Availa®Mins Improve Layer Production

Introduction

Layer producers are continually looking to improve their profitability via increased egg production, improved egg quality, increased number of salable eggs and sustained flock health. Recent research shows that feeding smaller and more bioavailable trace minerals (i.e. bonded to amino acids; AvailaMins) can positively affect these economic indicators.

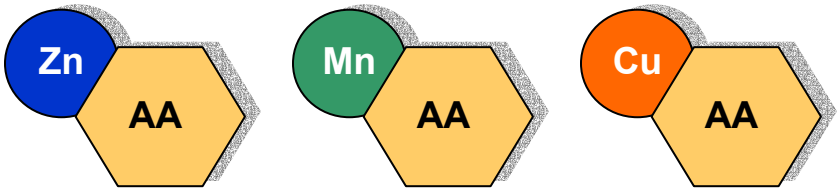
What are AvailaMins?

AvailaMins are the most recent generation of complexed trace minerals from Zinpro Corporation.

These metal amino acid complexes are the result of chemically bonding (complexing) a single amino acid to a specific metal atom (Figure 1), to form a stable and more bioavailable source of the trace mineral. Because of the size and stability of the AvailaMin products, they are absorbed through the gut wall directly, avoiding negative interactions that commonly antagonize and reduce absorption of other forms of trace minerals. With the ongoing commitment of Zinpro Corporation to research, new applications for the use of AvailaMins in poultry production are regularly being demonstrated and validated, such as the role of trace minerals in immune function, eggshell quality, egg production and feed to egg conversion.

Zinpro Corporation

Figure 1. AvailaMin Metal Amino Acid Complexes



Trace Minerals For Laying Hens

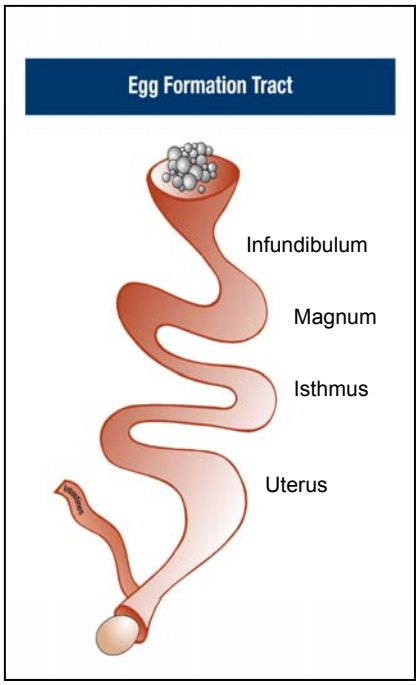
Zinc. Zinc is an essential component of numerous enzymatic systems involved in metabolism of energy, carbohydrates, nucleic acids and proteins. Zinc is also important in maintaining the integrity of epithelial tissue, the protection of the cells, cell division, and the transport and use of vitamin A. Moreover, zinc plays a key role in the immune system and is involved in the function of some reproductive hormones.

Function of Zinc in Egg Production

Zinc deficiencies can involve different consequences. A zinc deficiency affects the quality of epithelium due to the role of zinc in mitosis, protein synthesis and in the production of keratin (zinc helps the transformation of cysteine into cystine). A zinc deficiency is characterized by a reduction of cell division and replication resulting in an alteration in the quality of the epithelium. Zinc also indirectly affects epithelial secretions, by affecting the structure of epithelium, or directly during the synthesis of eggshell membranes, uterine fluid or eggshell.

Zinc plays a role in the **magnum** during the deposition of albumen (function of zinc in the protein synthesis) and in the **isthmus** where eggshell membranes are produced (proteins and chemical structure similar to keratin). Further, zinc is important in the **uterus** where:

- Albumen is hydrated
- The four layers of the shell are produced (mamillary cores, palissade, vertical crystals and cuticle) with the secretion of uterine fluid
- All the proteins of the shell are secreted inside the uterine fluid (ovotransferrin, ovalbumin, lysozyme, osteopontin, OC-17, OC-16, ovocalyxins). It is important to note the role of these proteins in calcite deposition, and in the crystallography of the eggshell. These represent a major parameter in the resistance and strength of the eggshell.



