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KeyShure®

Precision Release Minerals

Balchem Research Summary

KeyShure — Delivers animal performance in the presence of Antagonists

A summary of a Balchem sponsored study conducted by M. D. Sims*[1] and M. J. de Veth[2], [1]Virginia Diversified Research Corp.,Harrisonburg, VA, [2]Balchem Corp., New Hampton, NY.

Summary written by B. A. Barton, Ph.D., Research and Product Development Manager, Balchem Corporation, New Hampton, NY.

Background

IP6 (inositol hexaphosphate), also known as phytate, is a naturally occurring polyphosphorylated carbohydrate found in many feedstuffs including cereal grains, corn, and wheat bran. At least 97% of the inositol phosphates contained in grains occurs as IP6. Phytate is a known trace mineral antagonist. It binds with a trace mineral, such as Zinc (Zn), and reduces its availability to the animal. The reduced mineral bioavailability can negatively impact animal performance (e.g. weight gain, feed to gain ratio, mortality). In commercial monogastric diets, the enzyme phytase is often added to the diet to break down phytate and minimize its impact on animal performance. Even in this situation, phytase addition does not break down all the phytate. Organic trace minerals are fed to overcome the effect of antagonist(s) in the diet and restore animal performance.

Balchem has helped develop a broiler chick experimental model in which a diet containing known amounts of an antagonist is supplemented with Zn from either Zinc sulfate ($ZnSO_4$) or KeyShure® Zinc and broiler performance is monitored. The model is based on the principle that if supplemental zinc is able to mitigate negative effects on broiler growth and feed to gain ratio in the presence of phytate, then it is effectively able to resist binding by the antagonist and thus have higher bioavailability.

Previously, KeyShure Zinc, when fed as part of a broiler diet using cottonseed hulls (CSH) as an antagonist, restored broiler chick weight gain and feed to gain ratio to levels comparable to that achieved in the positive control treatment (Sims and de Veth, 2008). CSH contain two antagonists: phytate and gossypol. The decision to use phytate in the most recent work, instead of CSH, was based on the fact that phytate addition allows a more precise addition of a known amount of antagonist to the diet. The information reported below is from a broiler chick experiment where phytate was used as the antagonist.

General Experimental Design

Broiler chicks (Hubbard x Cobb) were fed diets containing no phytate or phytate (0.15% IP6) with or without supplemental Zn (to provide an additional 40 ppm) from either $ZnSO_4$ or KeyShure Zinc. The single phase Corn/Soy based diets were balanced to provide: 20% CP, 1400 kcal/lb Poultry ME, and 5.0 % fat. Basal diet Zn levels were 25 ppm

Treatments:

Treatment ID	Trace Mineral Source	Antagonist
Positive Control	Basal Zn	0
Phytate	Basal Zn	+
Phytate/$ZnSO_4$	Basal Zn plus $ZnSO_4$ – 40 ppm	+
Phytate/ KeyShure® Zinc	Basal Zn plus KeyShure® Zinc – 40 ppm	+

The feeding period was 12 days (1 day of age starting on day 0). Hubbard x Cobb broiler chicks were used with 8 replicates of 20 birds/pen for each treatment.

Figure 1. Body weight (d 12) for the positive control (NO IP6) vs. the diets containing the antagonist and either no added Zn (IP6), $ZnSO_4$ (IP6/$ZnSO_4$) or KeyShure Zinc (IP6/KeyShure Zinc) treatments. Performance of the broilers for the positive control treatment was set to 100 and all others treatments compared to it.

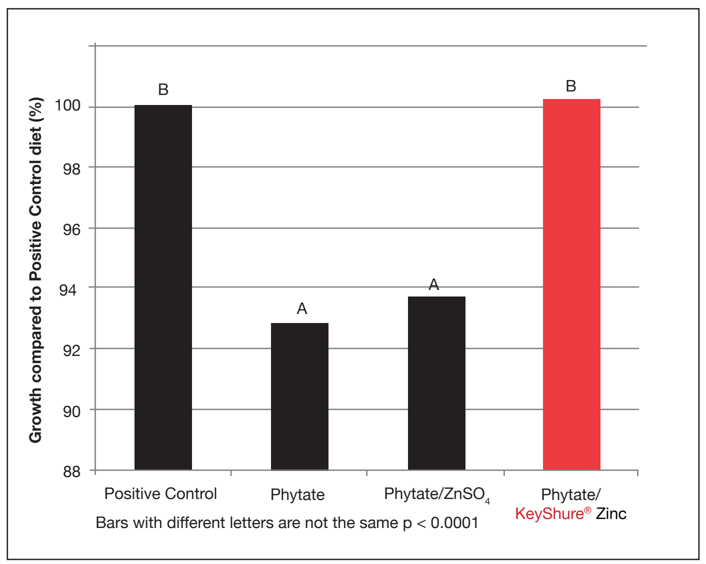
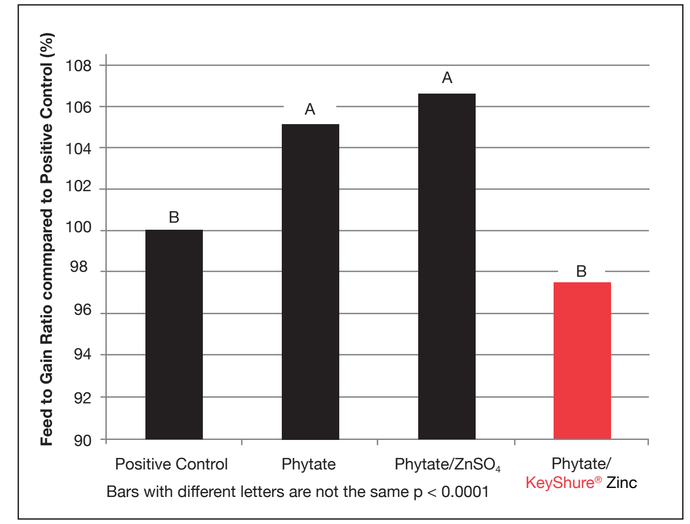


