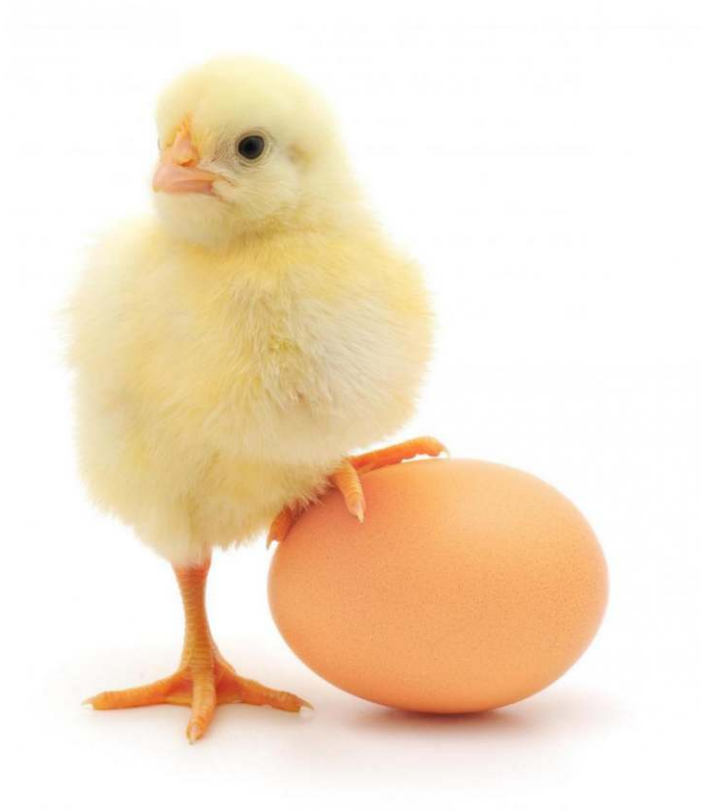
ISSN 1682-8356
ansinet.org/ijps



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 8 (3): 291-298, 2009
ISSN 1682-8356

Influence of Some Dietary Organic Mineral Supplementations on Broiler Performance

A.G. Abdallah[1], O.M. El-Husseiny[2] and K.O. Abdel-Latif[3]
[1]Animal Producation Research Institute, Ministry of Agriculture, Dokki, Egypt
[2]Department of Animal Producation, Faculty of Agriculture, Cairo University, Egypt
[3]El-Wafaa Farm Co., Tamouh, Giza, Egypt

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 trail 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 management 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 (1990). 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:

$$Yij = \mu + Ti + Eij$$

Where Yij = individual observation, μ = overall mean, Ti = the effect of treatments, Eij = the experimental random error.

Table 1: The experimental treatments

No	Abbr.	Treatment	Description	Chemical structure
1	100% IOTM	100% inorganic trace control	Inorganic trace minerals	Inorganic trace mineral in form of sulphate
2	100%OTM	100% organic trace control	100% organic, Zn, Cu, Mn, Fe	Bioplex- Zn, Cu, Mn and Fe
3	100%OZ	Organic Zn	100% organic Zn, the other minerals in inorganic forms.	Bioplex-Zn
4	100%O Cu	Organic Cu	100% organic Cu, the other minerals in inorganic forms.	Bioplex-Cu
5	100%O Mn	Organic Mn	100% organic Mn, the other minerals in inorganic forms.	Bioplex-Mn
6	100%O Fe	Organic Fe	100% organic Fe, the other minerals in inorganic forms.	Bioplex-Fe
7	50% OZn	Organic Zn	50% organic Zn, the other minerals in inorganic forms.	Bioplex-Zn
8	50% OCu	Organic Cu	50% organic Cu, the other minerals in inorganic forms.	Bioplex-Cu
9	50% OMn	Organic Mn	50% organic Mn, the other minerals in inorganic forms.	Bioplex-Mn
10	50% OFe	Organic Fe	50% organic Fe, the other minerals in inorganic forms.	Bioplex-Fe

