s, a greater availability for some organic trace mineral sources than for the inorganic forms was reported, leading to an increased interest in the feed industry for these products. Trace minerals from organic sources would appear to be protected from forming insoluble complexes with feed or endogenous components present in the digestive tract. Moreover, trace mineral complexing or chelating to small size organic molecules would enhance their absorption and even improve their metabolic utilization. Trace minerals are required for the normal functioning of all biochemical processes in animal body. However, the trace mineral requirements of poultry are not well defined. Commercial diets typically supplement inorganic trace minerals at a rate much higher than those recommended by National Research Council (Leeson, 2005). The use of organic mineral sources can improve intestinal absorption of trace elements as they reduce interference from agents that form insoluble complexes with the ionic trace elements (Van and Kemme, 2002).

Due to the concern for build-up of heavy metals when applying poultry litter to crop-land, environmental protection agencies around the world have pressed for lower levels of mineral waste applied to land. Organically complexed trace minerals provide alternative pathways for absorption, thus leading to a reduction in the excretion of minerals (Leeson, 2003). Supplementation of trace minerals with a large safety margin in broiler chickens has resulted in a high level of mineral excretion that ends up in the environment. Organically complexed trace minerals (organic minerals) may be able to replace the inorganic trace...
minerals, because the former appear to have a greater bioavailability. It is possible to use these lower levels of organic trace minerals in broiler diets to avoid high levels of trace mineral excretion (Bao et al., 2007). Nollet et al. (2008) found that trace mineral proteinates (for rapid absorption and assimilation) can replace inorganic supplements in broiler diets, possibly lowering inclusion rates and mineral excretions. They found no significant differences among Bioplex treatments (BP17, BP33, BP50, BP67 and BP 100%). The objective of this trial was to study the influence of some dietary organic trace elements levels on broiler performance and immune response.

MATERIALS AND METHODS

A trial was set up to evaluate the influence of some dietary organic mineral supplementations on broiler performance. A total of 1,500 day-old Ross 308 unsexed chicks were allotted into 10 groups with 3 replicates of 50 birds each. Two control diets were formulated to meet the requirement allowance of nutrients reported for Ross308 managem ent guide. The premix was formulated to contain the requirements of trace elements in combination of either inorganic (Sulphate form) or organic form (peptide chelate form). Diets were supplemented with the organic form of zinc, copper, manganese or iron (peptide chelate at the rate of 50% or 100% of the total requirements of the elements. The birds were weighed individually at the commencement of the experiment and those with extreme body weight were eliminated. Chicks were wing-banded and distributed randomly into 10 treatments of 150 chicks (three replicates of 50 chicks each). All birds were housed in floor pens that located in semi-closed house with climate control condition. They kept under similar condition of management throughout the experimental period. Artificial lighting was used to provide chicks with 24 h lighting daily during the whole experimental period. Initial brooding temperature was 33°C in the first week of age and reduced gradually 2°C per week up to 24°C then remains constant. Diets and water were provided ad libitum throughout the experimental period, which lasted for 35 days of age. The experimental design and compositions of these commercial feed additives are summarized in Table (1). Diets were formulated using linear programme of least cost to meet nutrient requirements of chicks recommended to Ross 308 management guide (2006). The compositions of the basal diets are illustrated in Table (2). Sheep Red Blood Cells (SRBC) were used as test antigens to quantitatively analyze specific antibody response as measure of humoral immunity. At 4 weeks of age, birds were immunized I.V (intra venous) via a wing vein with 0.07 ml packed SRBC mixed with 0.93 mL physiological saline (0.9% NaCl) for measure primary response. The SRBC,s were obtained in heparin solution from unrelated texel sheep and wash three time in physiological saline. Seven days following the antigen challenge, blood samples were collected and sera were used to measure humoral immunity. Antibody production to SRBC was measured using microtitration hemmagglutination technique with microtiter plate U-shape of 96 wells (8 row X 12 column) according to Bachman and Mashaly (1986) and Kai et al. (1988). At the end of the experimental period, a slaughter test was performed using 6 chicks from each treatment. The right tibia was removed of the slaughtered chicks, cleaned from tissues, set in hexane for 48 h to remove fat and dried in an oven for 24 h until constant weight. Their length (mm), width (mm), weight (gm), ash, Ca and phosphorus were determined to study the effect of dietary treatments on bone mineralization. Length and width of tibia were determined using vernier caliber. Ash percentage of defatted tibia and its relative Ca and P contents were determined after ashing at 600°C, according to the methods of AOAC (1980). The pH value was measured by pH meter as described by Aitken et al. (1962) as follows: About 10.0 gm of prepared samples from meat and drip were blended with 50 mL of distilled water for 10 min and then pH value was measured. Color intensity of meat and drip were determined according to the method of Husani et al. (1950) as follows: 10 gm of samples were shaken with 50 mL distilled water in dark room for 10 min then, filtered and the color intensity (absorbency) was measured photometrically at 543 mm. The ability of meat to hold water (WHC) and tenderness of meat were measured according to the method of Volovinskaia and Kelman (1962) in which 0.3 gm minced meat tissues were put under an ashless filter paper and pressed for 10 min using 1 kg weight. On the filter paper, two zones were formed. Their surface areas were measured by the planimeter. The WHC was calculated by subtracting the internal zone form the outer zone. The internal zone is due to the meat pressing only indicating the tenderness. The digestibility coefficients of nutrients of the experimental diets were examined at the end of the experimental period (5 weeks of age). Faecal nitrogen was determined according to the method outlined by Jakobson et al. (1960), while the urinary organic matter fraction was calculated according to Abou-Raya and Galal (1971). The proximate analyses of feed and dried excreta were carried out according to the official methods (AOAC, 1990). Data were subjected to the analysis of variance using General Linear Model (GLM) of SAS programme SAS® software (1996). One-way analysis of variance was carried out using the following model:

\[ Y_{ij} = \mu + T_i + E_{ij} \]

Where \( Y_{ij} \) = individual observation, \( \mu \) = overall mean, \( T_i \) = the effect of treatments, \( E_{ij} \) = the experimental random error.
Differences among treatments means were separated by Duncan’s multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION
The performances of chicks fed experimental diets are summarized in Table (3). The initial live body weights of experimental chicks were almost alike with a little bit difference indicating the well randomization way for distributing chicks within the experimental treatments. Chicks fed diets containing Inorganic Minerals (IOM) were significantly recorded the lowest live body weight. However, chicks fed diets containing 100% organic-Zn were significantly higher than that fed on 50% organic-Zn. There were no significant differences between groups fed 100% of organic Mn or Cu or Fe and those groups fed on 50% organic Mn or Cu or Fe. No significant differences were observed between treatments on feed intake. Feed Conversion (FC) of chicks fed on diets containing inorganic minerals was significantly inferior (1.74). However, chick fed containing 100% OM recorded the best ratio of feed conversion being, 1.63 with differences with 50% organic-Fe or 50% organic-Zn. These results agreed with Cao et al. (2000) who reported that feed intake, daily gain and bone Zn concentration were greatest in birds supplemented with organic Zn compared with those supplemented with inorganic Zn, which does not agree with the findings of Mohanna and Nys (1999) who reported that weight gain, feed intake and feed conversion in broilers were not influenced by Zn sulfate or Zn-Met. Pimentel et al. (1991) reported that Zn source (ZnO or Zn-Met) had no affect on growth or tibia and liver Zn levels, while broilers fed Zn-Met had higher levels of pancreatic Zn. Sacranie (2003) indicated that the total amount of inorganic minerals in a broiler premix could be totally replaced by 20% organic minerals without affecting growth performance and, at the same time reducing the environmental contamination. The use of organic mineral sources can improve intestinal absorption of trace elements as they reduce interference from agents that form insoluble complexes with the ionic trace elements (Van and Kemme, 2002). The results agreed with Paik (2001) who reported that broilers fed Cu-Met (organic) had increased daily gain and feed intake, while laying hen performance and eggshell quality were improved in layers fed Cu-Met compared with those fed Cu sulfate. In addition, Nollet et al. (2007) reported that in the starter period FCR tended to improve in broilers fed the organic mineral diet. However, no significant differences were observed in any of the productive performance parameters measured during the trial. Significantly lower excretion rates were recorded for all minerals in fecal samples taken from broilers receiving the organic mineral diet. Fecal levels of Mn, Zn, Fe and Cu were 46, 63, 73 and 55%, respectively, compared to the controls. However, Xia et al. (2004) showed that Cu-MONT supplementation significantly improved weight gain and decreased feed conversion. Henry et al. (1986) reported no difference in daily gain, feed intake, or feed conversion between broilers fed MnO and Mn SO₄; they reported that MnO had a relative bioavailability of 79, 58 and 64% for bone, kidney and liver responses compared with Mn sulfate, which was considered to have a relative bioavailability. On the other hand Leeson (2003) found that using trace minerals with greater bioavailability (Bioplex™ trace minerals) did not affect