Figure 2 illustrates feed/gain (d 12) for the positive control feed/gain (d 12) for the positive control (NO IP6) vs. the diets containing the antagonist and either no added Zn (IP6), $ZnSO_4$ (IP6/$ZnSO_4$) or KeyShure Zinc (IP6/KeyShure Zinc) treatments. Performance of the broilers for the positive control treatment was set to 100 and all others treatments compared to it. Lower the value = better the performance.



Results/Discussion

Figure 1. Addition of the antagonist to the diet depressed growth by approximately 7% (p<.0001) vs. the Positive Control treatment. When $ZnSO_4$ was added to the diet containing the antagonist, weight gain was not restored and growth was depressed by approximately 6%. Only the addition of KeyShure Zinc, to the diet containing the antagonist, was able to restore weight gain to levels obtained on the positive control treatment. This indicates that KeyShure Zinc was more available than inorganic Zn in the presence of the antagonist phytate and it was able to improve broiler growth.

Figure 2. Addition of the antagonist to the diet improved (p<.0004) feed to gain ratio by 5% vs. the positive control treatment. When $ZnSO_4$ was added to the diet containing the antagonist, the feed to gain ratio was still greater. Only the addition of KeyShure Zinc to the diet was able to restore the feed to gain ratio to levels obtained with the positive control diet. This also indicates that KeyShure Zinc was more available in the presence of the antagonist phytate and it was available to support a more efficient level of feed conversion than inorganic Zn.

Conclusion

- Phytate, as expected, proved to be an effective antagonist because it reduced growth rate and feed to gain ratio when added to the basal diet.
- The differences between Zn sources are amplified in the presence of antagonists. KeyShure Zinc, because of its higher bioavailability, permitted the broilers to achieve better growth and feed conversion.
- These results, along with the Sims and De Veth (2008) study confirms that KeyShure Zinc supplementation can overcome the negative impact of antagonists on animal performance.

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Balchem Research Summary

Deposition of and performance responses to Zn from three organic sources fed to broiler chickens in the presence of cottonseed hull diets containing gossypol.

A summary of a study conducted by M. D. Sims*[1] and M. J. de Veth[2], [1]Virginia Diversified Research Corp.,Harrisonburg, VA, [2]Balchem Corp., New Hampton, NY.

Objective

To evaluate the response (weight gain, feed efficiency, mortality) of broilers to dietary supplementation with inorganic Zinc (Zn) as Zn sulfate ($ZnSO_4$) or three different organic Zn sources in the presence of two dietary antagonists (phytate and gossypol) from cottonseed hulls (CSH). Antagonists negatively impact Zn absorption in monogastrics. Organic Zn sources, if highly bioavailable, can overcome the effect of an antagonists on Zn absorption.

Treatments

- $ZnSO_4$ no antagonist (PCON) - 40 ppm Zn from $ZnSO_4$, no antagonist.
- Basal Zn with antagonist (NCON) - no added Zn, antagonist added.
- $ZnSO_4$ - 40 ppm Zn from $ZnSO_4$, antagonist added.
- KeyShure® Zinc - 40 ppm Zn from KeyShure Zinc, antagonist added.
- Availa-Zn - 40 ppm Zn from Availa-Zn, antagonist added.
- Mintrex Zn - 40 ppm Zn from Mintrex Zn, antagonist added.

Diets and Birds

Diets: Single-phase 20% Protein, ME = 1400 kcal/lb, 9.9% fat – corn/soy diet, naturally adequate *for all minerals (except Mn and I which were added) and then* supplemented with appropriate Zn source at 40 ppm.