Differences among treatments means were separated by Duncan's multiple rang 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 SO_4; 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% -100% had no significant effect on the antibodies titer. Bartlett and Smith (2003) reported that high levels of organic zinc enhanced the immunocompetence of

Table 2: The Composition and chemical of the basal diets

Ingredients	Starter% 1-18 days	Grower% 19- 35 days
Yellow corn	57.93	59.625
Soybean meal (48%)	35.00	32.45
Corn oil	3.0	4.00
Di-calcuim phoshate	1.7	1.50
Salt (Na Cl)	0.35	0.35
Premix[1]	0.20	0.20
Limestone	1.30	1.40
DL- Met. 99%	0.22	0.175
L- Lys-HCL. 78.4%	0.20	0.20
Choline chloride 50%	0.10	0.10
Total	100	100
Calculated:		
Crude protein %	22.16	21.06
Metabolizable energy (ME Kcal/Kg diet)	3075	3155
Crude Fiber%	2.77	2.69
Crude Fat%	4.89	5.69
Total P%	0.78	0.73
Available P%	0.46	0.42
Calcium %	1.04	1.02
Lysine %	1.33	1.25
Methionine %	0.54	0.48
Methionine + Cystine %	0.89	0.82
Threonine%	0.84	0.80
Tryptophan%	0.26	0.25
Arginine%	1.47	1.39
Isoleucine%	0.98	0.93
Na%	0.16	0.18
Price/kg (LE)2	1.490	1.470

[1]Each 2 kg of Vit. and Min. Mixture contains: Vit. A 12000,000 IU, Vit. D_3 2200,000 IU, Vit. E 10,000 mg, Vit. k_3 2000 mg, Vit. B_1 1000 mg, Vit. B_2 5000 mg, Vit. B_6 1500 mg, Vit. B_{12} 10 mg, Pantothenic acid 10,000 mg, Niacin 30,000 mg, Folic acid 1000 mg, Biotin 50 mg, Manganese 100,000 mg, Zinc 80,000 mg, Copper 10,000 mg, Iron 50,000, Iodine 1000 mg, Selenium 300 mg, Cobalt 100 mg, Ca CO_3 to 2,000 gm.

[2]LE, Egyptian pound, 1 U$ equal 5.40 LE.

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 $ZnSO_4$ (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 achieved the best economical efficiency 94%.

Percentages of dressing and abdominal fat for chicks fed different treatments are presented in Table 4. No significant differences between the experimental treatment, with a little bit high dressing percentages when feeding diets with 100% OM and 50% OFe. Receiving diet with 100% OM recorded the lowest value of abdominal fat, being, 2.25 without significant differences between the other treatments. These results agreed closely with Lu, *et al.* (2006) who reported that birds fed supplemental organic Mn had numerically lower percentages of abdominal fat.

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.*

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

Treatment	Initial body weight^{1}, gm	Final average body weight, gm	Body weight gain, gm	Feed intake, gm	Feed conversion, g/g	Mortality, %^{2}	Immune response	Relative economic efficiency^{3}
100% IOTM	42.2	1618 ±16^{d}	1576 ±16^{d}	2823 ±22	1.74±0.02^{a}	5.33 ±0.66	7.76±0.04^{c}	100
100%OTM	42.1	1712 ±6.5^{a}	1670 ±6.5^{a}	2799±18	1.63 ±0.01^{d}	3.30±1.60	8.95±0.34^{ab}	94
100%OZn	42.2	1690 ±2.8^{ab}	1648 ±2.8^{ab}	2813 ±14	1.66 ±0.01^{bcd}	4.00 ±0.00	9.02±0.31^{a}	95
100%O Cu	42.2	1684 ±3.6^{abc}	1642 ±3.6^{abc}	2803 ±14	1.66 ±0.01^{bcd}	4.00 ±0.00	8.70±0.10^{ab}	95
100% O Mn	42.3	1689 ±4.5^{ab}	1646 ±4.5^{ab}	2795 ±8.2	1.65 ±0.01^{cd}	4.62±0.00	8.82±0.29^{ab}	95
100% O Fe	42.1	1684 ±3.1^{abc}	1641 ±3.1^{abc}	2775 ±13	1.65 ±0.01^{cd}	4.00±1.20	8.44±0.05^{ab}	95
50% OZn	42.0	1651 ±27^{c}	1609 ±27^{c}	2799 ±2.6	1.69 ±0.03^{b}	4.00 ±0.00	8.62±0.26^{ab}	96
50% OCu	42.2	1668 ±1.6^{bc}	1626 ±1.6^{bc}	2789 ±18	1.67 ±0.01^{bcd}	4.00 ±1.10	8.50±0.11^{ab}	96
50% OMn	42.1	1692 ±4.4^{ab}	1649 ±4.4^{ab}	2813±11	1.66 ±0.01^{bcd}	4.00±1.10	8.57±0.20^{ab}	95
50% OFe	42.3	1683 ±5^{abc}	1641 ±5^{abc}	2826±28	1.68 ±0.01^{bc}	4.00±1.10	8.24±0.02^{bc}	96
Average	42.2	1677	1635	2803	1.67 ±0.01^{b}	4.06	8.56	-
Probability		0.0004	0.0004	0.5491	0.0010	0.9265	0.0251	-

