Inorganic vs Bioplex trace minerals for broilers: effects on performance and mineral excretion

M. LIPPENS[(1)], G. HUYGHEBAERT[(1)*] and L. NOLLET[(2)]

[(1)] The Flemish Community, ILVO-Unit Animal Science, B-9090 Melle, Belgium. [(2)] Alltech Biotechnology Centre, Dunboyne co Meath, Ireland
***Corresponding author : gerard.huyghebaert@ilvo.vlaanderen.be**

It is a well known fact that the latest NRC requirements for trace mineral nutrition for poultry of 1994 is mainly based on quite a limited number of trials of which some were conducted already 60 years ago. Changes in genetics and more highly bioavailable trace mineral sources have led to uncertainty as to the optimum levels and forms for trace mineral inclusion in broiler diets. A broiler study designed to address these issues consisted of 7 treatments: (A) negative control diet without any added trace minerals, (B) a positive control diet with inorganic trace minerals added at 15 ppm Cu and 60 ppm Zn, Fe and Mn (Zn and Mn as oxides, Fe and Cu as sulphates), (C) a diet with organic trace minerals added at 2.5 ppm Cu and 10 ppm Zn, Fe and Mn as Bioplex (Alltech Inc.), (D-G) 4 diets containing a 2, 3, 4 and 6-fold higher "organic" trace mineral content than added to diet C, respectively.
At 21 days of age, body weight and feed conversion were significantly worse on the negative control (A) compared to all other treatments. The highest body weights were noted at the higher dietary concentrations of added Bioplex trace minerals (794 g), being not significantly different from the positive control on inorganic trace minerals (774 g) but significantly different from the treatment with the lowest inclusion levels of Bioplex trace minerals (761 & 744 g for treatments C & D, resp.). A similar pattern was found for feed conversion, with the response on the highest inclusion level of Bioplex trace minerals (G) being significantly better than on the negative and positive control and the lowest inclusion level of Bioplex trace minerals (C). At 42 days of age, body weight in all treatments receiving additional trace minerals was between 50 to 90 g heavier compared to the negative control. There were no significant differences in feed conversion for the entire period. The excretion of the trace minerals depended clearly on dietary treatment. The excetra levels of the trace minerals was clearly higher on the positive than on the negative control. The trace mineral excretion was significantly lower (P<0.01) at the lowest dosage of organic trace minerals than on the positive control (treatment B). The reduction in trace mineral excretion was most pronounced for (1) treatment C with of 2.5 ppm Cu and 10 ppm Zn, Fe and Mn (resp. 59.2, 53.4, 20.8 & 43.9% lower vs the positive control on inorganic trace minerals) and (2) treatment D with 5 ppm Cu and 20 ppm Zn, Fe and Mn (resp. 68.7, 54.2, 34.9 & 61.5% lower vs the positive control on inorganic trace minerals).
It could be concluded from this trial that reduction of trace minerals levels in broiler feed by using Bioplex at levels of 2.5 ppm Cu and 10 ppm Zn, Fe and Mn had no negative impact on performance thereby resulting in a considerable reduction in the trace mineral excretion. In particular, feeding higher levels of Bioplex minerals during the first days/weeks of age seems to exert a positive effect on performance.

Keywords : broilers; trace minerals; mineral excretion

Introduction

Minerals and trace minerals are essential in animal feeds to ensure optimal health, welfare and growth of animals. However, trace mineral needs of poultry have received little attention over the last 40 years compared to other aspects of nutrition, such as energy and amino acids. Moreover, intensive research has been conducted looking at the balance of nitrogen and phosphorus in poultry nutrition, together with the attempts to limit their concentration in manure. It seems inevitable that regulatory concerns will be raised about the level of other chemicals in manure, one of which will be the trace minerals. In other words, it seems inevitable that trace mineral levels in poultry diets will come under closer scrutiny, and providing amounts excess to requirements will have to be avoided.

The current used information to determine the requirements of the trace minerals are based on the NRC dating from 1994. A concern often raised about these values is the somewhat historical data they are based on. With changes in genetics of broilers with dramatic changes in their performance on the one hand and more highly bioavailable trace mineral sources on the other hand, the validity of such historic data can be questioned.