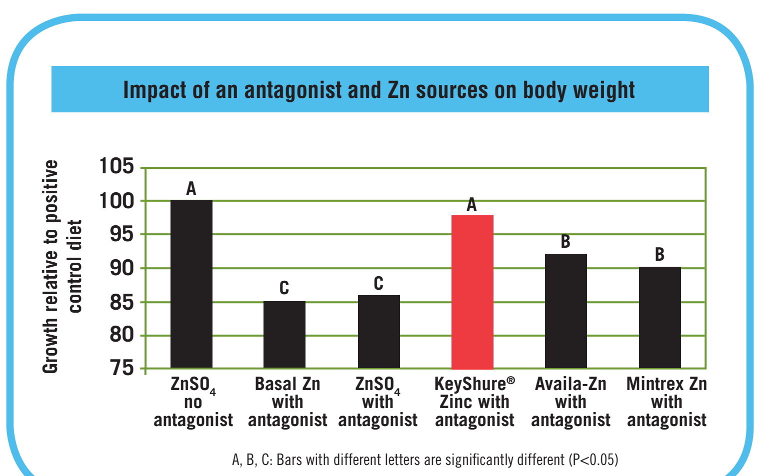
Birds: Straight-run Cobb x Ross broilers (1 to 42d of age). Housing consisted of 48 – 4' X 4' floor pens with 25/birds/pen.

Measurements

- Body weights by pen at 28d and 42d of age *(Figure 1)*
- Feed Conversion Ratio (FCR) at 28d and 42d *(Figure 2)*
- Bone Zn (Femurs) at 28d and 42d *(Table 1)*
- Total Mortality *(Table 2)*

Results

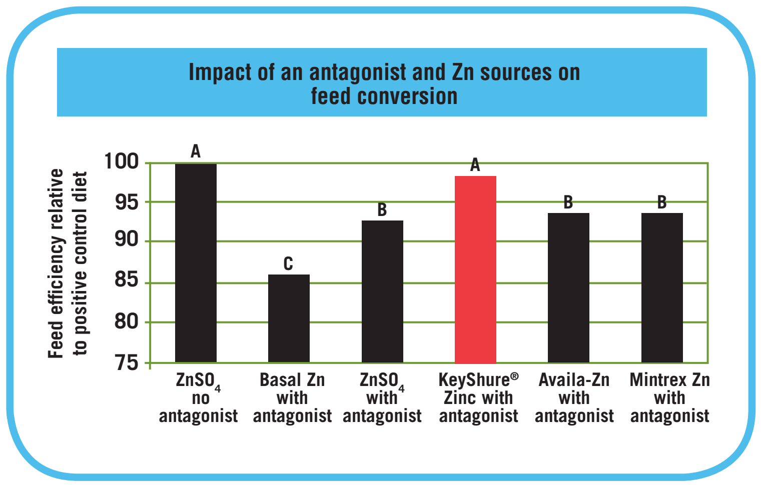
Figure 1. 42d Body weights of treatments compared to PCON treatment. PCON value was set to 100% (ideal standard ration with no anatagonist and adequate Zn).



A, B, C: Bars with different letters are significantly different (P<0.05)

- The Antagonist depressed broiler growth by 14% vs. PCON diet.
- Supplemental $ZnSO_4$ could not counteract the antagonist. Broiler weight was reduced 13% on this diet.
- Feeding supplemental Zn from the organic trace mineral, KeyShure Zinc, - reversed the effects of the antagonist. Similar growth rates were observed on PCON and KeyShure Zinc diets.
- Zn provided by Availa-Zn and Mintrex Zn was not as effective in counteracting the antagonist. Broiler growth was depressed by 7% and 9% ($P<0.05$) respectively on these treatments, as compared to PCON.

Figure 2. Feed conversion rates (FCR) compared to PCON. PCON value was set to 100% (ideal standard ration with no anatagonist and adequate Zn).



- The antagonist depressed FCR by 16% vs. the PCON diet.
- Supplemental $ZnSO_4$ could not completely reverse the affect of the antagonist. FCR for $ZnSO_4$ was depressed by 8% vs. PCON.
- Feeding supplemental Zn from KeyShure Zinc was able to reverse the effect of the antagonist on FCR. FCR was similar for PCON and KeyShure Zinc broilers.
- Feeding supplemental Zn from Availa-Zn and Mintrex Zn was not as effective at counteracting the effect of the antagonist on FCR. FCR was similar for Availa-Zn, Mintrex Zn and $ZnSO_4$.

Commercial Implications

The difference between Zn sources is amplified in the presence of an antagonist. Organic trace minerals, because of their higher bioavailability than the inorganic trace mineral source, permitted the birds to achieve better growth and feed conversion. The KeyShure Zinc treatment was the most bioavailable organic trace mineral source because it was able to counteract the antagonist, allowing the birds to obtain the greatest body weight at 42d of age with improved FCR.

KeyShure Zinc Advantages

Body weights: KeyShure Zinc treatment had the largest 42d body weights ($p < .05$) vs. all other antagonist-containing treatments. KeyShure Zinc birds had 42d body weights comparable to PCON birds.

42d Adjusted Feed Conversion Ratio (lb/lb):
KeyShure Zinc and PCON (positive control) treatments had similar feed conversion ratios (1.690 and 1.661, respectively) and were both more efficient than the other treatments.

Cost Analysis: KeyShure Zinc birds had higher ($p < .05$) rate of net return/broiler marketed over feed costs ($2.182) than broilers fed Availa-Zn ($1.996) or Mintrex Zn ($1.963) with a monetary difference of $0.19 and $0.22 per bird, respectively.