a,b, Means with different superscripts within the same column are significantly different (p = 0.0 5%). 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%. [1]Initial body weight at 0 days was 42gm±S.E, [2] Mortality rate of the whole experiment was 4.06% (61/1500). [3]Assuming that the relative EE of control equal 100, economic efficiency as measured by feed cost/kg dressed weight.

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

	Carcass characteristics				Tibia Characteristics				Muscles Characteristics		
Treatments	Dressing, %	Abdominal fat, %	Tibia length, mm	Tibia weight, gm	Tibia diameter, mm	Tibia Ash, %	Tibia Ca, %	Tibia phosphorus,%	pH	Color	WHC^{1}
100% IOTM	66.47± 0.11^{bc}	2.35± 0.02	109.0± 0.57	7.66± 0.17	11.30± 0.20	46.00^{c}± 0.38	20.20± 0.08	9.96± 0.12	6.71± 0.26	0.267± 0.001	5.68± 0.13
100%OTM	67.63± 0.14^{a}	2.25± 0.04	110.6± 0.88	7.76± 0.12	11.46± 0.14	47.50^{a}± 0.21	20.86± 0.08	10.30± 0.06	6.72± 0.02	0.265± 0.0003	6.07± 0.32
100%OZn	66.98± 0.07^{b}	2.28± 0.03	110.3± 0.30	7.76± 0.20	11.06± 0.30	46.70^{abc}± 0.17	20.46± 0.31	10.03± 0.23	6.81± 0.05	0.267± 0.001	5.70± 0.03
100%OCu	67.05± 0.11^{b}	2.27± 0.02	109.6± 1.20	7.73± 0.18	11.00± 0.15	47.06^{ab}± 0.08	20.46± 0.23	10.23± 0.08	6.72± 0.06	0.268± 0.004	5.68± 0.01
100%OMn	66.98± 0.13^{b}	2.26± 0.03	110.0± 0.57	7.73± 0.12	11.23± 0.12	46.90^{ab}± 0.26	20.60± 0.26	10.06± 0.14	6.72± 0.02	0.268± 0.002	6.07± 0.32
100%OFe	66.93± 0.10^{a}	2.28± 0.03	109.0± 0.57	7.70± 0.12	11.30± 0.26	46.66^{abc}± 0.13	20.46± 0.03	10.06± 0.20	6.78± 0.11	0.267± 0.001	5.66± 0.03
50%OZn	66.67± 0.12^{bc}	2.28± 0.08	109.0± 0.15	7.73± 0.26	11.16± 0.20	47.30^{a}± 0.15	20.86± 0.08	10.06± 0.20	6.77± 0.015	0.268± 0.001	5.68± 0.01
50%OCu	67.01± 0.07^{b}	2.29± 0.02	110.0± 1.52	7.66± 0.23	10.96± 0.16	46.36^{bc}± 0.24	20.40± 0.30	10.03± 0.23	6.66± 0.03	0.269± 0.003	5.71± 0.03
50%OMn	66.87± 0.2^{bc}	2.38± 0.04	109.6± 0.80	7.83± 0.06	10.96± 0.14	46.36^{bc}± 0.40	20.50± 0.30	9.86± 0.23	6.73± 0.03	0.271± 0.003	5.69± 0.01
50%OFe	66.77± 0.13^{bc}	2.37± 0.07	110.0± 0.57	7.86± 0.14	11.10± 0.20	46.76^{abc}± 0.12	20.63± 0.17	10.06± 0.20	6.73± 0.12	0.268± 0.001	5.69± 0.01
Overall means	67.09	2.30	109.7	7.74	11.15	46.76	20.55	10.09	6.73	0.268	5.76
Probability	0.0001	0.4189	0.909	0.971	0.737	0.0118	0.584	0.782	0.894	0.957	0.314