There is a wealth of information describing the mineral bioavailability from various salts. In general, sulphates are thought to have higher bioavailability than do their oxides (Ledoux et al., 1991; Smith et al., 1994; Pesti and Bakalli, 1996). To date this has not been a major concern since the obvious solution has been to over-formulate to ensure requirements. However, if there is need to minimize trace mineral excretion in manure, then we need greater confidence in bioavailability of 'reduced' diet inclusions. Furthermore, the increase in bioavailability could result in decreased excretion of the mineral into the waste, which will reduce environmental impact.

A trial is conducted to look at the effect of feeding different levels of organic and inorganic trace minerals on the performance and the mineral excretion in broilers.

Materials and methods

A block experiment was set up which consisted of 7 treatments (*Table 1*). Treatment A consisted of a negative control diet without any added trace minerals. Treatment B, a positive control diet, was supplemented with inorganic trace minerals at 15 ppm Cu and 60 ppm Zn, Fe and Mn (Zn and Mn as oxides, Fe and Cu as sulphates). Treatment C was a diet with organic trace minerals added at 2.5 ppm Cu and 10 ppm Zn, Fe and Mn as Bioplex (Alltech Inc.). The treatments D-G were 4 diets containing a 2, 3, 4 and 6-fold higher "organic" trace mineral content than added to diet C, respectively. Each treatment consisted of 7 replicates with 36 Ross 308 broilers (50 % males/50 % females). The total number of birds was (49*36) = 1764.

Broilers were kept on floor pens on a mixture of cutted straw and peat at a stocking density of 17 animals per m². A convential lighting schedule (23L/1D) and temperature schedule were used. The global composition of the starter (1-10 days), grower (11-21 days), finisher (22-42 days) diets is given in *Table 2*. All birds received feed (meal) and water *ad libitum*.

At day 37, excreta samples were collected overnight by using collecting trays covered with lattice-work. After removal of the non faecal material, faeces were dried analysed on Fe, Cu, Mn and Zn-contents.

Table 1 Level and form of the supplemented trace minerals

Added mineral		**Treatment (ppm)**						
		A	B	C	D	E	F	G
Fe	FeSulphate 30%		60					
Mn	MnOxide 62 %		60					
Cu	CuSulphate 25 %		15					
Zn	ZnOxide 79 %		60					
Fe	Bioplex Fe			10	20	30	40	60
Mn	Bioplex Mn			10	20	30	40	60
Cu	Bioplex Cu			2.5	5	7.5	10	15
Zn	Bioplex Zn			10	20	30	40	60

Table 2 Composition of the respective experimental diets.

	Starter (1-10 d)[1]	Grower (11-21 d)[1]	Finisher (22-42 d)[2]
Feedstuffs			
Wheat	39.92	59.14	59.45
Soybean meal-46+2	20	18.86	14.43
Corn	20.00	0.00	0.00
Full fat soybeans	14.05	12.98	16.07
R. animal fat	2.46	6.00	7.00
Ca-carbonate	0.85	0.76	0.76
Di-Ca phosphate	1.23	0.83	0.85
L-lys. HCl	0.28	0.25	0.26
DL-methionine	0.27	0.24	0.24
Threonine	0.12	0.11	0.11
NaCl	0.33	0.33	0.33
Vit. & Tr. El. Premix[4]	0.50	0.50	0.50
Nutrients			
MEn, MJ/kg	11.60	12.15	12.55
Cprotein, %	20.9	20.4	19.5
Cfat, %	6.8	9.6	11.1
Starch	37.4	36.1	36.2
Crude fibres	3.4	3.3	3.2
$Lys._{ad}$, %[3]	1.11	1.06	1.02
S amino $acids_{ad}$/ $Lys._{ad}$	0.73	0.73	0.73
$Thr._{ad}$/ $Lys._{ad}$	0.65	0.65	0.65
$Trypt._{ad}$/ $Lys._{ad}$	0.20	0.20	0.20
Ca, %	0.86	0.72	0.72
$P_{av.}$, %	0.45	0.38	0.38

[1] containing 200 g/ton Clinacox 0.5% (1 ppm Diclazuril)
[2] containing 500 g/ton Elancoban (11 ppm Monensin) except for the withdrawal period (36-42 days of age)
[3] ad = apparent digestible
[4] provided (mg/kg of diet): retinol, 12500 (IU/kg); cholecalciferol, 2500 (IU/kg); tocopherol, 50; menadione, 3; thiamin, 2; cholinechlorid, 500; riboflavin, 5; panthothenic acid, 30; pyridoxine, 3, cyanocobalamin, 0.03*;* nicotonic acid, 15*;* folic acid, 1; biotin, 0.1; I, 2; Co, 1; phytase, 500 U. Minerals see Table 1.