Table 1.
Bone Zn Levels (ppm)

Group	28-d	42-d
PCON	176.48[a]	120.69[a]
NCON	123.20[d]	99.94[b]
$ZnSO_4$	159.15[b]	110.56[a]
KeyShure® Zinc	154.65[bc]	115.75[a]
Availa-Zn	165.10[b]	113.64[a]
Mintrex Zn	142.65[c]	112.73[a]
SEM	*7.5984*	*2.8280*

- Highest bone Zn concentrations were observed at 28d and 42d in the PCON group.
- Availa-Zn and $ZnSO_4$ had greater ($p < .05$) femur Zn at 28d than Mintrex Zn. At 28d and 42d, KeyShure Zinc femur Zn levels were similar to Availa-Zn, Mintrex Zn and $ZnSO_4$.

Table 2.
Mortality (%)

Group	28-d	42-d
PCON	3.50[a]	4.00[a]
NCON	13.00[bc]	14.00[b]
$ZnSO_4$	20.50[c]	23.50[c]
KeyShure® Zinc	11.00[bc]	11.50[b]
Availa-Zn	11.50[bc]	12.50[b]
Mintrex Zn	12.50[bc]	14.00[b]
SEM	*0.0221*	*0.0255*

- Mortality at 42d for the three chelated Zn sources were not different.
- The three chelated sources had fewer deaths than $ZnSO_4$.

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Balchem Research Summary

Chemical characteristics and relative bioavailability of supplemental organic Zinc sources for poultry and ruminants.

A summary of research conducted at the University of Florida and published as:
J. Cao, P.R. Henry, R. Guo, R.A. Howlerda, J.P. Toth, R.C. Littell, R.D. Miles and C.B. Ammerman; J Anim Sci 2000, Volume 78:2039-2054 and J. Cao, P.R. Henry, S.R. Davis, R.J. Cousins, R.D. Miles, R.C. Littell and C.B. Ammerman; Anim Feed Sci and Tech 2002, Volume 101:161-170.
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Background

Trace minerals are universally recognized nutrients in livestock and human diets for their essential roles in enzyme systems, tissue integrity and immune function. Over the last twenty-five years there has been growing interest, and some evidence, for the use of trace minerals bound to organic ligands due to their hypothesized superior bioavailability in comparison to the inorganic salts of trace minerals. The existing research literature presents inconsistent physiological and production results in animal trials comparing inorganic and organic forms of trace minerals. In addition, there are no standardized chemical methods for the evaluation of organic trace minerals as it relates to the strength or degree of chelation between the trace mineral and its ligand. Lastly, very few studies have correlated chemical characterization with *in vivo* physiological effects. This research bulletin summarizes the results from two papers in which commercially available Zinc (Zn) organic trace minerals were chemically characterized and then compared to inorganic Zn salts in animal trials.

Methods

Chemical Characterization (J Anim Sci, 2000)

Eight commercially available organic trace minerals and reagent grade Zinc sulfate ($ZnSO_4$) were evaluated by several methods to determine: trace mineral and nitrogen content, strength of chelation, solubility at physiological pH, and chelation integrity at physiological pH. The products tested were: two Zn methionine products, a Zn polysaccharide, a Zn lysine, a Zn amino acid (AA) chelate and three Zn proteinates.

Nitrogen and Mineral Content: Samples were dried, ashed, solubilized in HCl, and filtered through ashless filter paper. The Zn content was evaluated by flame atomic absorption spectrophotometry. Nitrogen content was evaluated on a Technicon AutoAnalyzer II.

Polarographic Analysis: Chelation strength was analyzed with a hanging mercury drop electrode to determine the half-wave potential ($\Delta_{E½}$) of saturated solutions of each product. The more positive the $\Delta_{E½}$, the more stable a chelate is.

Solubility at pH 2 and 5: Solubility of each product at concentrations ranging from 0.125 mg/mL up to 12.5 mg/mL were evaluated in buffers at pH 2 and pH 5.

Gel Filtration Chromatography: The soluble fractions from the solubility evaluation were applied to a size exclusion gel and eluted in 0.2 mL aliquots. These were tested for mineral and nitrogen content to determine the separation of free metal ion, amino acids and small peptides, and metal chelates or complexes.

Bioavailability Trials

Experiment 1 (J Anim Sci, 2000)

Four hundred and thirty two broiler chicks were assigned to six pen replicates for each of eight treatments. The basal diet was formulated to meet NRC requirements for Zn. Additional $ZnSO_4$ was added at 0, 200, 400 or 600 mg/kg of DM as one set of treatments or additional Zn was added at either 200 or 400 mg/kg DM from one of two organic trace mineral sources, either a Zn AA chelate or a Zn proteinate (KeyShure Zinc). At 1, 2 and 3 weeks of age, three chicks from each pen were selected and sacrificed. Femurs, intestinal mucosa, intestinal serosa, and liver were harvested for analysis of Zn content or metallothionein activity.