a,b, Means with different superscripts within the same column are significantly different (P=0.0 5 %). 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%. [1]WHC, water holding capacity

(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, whereas Mn bioavailability is 1.2 times of the bioavailability of its sulfate and chelated Zn increased broiler tibia mineral levels by 35% more than inorganic form (Bruerton, 2005). The higher bioavailability of chelated may be linked to the shielding of the minerals positive charge during chelation. This allows the mineral to withstand the binding activity of the negative charged mucin layer and results in lower competition between minerals of similar charge in their resorption from gut and transfer to the enterocyte (Power, 2006). Use of inorganic 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 5: The influence of dietary organic mineral on digestion coefficients of the nutrients and fecal mineral excretion at 28 days

	Digestion coefficients of the nutrients						Fecal mineral excretion			
Treatment	DM, %	OM, %	CF, %	EE, %	CP, %	NFE, %	Cu, mg/kg	Mn, mg/kg	Zn, mg/kg	Fe, mg/kg
100% IOTM	78.53±0.33^{b}	78.63±0.33^{c}	27.13±0.55^{b}	73.68±0.56^{b}	90.20±0.11^{b}	79.22±0.58^{b}	62.1	272.1	236.4	561.2
100%OTM	81.66±0.12^{a}	80.94±0.14^{ab}	29.66±0.26^{b}	79.20±0.40^{a}	93.00±0.30^{a}	81.65±0.40^{a}	38.2	187.2	186.1	451.1
100%OZn	80.70±0.55^{a}	80.39±0.51^{ab}	28.47±0.43^{ab}	76.52±0.59^{c}	91.60±0.76^{ab}	80.63±0.50^{ab}	64.2	273.2	186.3	561.2
100%O Cu	80.73±0.49^{a}	79.87±0.33^{bc}	28.83±0.03^{ab}	77.43±0.44^{bc}	91.76±0.49^{ab}	81.28±0.45^{ab}	39.3	270.5	237.5	562.3
100%O Mn	80.10±0.68^{a}	80.40±0.57^{ab}	29.18±1.03^{a}	77.29±0.13^{a}	91.80±0.84^{ab}	80.65±0.85^{ab}	63.1	189.7	236.2	560.1
100%O Fe	80.50±0.10^{a}	81.36±0.65^{ab}	28.83±0.17^{ab}	79.50±0.30^{a}	92.14±1.12^{ab}	81.03±0.81^{ab}	61.2	269.9	234.8	453.3
50% OZn	80.16±0.77^{a}	81.53±0.45^{a}	29.60±0.93^{a}	78.70±0.60^{ab}	92.20±0.40^{ab}	80.27±0.63^{ab}	64.2	272	126.3	562.8
50% OCu	80.23±0.23^{a}	80.96±0.46^{ab}	28.73±0.27^{ab}	79.33±0.26^{a}	91.84±0.87^{ab}	80.70±0.84^{ab}	25.2	270.3	235	562
50% OMn	80.50±0.51^{a}	81.53±0.44^{a}	29.40±0.60^{a}	79.06±0.68^{a}	91.86±0.52^{ab}	80.27±0.63^{ab}	64.2	141.2	236	561.5
50% OFe	80.66±0.20^{a}	80.90±0.40^{ab}	28.73±0.20^{ab}	78.50±0.53^{ab}	90.80±0.17^{b}	80.73±0.66^{ab}	63.3	270	235.8	326.5
Average	80.38	80.65	28.96	77.95	91.72	80.64				
Probability	0.0228	0.0059	0.1417	0.0001	0.2475	0.4693				

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%.