Zinc and Carbonic Anhydrase

Carbonic anhydrase is a zinc dependent enzyme that plays a role in the formation of carbonate anions for use in converting post absorption calcium into calcium carbonate. Calcium carbonate is needed for eggshell manufacture and deposition. Layer diets commonly have high dietary calcium (3.6 to 4.2% Ca) but this may not be effectively utilized in eggshell formation if there is low carbonic anhydrase activity. In addition, high dietary calcium can antagonize zinc availability to the hen, further decreasing carbonic anhydrase activity. In order to prevent carbonic anhydrase from being the weak link in calcium utilization, supplementation of layers with zinc complexed to an amino acid, such as Availa®Zn, will ensure a consistent supply of zinc for adequate carbonic anhydrase activity and the production of calcium carbonate for eggshell formation.

Antagonists to Zinc and Recommended Dietary Inclusion Rate

Copper, cadmium, calcium and iron reduce zinc absorption and interfere with its metabolism. Dietary concentrations of between 30 and 80 ppm are typically included in layer diets. It is important to understand that stress, trauma or any kind of pathology affects zinc status of the layer.

Manganese. In general, manganese is an activator of enzyme systems in the metabolism of carbohydrates, fats, proteins and nucleic acids. Manganese also has multiple functions that relate to the synthesis of bone matrix (collagen) for skeletal growth and for joint function. Manganese is also involved in cholesterol synthesis and affects the metabolism of reproductive hormones.

Function of Manganese in Egg Production

For layers, a manganese deficiency primarily affects eggshell synthesis. Manganese is involved in collagen metabolism (collagen is a main constituent in eggshell membranes). It has been shown that a deficiency in manganese may lead to a reduction in collagen synthesis. Thus, this phenomenon could affect the protein matrix constituting the frame of the eggshell and the initiation of the crystallization of calcite.

Manganese influences eggshell structure. Manganese is believed to create a denser mineral frame providing more resistance and strength. Some studies using crystallography have been able to demonstrate this effect. Some *in vitro* trials have shown the influence of manganese on the shape of calcium carbonate crystals. The action of manganese on the calcification of the collagen is well known, since it is recognized in skeletal growth. It is therefore logical to believe the same mode of action may affect eggshell formation. This hypothesis tends to be confirmed with the presence of a non-collagenic bone phospho-protein inside the eggshell: osteopontine. Existing inside the uterine fluid, it may play a role in the formation of the calcified layer. However, studies have not yet confirmed the determining role of manganese in this mechanism.

It is also important to note that animals deficient in manganese during the growth period have been shown to have poor skeletal growth. Long bones are important as a mobilizable reserve of calcium used by the layer to produce the eggshell.

Antagonists to Manganese and Recommended Dietary Inclusion Rates

Manganese is one of the least toxic trace minerals. Dietary concentrations between 40 and 100 ppm are typically included in layer diets. Excesses in calcium intake (usual in layers) raise the inclusion rate of manganese because of increased fecal excretion of inorganic manganese.

Copper. The primary physiological role of copper is as an enzyme activator and enzyme constituent. In addition, it has a basic function in iron metabolism and red blood cell maturation, and is important in the immune system.

Function of Copper in Egg Production

Copper deficiencies affect the synthesis of eggshell membranes. In fact, these membranes are made from fibers of protein quite similar to elastin (rich in the amino acids proline, histidine and cystine) with linkages derived from lysine. This structure and composition give these membranes resistance and elasticity. The synthesis of these linkages is made by hydroxylation of lysine by a copper-containing enzyme, lysyl oxidase. When there is a deficiency in copper, degradation of the synthesis of these fibers is noticed with increasing permeability of membranes and increase in the size of the egg, leading finally to considerable disruption in eggshell formation.

Moreover, it is important to remember the role of copper in keratin synthesis. A copper deficiency will have negative consequences on the oviduct cells and epithelium quality. The role of copper in the formation of ovarian blood vessels is also important. A copper deficiency would create hemorrhages and may result in the presence of blood spots in the yolk.