body weight gain and had little effect on feed efficiency of broilers even when fed at 20% of the inorganic trace mineral level. Rossi et al. (2007) indicated that organic Zn (Bioplex Zn) does not affect growth performance of broilers but increases resistance of skin to tearing, therefore improving carcass quality. These results are consistent with a previous report which showed that supplementing a basal diet with Zn from Availa®Zn, an amino acid zinc complex, improved feed conversion without altering growth rate (Burrell et al., 2004). The effect of replacing inorganic minerals with organic minerals on the immune response figures are illustrated in Table (3). Chicks fed inorganic minerals or 50% organic Fe were significantly recorded the lowest antibody titer against SRBC being, 7.76 or 8.24, respectively. However, no significant differences were recorded between the other treatments. Chicks fed on 100% organic-Zn were recorded the highest value of average antibody titer being, 9.02. However, the control fed inorganic mineral recorded the lowest value being, 7.76. Increasing the levels of organic minerals from 50% to 100% had no significant effect on the antibodies titer. Bartlett and Smith (2003) reported that high levels of organic zinc enhanced the immunocompetence of
broilers. Dibner (2005) reported that weights of the primary immune organs bursa and thymus in progeny respond to hen mineral nutrition and appear to benefit from organic forms of zinc (Zn). Progeny from hens fed Organic Trace Minerals (OTM) appear to have an advantage in cellular immunity after hatch compared to those fed Inorganic Trace Minerals (ITM). This has been shown for Zn with few other minerals being studied. He also found that benefits of feeding OTM during the immune response to a vaccination can be seen in specific antibody production and later, in resistance to a challenge. In the case of coccidiosis, a disease reported to be more detrimental in mineral deficient birds, the feeding of OTM gives better performance and Zn status following challenge. Richards et al. (2006) tested the antibody response to the coccidiosis vaccination; they reported that birds supplemented with MINTREX Zn (organic Zn) or MINTREX Cu (organic Cu) exhibited a significantly improvement in immune response and intestinal health benefits of broiler. Organic trace minerals were good vehicles to supply broilers with more trace minerals without increasing the dietary trace mineral levels. Adding more than 120 ppm of Zn from zinc oxide to the broiler diets did not further improve market-age broiler weight, feed conversion and antibody titers to SRBC (Abou El-Wafa et al., 2003). Shinde et al. (2006) concluded that supplementation of 20-ppm zinc significantly improved the immune response and impact was more prominent with the ZAAC (organic source) compared to ZnSO₄ (inorganic source). Antagonism between Zn and Cu can be avoided through using proteinated forms of these minerals. Same results observed by Khajarern et al. (2002) indicated that Newcastle disease virus, infectious bursal disease and infectious bronchitis titers were increased when hen diets were supplemented with organic Zn. Hudson et al. (2004) indicated that broiler breeder hens provided diets supplemented with zinc from ZnAA might have increased thymulin activity; therefore, enhancing immune responses through increased maturation of T lymphocytes and activation of B lymphocytes by T-helper cells. Although enhanced immune status of hens consuming ZnAA did not decrease the occurrence of mortality, parental immunity of progeny from hens consuming ZnAA may be improved.