(1992) who found the relative bioavailability of an organic zinc source to be 177% relative to zinc sulfate. Leeson, 2003 reported that organically complexed trace minerals provide alternative pathways for absorption, thus leading to a reduction in the excretion of minerals. Bao *et al.* (2007) reported that at lower supplemental levels, the organically complexed trace minerals were adequate to support optimum broiler chicken performance at reasonable rates of excretion. One of the possible reasons of high availabilty of organic trace minerals that there are less chelating or other unwanted reactions with dietary constituents in the gastrointestinal tract for organic mineral complexes compared with those for inorganic minerals (Ammerman *et al.*, 1998). Many studies have been carried out on the use of organic trace minerals, as these present higher bioavailability and are transported more easily and stored for longer periods of time than its inorganic counterparts (Maiorka and Macari, 2002). Wang *et al.* (2007) reported that Mintrex®Cu has approximately 10-11% greater biological availability than reagent grade Cu sulfate for broilers. According to the authors, use of MintrexCu at adjusted dietary Cu levels should reduce fecal excretion of Cu in broilers. Dobrzanski *et al.* (2008) concluded that in comparison to inorganic forms (copper sulfate and manganese oxide) manganese and copper were significantly better available from used in poultry feeding *Saccharomyces cerevisiae* dried yeast enriched in bioelements. Moreover, it was found that iron availability from YFe and from inorganic form (iron sulfate) was on the same level.

Conclusion: 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

Abou El-Wafa, S.A., M.A. Sayed, S.A. Ali and A.G. Abdallah, 2003. Performance and immune response of broiler chicks as affected by methionine and zinc or commercial zinc-methionine supplementations. Egypt Poult. Sci., 23: 523-540.

Abou-Raya, A.K. and A.G.H. Galal, 1971. Evaluation of poultry feeds in digestion trials with reference to some factors involved. A. R. E. J. Anim. Prod., 11: 207-221.

Aitken, A., J.C. Casey, I.F. Peamy and C.A. Voyls, 1962. Effect of drying of pork. J. Sci. Fd. Agric., pp: 13: 439.

Ammerman, C.B., P.R. Henry and R.D. Miles, 1998. Bioavailability of organic forms of the microminerals. Proceedings of the 9th Annual Florida Ruminant Nutrition Symposium. Gainesville, Florida, p: 33-49.

Association of Official Analytical Chemists, A.O.A.C., 1990. Official methods of analysis. 15th Ed. Published by the AOAC., Washington, D. C., USA.

Bachman, S.E. and M.M. Mashaly, 1986. Relation between circulating thyroid hormones and humoral immunity in immature male chicken's .De Comp. Immunol.,10: 395.

Bao, Y.M., M. Choct, P.A. Iji and K. Bruerton, 2007. Effect of Organically Complexed Copper, Iron, Manganese and Zinc on Broiler Performance, Mineral Excretion and Accumulation in Tissues. J. Appl. Poult. Res., 16: 448-455.

Bartlett, J.R. and M.O. Smith, 2003. Effects of different levels of zinc on the performance and Immunocompetence of broilers under heat stress. Poult. Sci., 82: 1580-1588.

Bruerton, 2005. Novel approaches to improving poultry meat production: Do organic minerals have a role? Pages 179-186 in Redefining Mineral Nutrition. J. A. Taylor-Pickard and L. A.Tucker, ed. Nottingham Univ. Press, Nottingham, UK.

Burrell, A.L., W.A. Dozier III, A.J. Davis, M.M. Compton, M. E. Freeman, P.F. Vendrell and T.L. Ward, 2004. Responses of broilers to dietary zinc concentrations and sources in relation to environmental implications. Br. Poult. Sci., 45: 255-263.