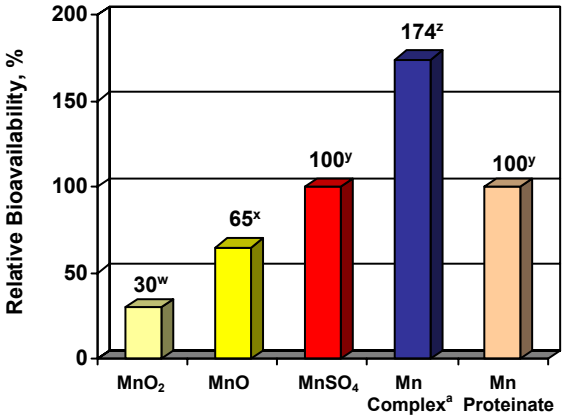
Antagonists to Copper and Recommended Dietary Inclusion Rates

Recommended dietary inclusion is between 8 and 25 ppm. Ten ppm is the most common level used, but it is important to note that zinc, calcium and iron reduce copper availability. In addition, producers feeding diets utilizing by-product feeds (for instance corn gluten) are cautioned about possible antagonisms (because of sulfur) and may need to adjust accordingly the dietary level and/or source of copper.

Bioavailability of Trace Minerals

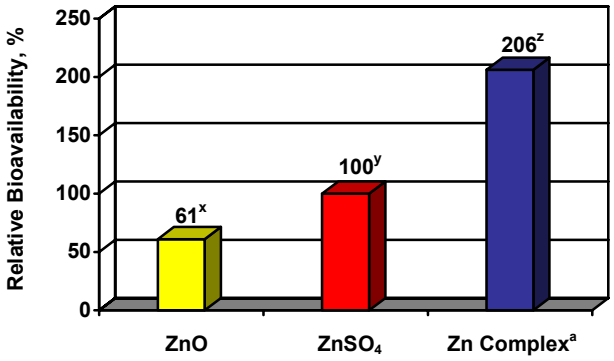
Trace minerals are not all created equal. Some forms of trace minerals have very poor bioavailability due to low solubility (e.g., copper oxide) or due to antagonism from other inorganic factors (zinc sulfate, copper sulfate). AvailaMins from Zinpro Corporation are engineered to resist antagonists in the diet, and are designed for improved absorption via the chemical bonding of a single amino acid to each mineral ion. Therefore, each zinc, manganese and copper metal atom has a single amino acid bonded to it, to facilitate absorption in the gut. This complexing process increases trace mineral bioavailability compared to other mineral sources (Figure 2 and 3).

Figure 2. Relative Bioavailability of Manganese Sources



[a] MANPRO® manganese methionine
[wxyz] Means lacking a common superscript letter differ ($P < 0.01$)
Baker, 1992

Figure 3. Relative Bioavailability of Zinc Sources

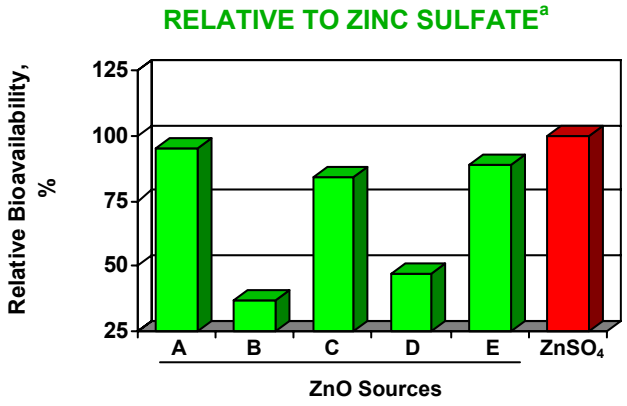


[a] ZINPRO® zinc methionine
Regression on total tibia Zn in chicks
[xyz] Means lacking a common superscript letter differ ($P < 0.01$)
Wedekind et al., JAS 70:178-187

Variation in Trace Mineral Bioavailability

Many factors may lead to large variations in bioavailability values of the same chemical form of a trace mineral. The graph below (Figure 4) shows the differences in bioavailability between numerous zinc oxide sources and zinc sulfate. This variation can partly explain inconsistent performance of animals consuming these and other mineral sources.