Experiment 2 (J Anim Sci, 2000)

Forty-two cross-bred lambs were assigned to seven treatment groups. The basal diet contained 58 mg/kg of Zn and was formulated to meet NRC requirements for growing lambs. The inorganic Zn treatments included 0, 700, 1400 or 2100 mg/kg of $ZnSO_4$. The organic Zn treatments consisted of 1400 mg/kg of either KeyShure Zinc, Zn AA chelate or Zn methionine. Diets were fed for 21 days, at which time the lambs were sacrificed and samples taken from liver, kidneys and pancreas for analysis of Zn content or metallothionein activity.

Experiment 3 (Anim Feed Sci Tech, 2002)

This experiment differed from Experiment 1 in that supplemented Zn was formulated to be much closer to NRC requirements rather than at pharmacological levels. A secondary objective was to evaluate treatments for a much shorter period of time (9 days) as compared to typical three or six week studies in broilers. Four hundred and thirty two broiler chicks were assigned to six pen replicates for each of eight treatments. The basal diet was formulated to meet or exceed NRC requirements for growing chicks, except for Zn, which was formulated for 24 mg/kg of Zn. The treatments included Zn supplemented at 0, 30, 60 or 90 mg/kg of DM as Zn acetate, or 30 or 60 mg/kg of DM as Zn methionine or Zn proteinate (the same as KeyShure Zinc in the Cao, 2000 paper). At days 3, 6 and 9 of the experiment, three chicks were selected from each pen and sacrificed. Tibias, intestinal mucosa and livers were harvested for analysis of Zn content or metallothionein activity.

Results

Chemical Characterization (J Anim Sci, 2000)

The results of chemical characterization and chelation effectiveness are presented in Table 1. The values in the $\Delta_{E½}$ column represent the voltage required to break the bond between the ligand and trace metal. The higher the value, the stronger the chemical bond. Similarly, the formation quotient, Q_f, is a quantitative measure of chelation effectiveness. Categorically, Q_f values <10 are representative of very weak chelation, values between 10 and 100 represent moderate chelation and over 100 should be considered as strongly chelated.

Zn Source Solubility

There was wide variation in the solubility of the Zn and nitrogen (N) fractions of the commercial products in deionized water as seen in Table 1. The Zn:N ratio for KeyShure Zinc was highly consistent in both soluble and insoluble fractions, indicating that it was the only product which remained chelated under the conditions of this evaluation.

Table 1. Characterization of Chelation Effectiveness of Organic Zn Sources.

Zn Source	$\Delta_{E½}$	Q_f	Zn Soluble*	Zn Insoluble	N Soluble	N Insoluble
Zn Methionine A	.008	1.9	60	5	14	6
Zn Methionine B	.005	1.5	164	3	31	3
Zn Polysaccharide	.017	3.8	348	33	--	7
Zn Lysine	.019	4.4	127	43	66	4
Zn Amino Acid Chel.	.067	180	149	17	48	77
KeyShure® Zinc	.033	13	41	206	45	131
Zn Proteinate B	.058	91	200	26	11	31
Zn Proteinate C	.062	120	216	10	40	58

Key to Chelation Effectiveness (Q_f):

Low	Moderate	High

** All solubility values are reported in mg*

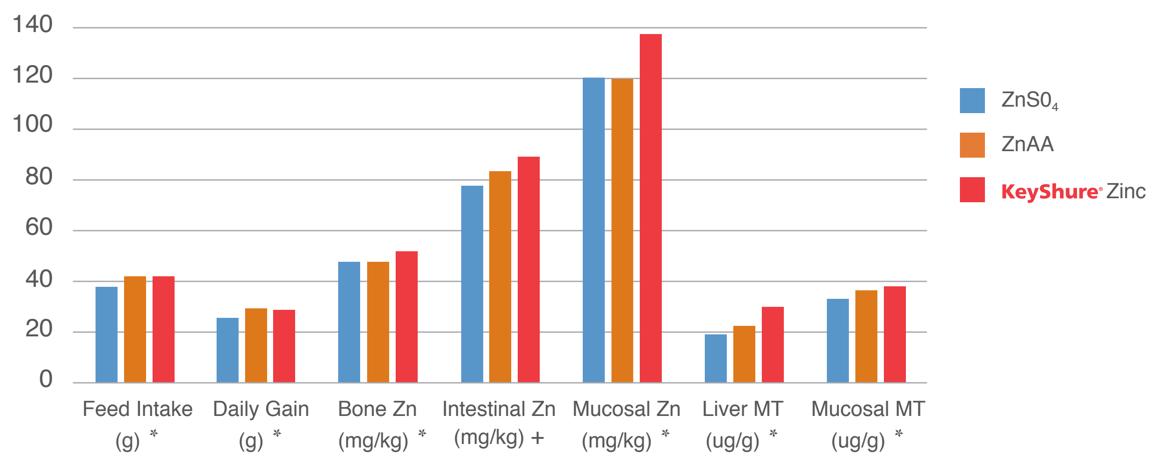
Gel Filtration Chromatography

This method was able to distinguish unique peaks between free Zn ions, amino acids, peptides, complexes and chelates. Applying filtrates of the Zn sources mixed into pH 2.0 and pH 5.0 buffers, to the chromatograph resulted in distinct peaks for free Zn ion, indicating that none of the material remained chelated under these pH conditions. Under conditions of neutral pH, only 2.2% up to 12.2% of the Zn remained bound to its ligand, with the chelates (Zn AA and all Zn proteinates) demonstrating the highest degree of bound Zn (10.2% to 12.2%). The proportion of Zn remaining bound was positively correlated (r=0.96) to the $\log_{10}$ of the chelation effectiveness (Q_f value in *Table 1*).