The influences of different experimental dietary treatments on Economic Efficiency (EE) measured by feed cost/kg dressed weight relative to control of broiler chicks are summarized in Table 3. All treatments were recorded economical efficiency better than the control (IOM). However, Chicks fed on diets containing 100% OM recorded economical efficiency better than the control of broiler feeding. Shinde et al. (2006) who reported that Mn sources did not show significant differences between the experimental treatments on Economic Efficiency (EE) measured by feed cost/kg dressed weight relative to control of broiler. Chick mortality, parental immunity of progeny from hens consuming ZnAA did not decrease the occurrence of mortality, parental immunity of progeny from hens consuming ZnAA may be improved.

The effects of replacing inorganic minerals with organic minerals on tibia and muscles characteristics are shown in Table 4. Diets supplemented with organic minerals tended to improve tibia and muscles characteristics. These results in good agreement with Lu, et al. (2006) who reported that Mn sources did not affect pH, drip loss and share forces. The digestibility nutrients coefficients of the experimental diets are shown in Table 5. Addition of organic minerals had a tendency to increase the digestibility of most nutrients. Broiler chicks fed diets containing organic minerals excreted much lower concentration of all minerals. These results agreed with Nollet et al.
(2007) who reported that broiler fed organic mineral diets excreted much lower concentration of all minerals. Webb et al. (2005) reported that organic minerals that are chelated to small peptides have much greater bioavailability through increased selective transport of peptide at gut level. Chelated Fe has a bioavailability of 1.3-1.85 times of bioavailability of their inorganic form, inorganic salts can result in poor bioavailability of the peptide at gut level. Chelated Fe has a bioavailability and transfer to the enterocyte (Power, 2006). Use of organic salts can result in poor bioavailability of the mineral, primarily because of the numerous nutrient and ingredient antagonisms that impair absorption (Underwood and Suttle, 2001). These data are consistent with results reported by Wedekind et al.


Table 3: The influence of dietary organic mineral on broiler performance and immune response at 35 days

