Enrichment of eggs with trace minerals using inorganic or organic trace sources: a feasibility?

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The objective of this research was to evaluate if eggs can be enriched with trace minerals from either inorganic or organic sources of trace minerals. Different levels of trace minerals were provided in the premix, constituting the 7 different treatments. Levels of added Fe, Zn, Mn and Cu were at maximum of 650, 80, 80 and 20 ppm respectively, in order not to surpass the max EU levels of 750, 150, 150 and 25 ppm taking into account the background levels of these trace minerals in the raw materials. In treatment A, no trace minerals were added. In treatments B and C, trace minerals were added either under inorganic forms (FeSO4, ZnO, MnO, CuSO4) or organic form (Bioplex Fe, Bioplex Zn, Bioplex Mn and Bioplex Cu) at the maximum level. In treatments D to G, all trace minerals were fed in inorganic form at maximum level, except one mineral which was replaced by its organic form at the same mineral level. During the last week of the 4 week-trial, eggs from each replicate (n=5) were pooled as yolk or albumen were freeze dried and analysed for their trace mineral content by ICP-AES.
The egg yolk did not reveal any enrichment of trace minerals; in fact, Cu and Mn remained very low and nearly undetectable (< 2 mg/kg DM) while levels of Fe varied on average between 90 and 118 mg/kg DM and those of Zn between 74 and 80 mg/kg DM. None of the differences were significant, mainly due to the variability on trace mineral contents of the samples within each treatment (Coefficient of variation was between 15 and 20 %). With regard to egg albumen, only Fe could be detected with a quite high variability (between 3 and 34 mg/kg DM) being not correlated with its dietary level.
It could be concluded that the deposition of these 4 trace minerals in eggs and, as a result, their concentration in eggs were very slightly affected (due to a specific metabolism at ovarium/uterus) by both dietary levels and chemical "inorganic/organic" form. The observations for the present trace minerals are in contrast with the dose-response to dietary selenium (e.g. in the organic form Sel-Plex).

Keywords: laying hens, trace minerals, egg quality

Introduction

Twenty two mineral elements are believed to be "essential" for the higher forms of animal life, comprising of 7 macronutrient minerals and 15 trace mineral elements. Mineral elements exist in the cells and tissues of the animal body in a variety of functional, chemical combinations and in characteristic concentrations, within quite narrow limits (via homeostatic mechanisms) in order to safeguard the functional and structural integrity of the tissues. Animals have to be supplied with a diet which contains nutrients and trace minerals in adequate amounts, proper proportions and available form (inorganic vs organic form) in order to prevent nutritional disorders, which may vary from mild and transient conditions to acute or severe pathological changes.
The objective of the trial is to evaluate if eggs can be enriched with trace minerals by using inorganic or organic sources.

Materials and methods

The experiment was designed as a Complete Block Design (7 treatments * 5 replicates = 35 pens with 4 ISA brown layers per pen) with a total number of birds housed of 140. The laying hens were housed in battery cages under the normal conditions for temperature, ventilation and lighting (16 h light per day). The laying hens were just on peak production at about 50 weeks of age at the start of the trial. They were fed during 4 weeks 7 different diets only differing in the trace minerals content and trace mineral source (inorganic/organic) under study. The feed formula of the basal diet is given in Table 1.

Different levels of minerals were provided in the premix, constituting the 7 different treatments (Table 2). Irrespective of the origin of the trace minerals (either inorganic or organic from Bio-Plex, Alltech Inc., USA), levels of added Fe, Zn, Mn and Cu were at maximum of 650, 80, 80 and 20 ppm respectively. This was done in order not to surpass the max EU levels of 750, 150, 150 and 25 ppm taking into account the background levels of these minerals in the raw materials. In treatment A, no trace minerals were added as a negative control. In treatments B and C, minerals were added under either inorganic forms ($CuSO_4$, Zn0, MnO, $FeSO_4$) or organic form (Bioplex Cu, Bioplex Zn, Bioplex Mn and Bioplex Fe). In treatments D to G, all trace minerals were fed in inorganic form, except one which was replaced by its organic form at the same dietary concentration. A sample of each feed was analysed for its trace mineral content using ICP-MS (Induced Coupled Plasma - Mass Spectroscopy / duplo analysis on a sample).

During the last week, eggs of a 24 h production were sampled of which egg yolks and egg albumens were pooled separately (thus 5 samples egg yolk and 5 samples egg albumen per treatment) and freeze dried. The dried egg yolk and egg albumen were analysed for their trace mineral content by ICP-AES (Induced Coupled Plasma -Atomic Excitation spectroscopy / duplo analysis on a sample).