Figure 4. Relative Bioavailability of Zinc Oxide

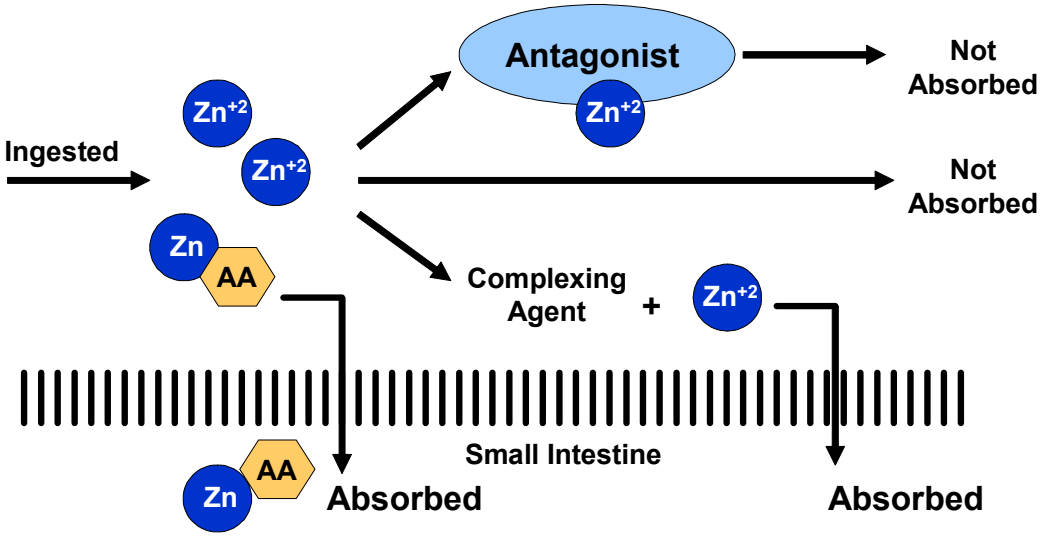


[a] Relative bioavailability of zinc oxide sources with $ZnSO_4 \cdot 7H_2O$ as the standard set to 100%
Edwards, H.M., 2000 Mid-South Ruminant Nutrition Conference

Absorption Theory

Other forms of trace minerals require a ligand to transport them through the gut wall and then to be absorbed. If these minerals fail to attract and bond with a ligand, they are simply excreted and wasted. AvailaMins are built with an amino acid chemically attached and are, therefore, more readily absorbed (Figure 5).

Figure 5. Proposed Absorption Theory



Eggshell Quality Research

Khon Kaen University, Thailand

This full cycle layer production trial evaluated the effects of adding Availa-Zn and Availa®Mn to the diet of layers. The control diet contained a standard industry level of trace minerals (60 ppm Zn from ZnO and 60 ppm Mn from MnO). The treatment diets contained added zinc and manganese from Availa-Zn and Availa-Mn at levels of 20-20 ppm, 30-30 ppm and 40-40 ppm of zinc and manganese respectively. Data were collected during each of two phases and were combined within phase and for the total period. Phase I represents data from week 18 to 37. Phase II represents data from week 38 to 65.

Zinpro Corporation

Results of this 47-week experiment demonstrated a positive effect of complexed zinc and manganese for improving eggshell quality. The addition of zinc from Availa-Zn and manganese from Availa-Mn improved eggshell weight and eggshell thickness in Phase II as well as a numerical improvement in Phase I and for the Overall experiment (Table 1 and 2).