Cao, J., P.R. Henry, R. Guo, R.A. Holwerda, J.P. Toth, R.C. Littell, R.D. Miles and C.B. Ammerman, 2000. Chemical characteristics and relative bioavailability of supplemental organic zinc sources for poultry and ruminants. J. Anim. Sci., 78: 2039-2054.

Dibner, J., 2005. Early nutrition of zinc and copper in chicks and poults: Impact on growth and immune function. Pages 23-32 in Proc. Mid-Atl. Nutr. Conf. Timonium, MD.

Dieck, H.T., F. Doring, H.P. Roth and H. Daniel, 2003. Changes in rat hepatic gene expression in response to zinc deficiency as assessed by DNA arrays. J. Nutr., 133: 1004-1010.

Dobrzañski, Z., S. Opaliñski, H. Górecka, M. Korczyñski, R. Kolacz and T. Trziszka, 2008. Bioavalability of Fe, Cu and Mn from yeast enriched in biolements used in laying hens feeding. Electronic J. Polish Agric. Universities, 11: # 12.

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

Henry, P.R., C.B. Ammerman and R.D. Miles, 1986. Bioavailability of manganese sulfate and manganese monoxide in chicks as measured by tissue uptake of manganese from conventional dietary levels. Poult. Sci., 65: 983-986.

Hudson, B.P., W.A. Dozier, III, J.L. Wilson, J.E. Sander and T.L. Ward, 2004. Reproductive Performance and Immune Status of Caged Broiler Breeder Hens Provided Diets Supplemented with Either Inorganic or Organic Sources of Zinc from Hatching to 65 wk of Age. J. Appl. Poult. Res., 13: 349-359.

Husani, S.A., F.B. Deatherage and L.E. Kunlkle, 1950. Studies on meat energy, protein and lysine content on performance and yield of two strains of male broiler chicks. Poult. Sci., 71: 872-879.

Jakobson, P.E., S.G. Kirsten and S.H. Nelson, 1960. Digestibility trails with poultry. 322 berthing fraforsgs laboratories, Udgivet of Stants. Husdyrbugsud Valy-Kobenhavn.

Kai, O.H., N. Nagase, M. Ishikawa, K. Suzuki and K. Sato, 1988. Effects propylthiouracial (PTU) on the immunological status of the chickens. Develop. Comp. Immunol., 12: 145.

Khajarern, J., C. Ratanasethakul, S. Kharajarern, T.L. Ward, T.M. Fakler and A.B. Johnson, 2002. Effect of zinc and manganese amino acid complexes (AvailaZ/M) on broiler breeder production and immunity. Poult. Sci. ,81(Suppl. 1):40 (Abstr.).

Leeson, S., 2003. A new look at trace mineral nutrition of poultry: Can we reduce the environmental burden of poultry manure? Pages 125-129 in Nutritional Biotechnology in the Feed and Food Industries. Proc. Alltech's 19th Annu. Symp. T. P. Lyons and K. A. Jacques, Ed. Nottingham Univ. Press, Nottingham, UK.

Leeson, S., 2005. Trace mineral requirements of poultry -validity of the NRC recommendations. In: Tucker, L. A., Taylor-Pickard, J.A., Re-defining Mineral Nutrition. Nottingham University Press, Nottingham, UK, PP: 107-117.

Lu, L., C. Ji, X.G. Luo, B. Liu and S.X. Yu, 2006. The effect of supplemental manganese in broilers diets on abdominal fat deposition and meat quality. Anim. Feed Sci. Technol., 129: 49-59.

Maiorka, A. and M. Macari, 2002. Absorção de minerais In: Macari M; Furlan, RL, GonzalesE. Fisiologia aviária aplicada a frangos de corte. 2ed. Jaboticabal: Funep/Unesp, p. 167-174.

Mohanna, C. and Y. Nys, 1999. Effect of dietary zinc content and sources on the growth, body zinc deposition and retention, zinc excretion and immune response in chickens. Br. Poult. Sci., 40:108-114.

