

Estimation of the relative bioavailability of zinc sources for broiler chicks.

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An experiment was conducted with 260 day-old male broiler chicks to estimate the biological availability of three sources of Zn, two Zn-montmorillonites (Zn-MONT-A and Zn-MONT-B) and MINTREX[®]Zn. Zinc sulfate (ZnSO₄) was used as the standard in the bioavailability assay. Chicks were allotted randomly to dietary treatments that included an un-supplemented corn-soybean meal basal diet (32 mg/kg Zn), or the basal diet supplemented with 10, 20 or 30 mg/kg Zn as either ZnSO₄ (40.5% Zn), Zn-MONT-A (1.3% Zn), Zn-MONT-B (1.85% Zn) or MINTREX[®]Zn (10% Zn). Dietary Zn level or source had no effect (P>0.05) on feed intake or body weight gain of chicks, which averaged 986 g and 801 g, respectively. Using the slope-ratio technique from the regression of tibia and toe Zn concentration on supplemental dietary Zn, and with Zn from ZnSO₄ set at 100%, the relative biological availability values using tibia Zn were estimated to be 73, 118, and 132% for Zn-MONT-A, Zn-MONT-B, and MINTREX[®]Zn, respectively. For toe Zn, the bioavailability values were 88, 101, and 111% for Zn-MONT-A, Zn-MONT-B, and MINTREX[®]Zn, respectively. Data suggest that both modified MONTs provided a source of bioavailable Zn, but Zn from MINTREX[®]Zn was more available to broiler chicks than Zn from Zn-MONT-A.

Keywords: Zinc; bioavailability; tibia; toe; broiler

Introduction

Originally, adsorbents (clays) were incorporated in animal diets to improve feed manufacture by functioning as flow agents and pellet binders. Montmorillonite (MONT), an aluminosilicate clay has been shown to reduce bacterial contamination of the gut (Venglovsky et al., 1999), to reduce the detrimental effects of aflatoxin (Phillips et al., 1988), and to promote weight gain and feed efficiency (Tauqir and Nawaz, 2001).

Pharmacological concentrations of zinc (1,500-3,000 mg/kg) have been shown to improve performance of weanling pigs (NRC, 2005), whereas pharmacological concentrations of copper (100-250 mg/kg) have been shown to improve performance of both poultry and pigs (NRC, 2005). In an attempt to combine the benefits of MONT with zinc and copper, modified montmorillonites containing Zn (Zn-MONT) and Cu (Cu-MONT) were prepared at the Institute for Technology of Nuclear and Other Mineral Raw Materials, Serbia using an ion exchange reaction (Tomašević-Čanović et al., 2001).

The resulting modified MONTs are currently being evaluated for their ability to promote growth, to bind AF, and to determine if the modified MONTs would provide a source of bioavailable Zn and Cu. The specific objective of this study was to determine the biological availability of Zn from three sources of zinc, two different sources of Zn-MONT and an organic Zn source (MINTREX[®]Zn).

Materials and methods

Two hundred and sixty day old broiler chicks were purchased from a commercial hatchery, weighed, wing-banded, and assigned to pens in stainless steel chick batteries. Birds were maintained on a 24-hour constant light schedule and allowed *ad libitum* access to feed and water.

Chicks were allotted randomly to dietary treatments (4 replicate pens of 5 chicks each per treatment) that included an un-supplemented basal corn-soybean meal (32 mg/kg Zn), or the basal diet supplemented with 10, 20 or 30 mg/kg Zn as either ZnSO₄ (40.5% Zn), Zn-MONT-A (1.3% Zn), Zn-MONT-B (1.85% Zn), or MINTREX[®]Zn (10% Zn). The basal diet was a commercial corn-soybean meal type diet formulated to meet or exceed the nutritional requirements (except for Zn) of growing chicks as recommended by the National Research Council (NRC, 1994).

Birds were individually weighed at the beginning and end of the study. Feed consumption was determined at the end of the study, and mortality was recorded as it occurred. In addition, birds were inspected daily and any health related problems were recorded. On day 21, 12 chicks (4 replicates of 3 chicks each) from each treatment were euthanized and both middle toes and right tibias were collected from all birds to determine Zn concentration. Zinc concentrations in diets and tissues were measured by flame atomic absorption spectrophotometry after samples were wet ashed with nitric and perchloric acids.

Data were analyzed as a 4 x 3 factorial with an extra treatment (basal) by ANOVA using the General Linear Models procedure of SAS (SAS Institute, 1996). The means for treatments showing significant differences in the analysis of variance were compared using Fisher's protected least significant difference procedure. All statements of significance were based on the 0.05 level of probability. Relative Zn bioavailability was calculated by a slope-ratio technique from regression of tibia Zn, tibia ash Zn, toe Zn, and toe ash Zn on supplemental Zn with ZnSO₄ set at 100% (Finney, 1978).

Results and discussion

There was no level effect, source effect, or level by source interaction ($P > 0.05$) for feed intake and body weight gain of chicks fed different sources and levels of Zn, which averaged 986g and 801g, respectively. A source by level interaction ($P < 0.05$) was observed for feed conversion. Birds fed MINTREX[®]Zn were more efficient in converting feed to gain compared to the other sources (Table 1). Mohanna and Nys (1999) reported that a dietary Zn concentration of 45 mg/kg was sufficient to obtain normal performance in broilers fed corn-soybean meal diets from hatch to 21 d of age. In this study, supplementing the low Zn basal diet with 10 mg /kg Zn (total 42 mg/kg Zn) resulted in improved performance regardless of Zn source. Results of the current study are also consistent with the current NRC (1994) dietary recommendation of 40 mg Zn/kg for starting broiler chicks.