Table 1. Effects of Zinc and Manganese Amino Acid Complexes on Eggshell Weight

		AvailaMins Feeding Rate (Zn-Mn, ppm)[a]		
Eggshell Weight (g)	Control[b]	20-20	30-30	40-40
Phase I (18 - 37 wk)	6.12	6.16	6.15	6.16
Phase II (38 - 65 wk)	6.88[z]	6.92[y]	6.95[y]	6.95[y]
Overall (18 - 65 wk)	6.56	6.61	6.62	6.62

[a] Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex
[b] Control = 60 ppm Zn from ZnO and 60 ppm Mn from MnO
[yz] Means lacking a common superscript letter differ ($P < 0.05$)

Table 2. Effects of Zinc and Manganese Amino Acid Complexes on Eggshell Thickness

		AvailaMins Feeding Rate (Zn-Mn, ppm)[a]		
Eggshell Thickness (mm)	Control[b]	20-20	30-30	40-40
Phase I (18 - 37 wk)	0.346	0.349	0.347	0.348
Phase II (38 - 65 wk)	0.354[z]	0.357[y]	0.357[y]	0.357[y]
Overall (18 - 65 wk)	0.350	0.354	0.352	0.352

[a] Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex
[b] Control = 60 ppm Zn from ZnO and 60 ppm Mn from MnO
[yz] Means lacking a common superscript letter differ ($P < 0.05$)

Figure 6. Common Eggshell Defects (Adapted from: Roche Vitamins; Egg Quality, a Practical Approach):

Break or Toe-Pinch | Internal Crack | Soft Shell

Commercial Field Trial

Recent research conducted with a large layer operation in the Western U.S. further evaluated the effects of Availa-Zn on egg quality. One hundred thirty-five thousand pullets (Isa White) were used to determine the effect of complexed Zn on layer production and egg quality. Pullets were allocated arbitrarily to one of two paired houses at one day of age. Each house was randomly assigned to one of two treatment diets. Treatments included a series of standard commercial diets (66 ppm added Zn from ZnO) and the same commercial diets with 40 ppm added Zn from Availa-Zn. At 18 wk of age, birds were transferred to three lay houses (average of 34,312 layers per house) keeping integrity of treatments within two houses (Control and Availa-Zn) and the third house containing a mixture of the two grow-out treatment groups. Feeding 40 ppm Zn from Availa-Zn commenced with the day-old chick and continued through the entire lay cycle. Egg quality data was determined during the five weeks preceding the molt (61-65 wk). Feeding Availa-Zn reduced the percentage of undergrade eggs (Table 3).

Table 3. Effects of Zinc Amino Acid Complexes on Egg Quality

	Undergrade Eggs, %		
Time Period	Control[a]	Mixed[b]	ZnAA[c]
61 – 65 wk[d]	9.2 %	8.8 %	8.4 %

[a] 66 ppm Zn from ZnO
[b] One-half fed control and one-half fed ZnAA from hatch; all fed control during lay
[c] Control plus 40 ppm Zn from Availa®Zn zinc amino acid complex fed from hatch
[d] Only time period for which data is available for individual layer houses

Egg Production Research

Egg Production Research, Forced Molt and Heat Stress

Research has shown that feeding AvailaMins improves layer performance. A U.S. study conducted on birds in late lay and through forced molting demonstrated the positive effect of adding 30 ppm of zinc and manganese amino acid complexes (Z/M Complex) on top of the treatment diet which contained a basal level of inorganic zinc and manganese. Improvements were seen in body weight ($P < 0.05$) of the hens and a trend to increased hen-day egg production during molt. The birds were evaluated from 61 to 80 weeks of age (Table 4).

Table 4. Effects of Zinc and Manganese Amino Acid Complexes on the Performance of Laying Hens

	Control	Z/M Complex[a]
During Forced Molt:		
Hen-day production[b], %	9.42	11.23
Mortality[b], %	0.74	0.00
Egg weight, g	62.1[y]	63.7[z]
Overall Experiment:		
Hen-day production, %	55.60	56.23
Body weight, kg	1.547[y]	1.565[z]

[a] Z/M Complex (ZINPRO® zinc methionine, 30 ppm Zn and MANPRO® manganese methionine, 30 ppm Mn)
[b] Significant treatment effect ($P < 0.10$)
[yz] Within a row, means lacking a common superscript letter differ ($P < 0.05$)

The layers in this study were housed under different temperatures (Table 5). This trial demonstrates a performance response to Z/M complex in medium (23.9 to 29.4°C) and warm (23.9 to 37.2°C) temperatures. Layers fed Z/M complex had higher ($P < 0.10$) hen-day egg production and increased ($P < 0.05$) feed intake over the control birds under both temperatures.