Results and discussion

The results of the starter period (1-10 days of age) are summarised in *Table 3*. In this period, treatments had a significant effect on the zootechnical performances of the birds. Except for the treatments D and G, mean growth rates were higher compared to the negative control (treatment A). However, only for treatment E and F, growth rates were significantly better compared to the negative control (+ 15.5 % and + 19.3 %, respectively). Similar results were found for daily feed intake (+ 8.2 and + 9.7 % for treatment E and F against the negative control, respectively) and feed conversion (- 6.6 % and - 8.4 %, respectively). Treatment F even had a significantly better growth rate and higher daily feed intake compared to the treatment with the inorganic mineral sources (+ 10.9 % and + 6.4 %, respectively).

At 21 days of age (*Table 4*), body weight and feed conversion were significantly worse on the negative control (A) compared to all other treatments. The highest body weights were noted at the higher dietary concentrations of added Bioplex trace minerals (treatment F and G), being only significantly different from the treatment with the lowest inclusion levels of Bioplex trace minerals (treatments C & D). A similar pattern was found for feed conversion (1-21 days of age), with the response on the highest inclusion level of Bioplex trace minerals (G) being significantly better than on the negative and positive control and the lowest inclusion level of Bioplex trace minerals (C).

No significant effects on growth rate are found during the finisher period (22-42 days of age; *Table 5*). Final body weights in all treatments receiving additional trace minerals was between 50 to 90 g higher compared to the negative control birds (treatment A). Differences were statistically significant for treatment B and G (+ 3.7 % and + 3.0 %, respectively). There were no significant differences in feed conversion for the entire period.

The excretion of the trace minerals was significantly influenced by treatments (*Table 6*). The reduction in trace mineral excretion was most pronounced for treatment C, supplemented with 2.5 ppm

Cu and 10 ppm Zn, Fe and Mn, being 59.2, 53.4, 20.8 & 43.9% lower vs the positive control on inorganic trace minerals, respectively. This is followed by treatment D (5 ppm Cu and 20 ppm Zn, Fe and Mn) with a respective reduction in excretions of 68.7, 54.2, 34.9 & 61.5% vs the positive control on inorganic trace minerals.

It could be concluded from the current trial that levels of trace minerals in broiler feed can be reduced to levels of 2.5 ppm Cu and 10 ppm Zn, Fe and Mn by using Bioplex without any negative impact on performance thereby resulting in a considerable reduction in the trace mineral excretion. In particular, feeding higher levels of Bioplex minerals during the first days/weeks of age seems to exert a positive effect on performance.

Table 3 Effect of the different mineral supplementations on the zootechnical performances of the broilers in the starter period (1-10 days of age)

	BW-1d g	BW-10 d g	Daily feed intake (g/a/d)	Growth (g/a/d)	FC
Anova					
Diet (n=7)	0.844	0.000	0.000	0.000	0.001
LSD m.r. test					
A	41.6	228^{cd}	25.7^{cd}	18.7^{cd}	1.379^{cd}
B	41.6	242^{bc}	26.5^{bc}	20.1^{bc}	1.332^{abc}
C	41.6	234^{c}	26.0^{c}	19.3^{c}	1.352^{bcd}
D	41.5	215^{d}	24.5^{d}	17.3^{d}	1.418^{d}
E	41.4	257^{ab}	27.8^{ab}	21.6^{ab}	1.288^{ab}
F	41.4	265^{a}	28.2^{a}	22.3^{a}	1.263^{a}
G	41.3	228^{cd}	26.0^{c}	18.6^{cd}	1.395^{cd}
SEM	0.1	3	0.2	0.3	0.012

[1] averages with the same subscript are not significantly different from each other at p=0.05

Table 4 Effect of the different mineral supplementations on the zootechnical performances of the broilers in the grower period (11-21 days of age) and the period 1-21 days of age.