Tibia Zn was affected by both level ($P < 0.0001$) and source ($P < 0.003$) of dietary Zn, but there was no source by level interaction ($P > 0.05$; Table 1). Toe Zn was affected by level ($P < 0.02$) but not source of dietary Zn ($P > 0.05$), and there was no source by level interaction ($P > 0.05$; Table 1). Using the slope-ratio technique from regression of tibia and toe Zn concentrations on supplemental Zn with Zn from ZnSO₄ set at 100%, the relative bioavailability values for the three sources were determined and are presented in Table 2. Across the four response variables, the average relative bioavailability estimates were determined to be 86%, 113% and 120% for Zn-MONT-A, Zn-MONT-B, and MINTREX[®]Zn, respectively.

A review of Zn bioavailability data (Ledoux, 2005) indicates that in most studies, organic mineral sources were at least as available as the standard inorganic sources, and in some cases were more available. One of the hypothesized reasons for increased bioavailability of organic minerals is that this form of mineral is protected from unwanted interactions in the gastrointestinal tract. Data suggest that both modified MONTs provided a source of bioavailable Zn, and that Zn from MINTREX[®]Zn was more available to broiler chicks than Zn from Zn-MONT-A.

Table 1. Effects of source and level of dietary zinc on chick performance, toe and tibia zinc.

Source	Level (ppm)	Feed intake (g) ¹	Body weight gain (g) ¹	Feed conversion (g:g) ¹	Toe Zn (ppm) ¹	Tibia Zn (ppm) ²
Basal	0	931	759	1.23	41.7	105.3
ZnSO ₄	10	992	815	1.22	48.8	134.9
ZnSO ₄	20	992	800	1.24	53.7	142.7
ZnSO ₄	30	963	769	1.25	56.4	147.3
Zn-MONT-A	10	991	819	1.22	51.7	127.0
Zn-MONT-A	20	970	797	1.23	53.7	140.8
Zn-MONT-A	30	983	789	1.25	54.1	142.8
Zn-MONT-B	10	989	797	1.24	51.3	132.5
Zn-MONT-B	20	967	776	1.25	54.7	148.9
Zn-MONT-B	30	978	796	1.23	55.0	150.1
MINTREX [®] Zn	10	1029	841	1.22	51.5	140.5
MINTREX [®] Zn	20	986	818	1.21	54.2	149.0
MINTREX [®] Zn	30	1027	843	1.22	56.4	151.1
Pooled SEM		25	22	.008	2.2	3.2
Source of Variation				P		
Level		0.4424	0.3518	0.1786	0.0135	<.0001
Source		0.2828	0.0721	0.0050	0.9257	0.0023
Level x Source		0.9049	0.8415	0.0186	0.9418	0.8327

¹Data are means of 4 replicate pens of 5 chicks each; ²Data are means of 4 replicate pens of 3 chicks each

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Table 2. Estimated relative bioavailability values of zinc sources (Zn from ZnSO₄ set at 100%).

Source	Tibia Zn	Tibia Ash Zn	Toe Zn	Toe Ash Zn	Mean
Zn-MONT-A	73%	80%	88%	102%	86%
Zn-MONT-B	118%	125%	101%	106%	113%
MINTREX [®] Zn	132%	129%	111%	108%	120%

References

- FINNEY, D.J.** (1978). *Statistical Methods in Biological Assay*, 3rd ed., Charles Griffin & Co., London, UK.
- LEDOUX, D.R.** (2005). Bioavailability and antagonists of trace minerals in ruminant metabolism. Proc. 2005 Florida Ruminant Nutrition Symp., 16th Annual Meeting, Gainesville, Florida, pp. 23-37.
- MOHANNA, C., and NYS, Y.** (1999). Effect of dietary zinc content and sources on the growth, body zinc deposition and retention, zinc excretion and immune response in chickens. *Brit. Poult. Sci.* **40**:108-114.
- NATIONAL RESEARCH COUNCIL.** (1994). *Nutrient Requirements for Poultry*. 9th rev. ed. National Academy Press, Washington, DC.
- NATIONAL RESEARCH COUNCIL.** (2005). *Mineral tolerance of animals*. 2nd rev. ed. The National Academies Press, Washington, DC.
- PHILLIPS, T.D., KUBENA, L.F., HARVEY, R.B., TAYLOR, D.R., and HEIDELBAUGH, N.D.** (1988). Hydrated sodium calcium aluminosilicate. A high affinity sorbent for aflatoxin. *Poult Sci.* **67**:243-247.
- SAS.** 1996. *Statistics*, in: SAS User's Guide, 1996 ed., SAS Institute, Cary, NC.
- TAUQIR, N.A., and NAWAZ, H.** (2001). Performance and economics of broiler chicks fed on rations supplemented with different levels of sodium bentonite. *Int. J. Agric. Biol.* **3**:149-150.
- TOMAŠEVIĆ-CANOVIĆ, M., DAKOVIĆ, A., MARKOVIĆ, V., and STOJŠIĆ, D.** (2001). The effect of exchangeable cations in clinoptilolite and montmorillonite on the adsorption of aflatoxin B₁. *J. Serb. Chem. Soc.* **66**: 555-561.
- VENGLOVSKY, J., PACAJOVA, Z., SASAKOVA, N., and VUCEMILO, M.** (1999). Adsorption properties of natural zeolite and bentonite in pig slurry from the microbiological point of view. *Vet. Med. (Praha)*. **44**:339-344.