All parameters were subjected to a 2-factorial analysis of variance (“7*5” / 7 dietary combinations * 5 blocks) and the corresponding LSD-multiple range test (Statgraphics version 5, 1991 ; Snedecor and Cochran, 1989).

Results and discussion

The trace mineral analysis of the feed indicate a background level of trace minerals of 8, 147, 40 and 44 mg/kg DM of Cu, Fe, Mn and Zn, respectively. The results of the trace minerals in the other layer diets were in line with the supplementated minerals, considering the variability on the analytical method.

The dietary concentrations of the trace minerals under study did not have any effect on zootechnical performance in terms of egg production and feed conversion. This finding means that the respective dosages (treatment A as negative control vs the other treatments) did not induce any deficiency during this 4-week trial.

The egg yolk did not reveal any enrichment of trace minerals; in fact, Cu and Mn remained undetectable (< 2 mg/kg DM) while levels of Fe varied on the average between 90 and 118 mg/kg DM and those of Zn between 74 and 80 mg/kg DM. None of these differences were significant, mainly due to the variability on trace mineral contents of the samples within one treatment (Coefficient of variation between 15 and 20 %). With regard to egg albumen, only Fe could be detected. However, the quite high variability in Fe was not correlated with its concentration in the layer diet, neither under organic or inorganic form.

It seems that the deposition of these trace minerals in eggs and tissues is carefully regulated, and unless a deficiency is induced, a great deal of effect from dietary manipulation seems not to be the case. This "short-term" trial does not address deficiency state (extrapolation to a 1-year laying cycle ?). As a result, it is very likely that trace mineral content in eggs is controlled metabolically and not significantly influenced by its form in the diet. From these data, it appears that adding these trace minerals to the hen's diet (inorganic or organic) even to the maximum EU levels does not lead to an enrichment of the egg. Therefore it seems that the enrichment of the eggs with these trace minerals, from either Bioplex or inorganic sources, was much lower than the clear enrichment of eggs with Se by supplying the diet with the organic source Sel-Plex.

References

SNEDECOR, G.W. and COCHRAN, W.G. (1989) Statistical methods (8th edn.). Iowa State University Press. Ames, IA, USA.

STATGRAPHICS version 5 (1991) Reference Manual. Statistical Graphics Corporation (Rockville, M.D., U.S.A.).

Table 1 : The nutrient composition of the basal layer diet

Feedstuff	(%)
Corn	16.84
Wheat	35.50
Fullfat soybean HT	19.55
Soybean oil meal 46+2	1.53
Sunflower extract 28 % CP	7.50
Bicalciumphosphate.H_2O	0.75
$CaCO_3$-white powder	5.99
$CaCO_3$-white granular	1.90
Salt fine dry	0.22
Sodium bicarbonate	0.19
Methionine HCl	0.11
Lysine HCl	0.03
Premix Layer 10 % *	10.00
Sum	100.00

* supplying equal dosages of all vitamins and trace elements (except for the trace minerals under study)

Table 2: Level and form of trace minerals added to the feed

Trace mineral & its form	Treatment (dosages in mg/kg)						
	A	B	C	D	E	F	G
Fe-sulphate 30%	0	650	0	650	0	650	650
Mn-oxide 62 %	0	80	0	80	80	0	80
Cu-sulphate 40 %	0	20	0	0	20	20	20
Zn-oxide 79 % Zn	0	80	0	80	80	80	0
Bioplex Fe (10 % Fe)	0	0	650	0	650	0	0
Bioplex Mn (10 % Mn)	0	0	80	0	0	80	0
Bioplex Cu (10 % Cu)	0	0	20	20	0	0	0
Bioplex Zn (10 % Zn)	0	0	80	0	0	0	80

Table 3: Analysed concentrations of the trace minerals of the feed, egg yolk and egg albumen (mg/kg DM)

	Treatment						
	A	B	C	D	E	F	G
Feed							
Cu	8	35	32	27	38	28	27
Fe	147	774	835	734	811	828	855
Mn	40	87	116	120	116	121	124
Zn	44	122	130	125	153	105	136
Egg yolk							
Cu	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Fe	99	118	103	110	90	114	110
Mn	< 2	< 2	2	2	2	< 2	2
Zn	76	76	80	75	80	76	74
Egg albumen							
Cu	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Fe	5	15	9	34	12	24	3
Mn	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Zn	< 4	< 4	< 4	< 4	< 4	< 4	< 4