Experiment 1: Broiler Chick Study (J Anim Sci, 2000)

In this study, only Zn sulfate ($ZnSO_4$), Zn AA chelate and KeyShure Zinc were used as dietary treatments. There were significant main effects of Zn source and supplementation level at each week of the study across all of the response variables of feed intake, daily growth, bone Zn, intestinal Zn, mucosal Zn, liver metallothionein and mucosal metallothionein. The results for the terminal week of the experiment (week 3) and the highest level of Zn supplementation (400 mg/kg of added Zn) are summarized in Figure 1. The estimated bioavailability, based on bone and mucosal Zn, was 104% for Zn AA chelate and 139% for KeyShure Zinc when compared to results with Zn sulfate ($ZnSO_4$).

Figure 1. Effect of Zn Source on Performance and Tissue Zn

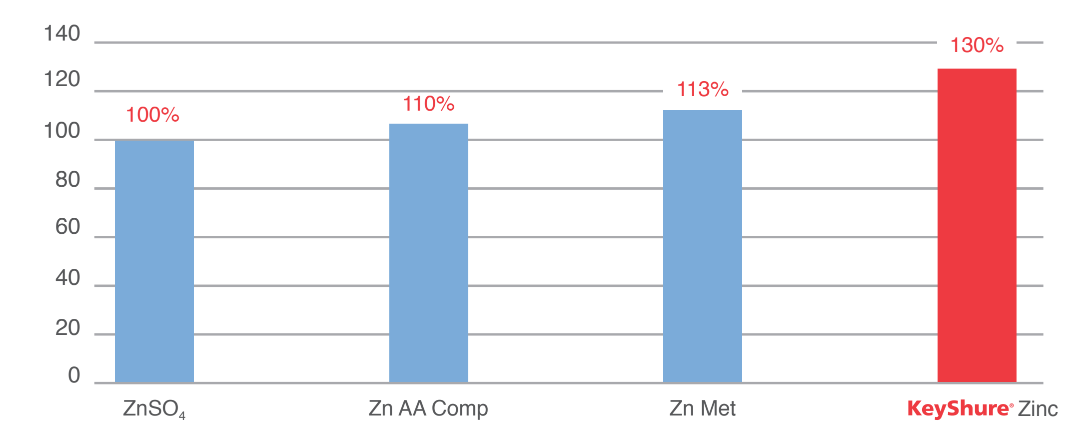


Significant main effect of Zn source * P<.0001; +P<.01

Experiment 2: Lamb Study (J Anim Sci, 2000)

As expected, Zn levels increased in all tissues with increasing Zn intake. When regressing tissue levels on Zn intake, liver Zn had the poorest fit with an R^2 of 0.61. The linear fit for kidney and pancreas Zn and liver metallothionein were 0.73, 0.74 and 0.77, respectively. For these same measures, the slope of the line was greatest for KeyShure Zinc, indicating a higher level of bioavailability than for Zn sulfate ($ZnSO_4$). Based on all four parameters measured, the bioavailability relative toZn sulfate ($ZnSO_4$) (100%) was 110% for Zn amino acid complex, 113% for Zn Methionine B and 130% for KeyShure Zinc (Figure 2).

Figure 2. *Relative Bioavailability of Zinc Sources in Lambs*



Experiment 3: Broiler Chick Study (Anim Feed Sci Tech, 2002)

There were significant effects of age, Zn supplementation level and Zn source on the accumulation of Zn in bone and mucosal metallothionein. Only the Zn proteinate had a significant effect on feed intake (P<.05). The results are summarized in Table 2 for the terminal time point (9 days) and highest Zn supplementation level (60 mg/kg) used across all treatments.

Table 2.

Zn Source	Daily Feed Intake (g)+	Body Weight (g)	Bone Zn (mg/kg)*	Liver MT (ug/g)*	Mucosal MT (ug/g)*
Zn Acetate	19.2	148.7	456	10.5	34.0
KeyShure Zinc	20.3	163.0	476	14.4	37.0
Zn Methionine	19.3	153.6	436	11.6	33.5

+ Significant main effect of source, P<.05; * Significant main effect of source, P<.001

The mucosal metallothionein response to dietary Zn level was the most consistent response variable for all of the time points with R^2 of 0.83, 0.80 and 0.81 for days 3, 6 and 9, respectively. Using the mucosal metallothionein response at day 9 to calculate bioavailability relative to Zn acetate (100%), Zn methionine was 77% and Zn Proteinate was 130%. In summary, shorter supplementation trials can be effective when Zn is supplemented in ranges closer to animal requirements. Mucosal metallothionein appears to be the most consistent response.