	BW-21 d g	Daily feed intake (g/a/d) 11-21 d	Growth (g/a/d) 11-21 d	FC 11-21 d	Daily feed intake (g/a/d) 1-21 d	Growth (g/a/d) 1-21 d	FC 1-21 d
Anova							
Diet (n=7)	0.000	0.004	0.000	0.000	0.000	0.000	0.000
LSD m.r. test							
A	707^{d}	71.4^{c}	43.5^{c}	1.647^{d}	49.5^{cd}	31.7^{d}	1.566^{c}
B	774^{abc}	74.1^{ab}	48.4^{b}	1.533^{c}	51.3^{ab}	34.9^{abc}	1.470^{b}
C	761^{bc}	72.0^{bc}	47.9^{b}	1.506^{bc}	50.0^{bc}	34.2^{bc}	1463^{b}
D	744^{c}	70.1^{c}	48.1^{b}	1.458^{ab}	48.3^{d}	33.4^{c}	1.446^{ab}
E	789^{ab}	74.1^{ab}	48.4^{b}	1.532^{c}	51.9^{a}	35.6^{ab}	1.459^{ab}
F	794^{a}	74.7^{a}	48.1^{b}	1.553^{c}	52.4^{a}	35.8^{a}	1.464^{b}
G	794^{a}	73.9^{ab}	51.5^{a}	1.435^{a}	51.0^{abc}	35.8^{a}	1.422^{a}
SEM	6	0.4	0.4	0.012	0.3	0.3	0.008

[1] averages with the same subscript are not significantly different from each other at p=0.05

Table 5 Effect of the different mineral supplementations on the zootechnical performances of the broilers in the finisher period (22-42 days of age)[2] and the period 1-42 days of age

	BW-42 d g	Daily feed intake (g/a/d) 22-42 d	Growth (g/a/d) 22-42 d	FC 22-42 d	Daily feed intake (g/a/d) 1-42 d	Growth (g/a/d) 1-42 d	FC 1-42 d
Anova							
Diet (n=7)	0.258	0.049	0.566	0.025	0.003	0.256	0.209
LSD m.r. test							
A	2484[b]	145.7[c]	84.6	1.722[a]	97.3	58.2	1.674
B	2575[a]	149.0[ab]	85.7	1.739[abc]	99.5	60.3	1.651
C	2535[ab]	146.7[bc]	84.5	1.735[abc]	98.0	59.4	1.651
D	2542[ab]	147.9[abc]	85.6	1.728[ab]	97.9	59.5	1.644
E	2554[ab]	149.1[ab]	84.0	1.776[bcd]	100.0	59.8	1.673
F	2543[ab]	149.3[ab]	83.3	1.793[d]	100.7	59.6	1.691
G	2559[a]	149.8[a]	84.0	1.785[cd]	100.1	59.9	1.671
SEM	10	0.4	0.4	0.008	0.3	0.2	0.005

[1] averages with the same subscript are not significantly different from each other at p=0.05

Table 6 Effect of the different trace mineral supplementations on their excretion at 37 days of age (mg/kg DM)

Treatment	Cu	Fe	Mn	Zn
A	37	516	200	254
B	73,5	681	339	413
C	30	539	190	192
D	23	443	131	189
E	45	534	231	286
F	56	607	271	353
G	72	680	310	412

References

LEDOUX, D.R., P.R. HENRY, C.B. AMMERMAN, P.V. RAO and R.D. MILES (1991) Estimation of the relative bioavailability of inorganic copper sources for chicks using tissue uptake of copper. *Journal of Animal Science* **69**: 215-222.

SMITH, M.O., I.L. SHERMAN, L.C. MILLER and K.R. ROBBINS (1995) Relative biological availability of manganese from manganese proteinate, manganese sulfate, and manganese monoxide in broilers reared at elevated temperatures. *Poultry Science* **74**: 702-707.

PESTI, G.M. and R.I. BAKALLI (1996) Studies on the feeding of cupric sulfate pentahydrate and cupric citrate to broiler chickens. *Poultry Science* **75**: 1086-1091.