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Initial body weight*</th>
<th>Final average body weight</th>
<th>Feed gain, g/m</th>
<th>Feed intake, g/m</th>
<th>Mortality, %</th>
<th>Immune response</th>
<th>Relative economic efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% OTM</td>
<td>42.2 1618 ±16*</td>
<td>1576 ±16*</td>
<td>2823 ±22</td>
<td>1.74 ±0.2*</td>
<td>5.33 ±0.66</td>
<td>7.76 ±0.04*</td>
<td>100</td>
</tr>
<tr>
<td>100%OZn</td>
<td>42.2 1712 ±6.5*</td>
<td>1670 ±6.5*</td>
<td>2798±15</td>
<td>1.63 ±0.01*</td>
<td>3.30 ±1.60</td>
<td>8.95 ±0.34*</td>
<td>94</td>
</tr>
<tr>
<td>100%OCu</td>
<td>42.2 1690 ±2.8*</td>
<td>1648 ±2.8*</td>
<td>2813 ±14</td>
<td>1.66 ±0.01*</td>
<td>4.00 ±0.00</td>
<td>8.70 ±0.10*</td>
<td>95</td>
</tr>
<tr>
<td>100%O Mn</td>
<td>42.2 1684 ±3.6*</td>
<td>1642 ±3.6*</td>
<td>2803 ±14</td>
<td>1.66 ±0.01*</td>
<td>4.00 ±0.00</td>
<td>8.70 ±0.10*</td>
<td>95</td>
</tr>
<tr>
<td>100%O Fe</td>
<td>42.3 1689 ±4.5*</td>
<td>1646 ±4.5*</td>
<td>2785 ±12</td>
<td>1.67 ±0.01*</td>
<td>4.00 ±0.00</td>
<td>8.82 ±0.29*</td>
<td>95</td>
</tr>
<tr>
<td>100% OZn</td>
<td>42.1 1684 ±3.1*</td>
<td>1643 ±3.1*</td>
<td>2775 ±18</td>
<td>1.65 ±0.01*</td>
<td>4.00 ±0.10</td>
<td>8.44 ±0.05*</td>
<td>95</td>
</tr>
<tr>
<td>50%OZn</td>
<td>42.0 1651 ±3.3*</td>
<td>1609 ±3.3*</td>
<td>2799 ±11</td>
<td>1.69 ±0.03*</td>
<td>4.00 ±0.00</td>
<td>8.62 ±0.26*</td>
<td>96</td>
</tr>
<tr>
<td>50% O Cu</td>
<td>42.1 1692 ±4.4*</td>
<td>1649 ±4.4*</td>
<td>2803 ±11</td>
<td>1.66 ±0.01*</td>
<td>4.00 ±1.10</td>
<td>8.57 ±0.20*</td>
<td>95</td>
</tr>
<tr>
<td>50% O Mn</td>
<td>42.3 1683 ±5.6*</td>
<td>1641 ±5.6*</td>
<td>2826 ±28</td>
<td>1.68 ±0.01*</td>
<td>4.00 ±1.10</td>
<td>8.24 ±0.02*</td>
<td>96</td>
</tr>
<tr>
<td>Average</td>
<td>42.2 1677</td>
<td>1635</td>
<td>2803</td>
<td>1.67 ±0.01*</td>
<td>4.06 ±0.00</td>
<td>8.56 ±0.00</td>
<td>-</td>
</tr>
</tbody>
</table>

a,b, Means with different superscripts within the same column are significantly different (p = 0.05%). Negative control (IOTM) 100% inorganic minerals.

Table 4: The influence of dietary organic mineral on carcass, tibia and muscles characteristics at 35 days

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Carcass characteristics</th>
<th>Tibia characteristics</th>
<th>Muscles Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Dressing</td>
<td>Abdominal fat, %</td>
<td>Tibia length, mm</td>
</tr>
<tr>
<td>100% OTM</td>
<td>66.47±0.11*</td>
<td>23.5±0.07</td>
<td>109.0±0.17</td>
</tr>
<tr>
<td>100%OZn</td>
<td>67.63±0.14*</td>
<td>22.5±0.08</td>
<td>110.6±0.12</td>
</tr>
<tr>
<td>50%OZn</td>
<td>69.98±0.07*</td>
<td>22.6±0.03</td>
<td>110.3±0.03</td>
</tr>
<tr>
<td>50% O Cu</td>
<td>67.95±0.01*</td>
<td>22.7±0.20</td>
<td>109.6±0.20</td>
</tr>
<tr>
<td>50% O Mn</td>
<td>66.98±0.11*</td>
<td>22.6±0.12</td>
<td>110.2±0.12</td>
</tr>
<tr>
<td>Overall means</td>
<td>67.09</td>
<td>23.0</td>
<td>109.7</td>
</tr>
</tbody>
</table>

a,b, Means with different superscripts within the same column are significantly different (P = 0.05%). Negative control (IOTM) 100% inorganic minerals, OTM 100% organic minerals, 100% organic Zn (OZn), Organic Cu 100% (OCu), Organic Mn100%, Organic Fe 100%, O zn 50%, O Cu 50%, O Mn 50%, O Fe 50%. **WHT, water holding capacity**
It is concluded that inorganic minerals could be replaced completely or partially by organic mineral without any negative adverse on the performance, considering the negative impact of using organic minerals on environment. Organic minerals can be supplied to broiler diets at much lower levels than the current recommendations of inorganic minerals form without negative impact on broiler performance.

REFERENCES