Summary

Across the chemical characterizations and animal trials, KeyShure Zinc demonstrated the most consistent chelation effectiveness and performance. KeyShure Zinc exhibited a moderate chelation strength, consistent solubility of metal and nitrogen components and the highest degree of binding at a neutral pH. In animal trials in broilers and lambs, KeyShure Zinc had the highest bioavailability, >130% relative to $ZnSO_4$, of any of the commercial products tested when assessed by growth performance, and Zn accumulation in bone, tissue or enzyme systems.

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Balchem Research Summary

Effects of an organic source of copper, manganese and zinc on dairy cattle productive performance, health status and fertility

A summary of a study conducted by Andrea Formigoni, et al. "Effects of an organic source of copper, manganese and zinc on dairy cattle productive performance, health status and fertility." *Animal Feed Science and Technology.* 164.3 (2011): 191-198. Print.

Background

Providing adequate amounts of essential minerals is critical to maintain health and maximize productivity of dairy cows (NRC, 2001). Organic minerals can be described as nutritionally essential minerals attached to a carbon–hydrogen based molecule which acts as a ligand. Ligands that are used most frequently include amino acids, peptides and proteins. In particular, complexes where a mineral is bonded to amino acids with at least two bonds from each amino acid are referred to as chelated minerals or mineral chelates. Chelates are less likely to be bound by antagonists in the rumen and are characterized by higher bioavailability and retention by the animal than inorganic minerals.

Several beneficial effects were reported when organic trace minerals were fed to dairy cows, including improved fertility, prevention of mastitis and foot lesions, and improved productive performances. In most of the cited studies, organic trace minerals were used at levels considerably higher than NRC (2001) guidelines. The objective of this study was to determine effects of partially replacing Zn, Cu and Mn provided in sulfate form with organic trace minerals during the dry period and lactation on dairy cow productive performance, fertility and health status. Zn and Cu will be supplied to meet NRC (2001) guidelines for lactating Holstein dairy cows in mid-lactation, and Mn above NRC (2001) guidelines.

Materials and Methods

The experiment was conducted on a commercial dairy farm in Italy. Over the course of the experiment, 296 cows were assigned to one of two treatments, with 147 cows in the control and 149 in the KeyShure® group. Cows were fed their respective treatments from 60 days pre-calving to 240 days post-calving. Diets formulated using CPM Dairy version 3 software to meet Dairy NRC (2001) guidelines for Holstein lactating cows in mid-lactation. Ingredient composition of the diet remained the same throughout the trial. During the dry period, cows were fed a diet where Cu, Mn, and Zn were supplied as sulfates (control) or a diet in which 500 g/kg of Cu, Mn, and Zn was supplied as sulfates and 500 g/kg as OTM (KeyShure; Balchem, New Hampton, NY, USA). During lactation, cows were fed a diet for 240 d where Cu, Mn and Zn were supplied as sulfates (control) or a diet in which 750 g/kg of Cu, Mn, and Zn was supplied as sulfates and 250 g/kg as OTM (KeyShure). KeyShure Cu, Mn and Zn are individual products that each contains 150 g/kg of the respective metal which is bound with amino acids and partially hydrolyzed protein to form a metal proteinate.

Colostrum production was recorded over the first two milkings. Milk production was recorded daily and samples were collected every four weeks for analyses of fat, protein, and Somatic Cell Count. Reproductive performance was assessed by recording days to first estrus, days to first service, number of services per conception, and days open. Cows were scored for body condition every 4 weeks (based on a scale of 1 = emaciated to 5= obese). Animal health status was monitored daily and all disorders recoded. Disorders monitored included: retained placenta, metritis, ketosis, mastitis, displaced abomasum, and calf mortality. Hoof health was examined at the start of the dry period and at 0, 150, and 240 days of lactation and hoof abnormalities were recorded under the headings: sole ulcers, digital dermatitis, foot rot, abscess (both wall and toe), and white line disease.

Results and Discussion

Throughout the study, average daily DM intake was 12.0 and 23.8 kg/cow during the dry and lactation phases, respectively. **Colostrum from cows fed OTM contained more immunoglobulins ($P < 0.01$)** and tended ($P = 0.08$) to contain more Ca and Mg (not shown), whereas OTM supplementation had no effect on concentrations of trace minerals in colostrum (Figure 1).

During the first 150 d of lactation, **OTM supplementation increased milk fat content ($P < 0.05$)** while milk yield, CP content and SCC were not affected (Figure 2). Body condition score of cows was not influenced by treatment and averaged 2.83 between 0 and 150 days and 3.02 between 151 and 240 days.

Feeding dairy cows with OTM had no effect on days to first estrus, days to first service, and proportion of cows pregnant by 150 d in milk. Because more cows from the OTM group became pregnant between 150 and 240 d, the number of services per conception was increased in cows fed OTM (data from cows that did not get pregnant were not included in the analysis). Cows fed OTM had a higher ($P < 0.01$) number of services per conception (2.01 versus 2.61 for control and OTM, respectively).