Nollet, L., G. Huyghebaert† and P. Spring, 2008. Effect of Different Levels of Dietary Organic (Bioplex) Trace Minerals on Live Performance of Broiler Chickens by Growth Phases. J. Appl. Poult. Res., 17: 109-115.

Nollet, L., J.D. van der Klis, M. Lensing and P. Spring, 2007. The Effect of Replacing Inorganic With Organic Trace Minerals in Broiler Diets on Productive Performance and Mineral Excretion. J. Appl. Poult. Res., 16: 592-597.

Paik, I., 2001. Application of chelated minerals in animal production. Asian-Aust. J. Anim. Sci., 14: 191-198.

Pimentel, J.L., M.E. Cook and J.L. Greger, 1991. Bioavailability of zinc-methionine for chicks. Poult. Sci., 70: 1637-1639.

Power, R., 2006. Organic mineral absorption: Molecular mimicry or modified mobility. Pages 228-235 in Nutritional Biotechnology in the Feed and Food Industries, Proceedings of the 22th Annual Symposium. T. P. Lyons and K. A. Jacques, Ed. Nottingham Univ. Press, Nottingham, UK.

Richards, J., T. Hampton, C. Wuelling, M. Wehmeyer and J. J. Dibner, 2006. Mintrex Zn and Mintrex Cu organic trace minerals improve intestinal strength and immune responses to coccidiosis infection and/or vaccination in broilers. Proc. 2006 Int. Poult. Sci. Forum, Atlanta, GA. US Poult. Egg Assoc. Tucker, GA.

Rossi, P., F. Rutz, M.A. Anciuti, J.L. Rech and N.H.F. Zauk, 2007. Influence of Graded Levels of Organic Zinc on Growth Performance and Carcass Traits of Broilers. J. Appl. Poult. Res., 16: 219-225.

SAS, 1996. Statistical Analysis System 9th Ed. Users Guide. Static's. SAS Instant. Cary, North Carolina.

Sacranie, A., 2003. At the cutting edge. Asia-Pacific Poultry Newsletter. Alltech., V.2 n.3.

Shinde, P., R.S. Dass, A.K.Garg, V.K. Chaturvedi and R. Kumar, 2006. Effect of zinc supplementation from different sources on growth, nutrient digestibility, blood metabolic profile and immune response of male guinea pigs. Biological Trace Element Research, 12: 247-262.

Underwood, E. and N. Suttle, 2001. The Mineral Nutrition of Livestock. CABI Publishing, London, UK.

Van Der Klis, J.D. and A. D. Kemme, 2002. An appraisal of trace elements: Inorganic and organic, pp: 99-108. in Poultry Feedstuffs: Supply, Composition and Nutritive Value. J. M. McNab and K. N. Boorman, Ed. CAB Int., Wallingford, UK.

Volovinskaia, V.P. and B.Y. Kelman, 1962. Modification of the water holding capacity method of meat F.D. industry, 11: 80 Moscow.

Wang, Z., S. Cerrate, C. Coto, F. Yan and P.W. Waldroup. 2007. Evaluation of Mintrex® copper as a source of copper in broiler diets. Int. J. Poult. Sci., 6: 308-313.

Webb, K.E., E.A. Wong, Y.-X. Pan, H. Chen, C.A. Poole, L. Van and J. E. Klang, 2005. The role of peptides in absorption pathways. pp: 197-225 in Redefining Mineral Nutrition. J. A. Taylor-Pickard and L. A. Tucker, Ed. Nottingham Univ. Press, Nottingham, UK.

Wedekind, K.J., A.E. Hortin and D.H. Baker, 1992. Methodology for assessing zinc bioavailability: Efficacy estimates for zincmethionine, zinc sulfate and zinc oxide. J. Anim. Sci., 70: 178.

Xia, M.S., C.H. Hu and Z.R. Xu, 2004. Effects of copper-bearing montmorillonite on growth performance, digestive enzyme activies and intestinal microflora and morphology of male broilers. Poult. Sci., 83: 1868.