Calf mortality at calving was lower ($P < 0.05$) in multiparous cows fed OTM (15.6 versus 5.6/100 calves for control and OTM, respectively); but there were no differences with regard to other pathologic events. Incidence of claw disorders was not influenced by OTM supplementation.

Figure 1. Colostrum and IgG yield and Zinc, Copper, and Manganese concentration for control vs. OTM treatment groups.

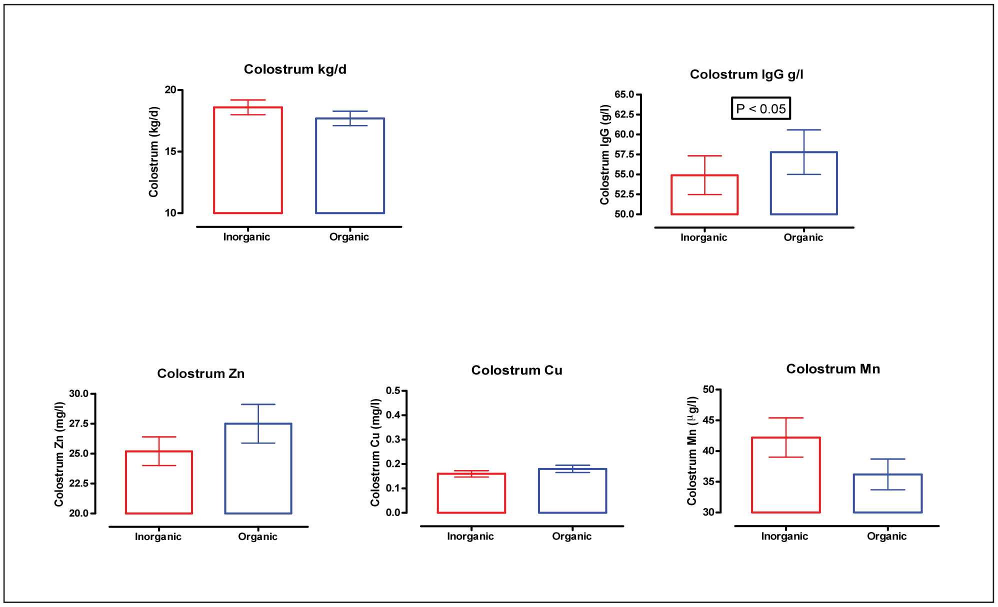
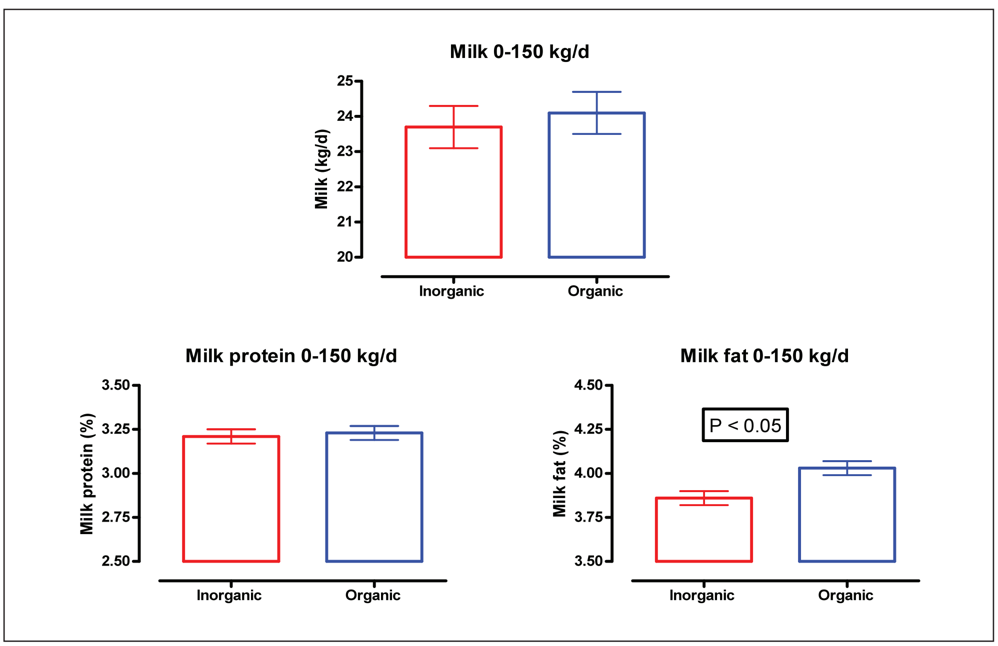


Figure 2. Milk yield and milk protein and fat % for 0-150 days in milk for Inorganic vs. Organic TM Treatment groups.



Summary

Partial substitution of Zn, Cu and Mn sulfates with OTM during the dry period and lactation resulted in higher colostrum immunoglobulin levels and lower calf mortality at calving. In this study, productive and reproductive performance, as well as incidences of pathologic events and claw disorders, were not influenced by feeding organic trace minerals in partial replacement for the minerals in a sulfate form.

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