Table 5. Effects of Zinc and Manganese Amino Acid Complexes on the Performance of Laying Hens Housed at Different Environmental Temperatures

	Temperature[a]			
	Medium		Warm	
	Control	Z/M Complex[b]	Control	Z/M Complex
Overall Experiment:				
Hen-day production[c], %	56.96	57.59	54.90	56.62
Feed intake, g/d	94.48[y]	96.93[z]	88.95[x]	90.99[xy]

[a] Medium: 23.9 to 29.4°C; warm: 23.9 to 37.2°C
[b] Z/M Complex (ZINPRO® zinc methionine, 30 ppm Zn and MANPRO® manganese methionine, 30 ppm Mn)
[c] Significant treatment effect ($P < 0.10$)
[xyz] Means lacking a common superscript letter differ ($P < 0.05$)

Egg Production Research – Thailand

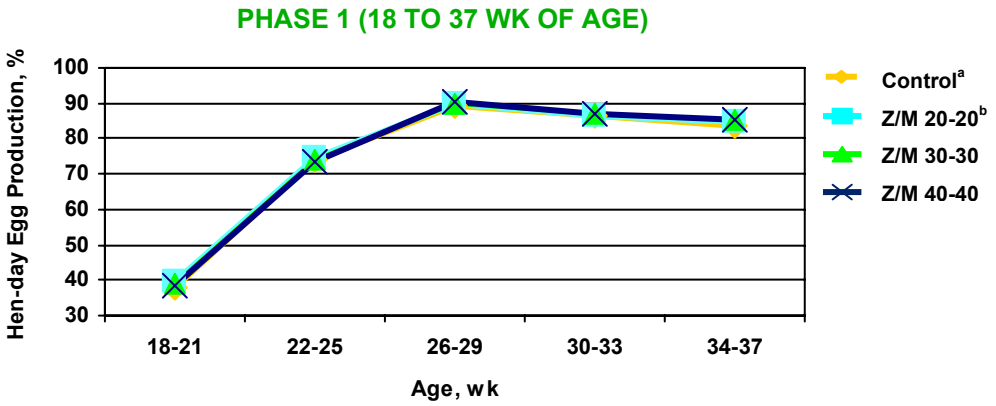
Research conducted at Khon Kaen University in Thailand evaluating zinc and manganese complexes reconfirmed earlier results. A full production cycle trial (18 to 65 weeks of age) was conducted using Availa-Zn and Availa-Mn. One hundred sixty-eight DeKalb Brown layers were randomly assigned to four treatments. A control diet was formulated containing 60 ppm zinc and 60 ppm manganese each in the form of oxides. Availa-Zn and Availa-Mn treatment levels were added on top of the control (20-20, 30-30 and 40-40 ppm Zn and Mn respectively). The addition of Availa-Zn and Availa-Mn improved hen-day egg production over the control diet (Table 6; Figure 7 and 8).

Table 6. Effects of AvailaMins on Egg Production

Hen-day Egg Production, %	Control[a]	Z/M 20-20[b]	Z/M 30-30	Z/M 40-40
Phase 1 (18 to 37 wk)	74.24	75.13	75.05	74.91
Phase 2 (38 to 65 wk)	77.97[z]	78.65[yz]	79.22[y]	78.75[yz]
Overall (18 to 65 wk)	76.42[z]	77.19[yz]	77.47[y]	77.15[yz]

[a] Control = 60 ppm Zn from ZnO and 60 ppm Mn from MnO
[b] Added Zn-Mn (ppm) from Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex
[yz] Within a row, means lacking a common superscript letter differ ($P < 0.05$)

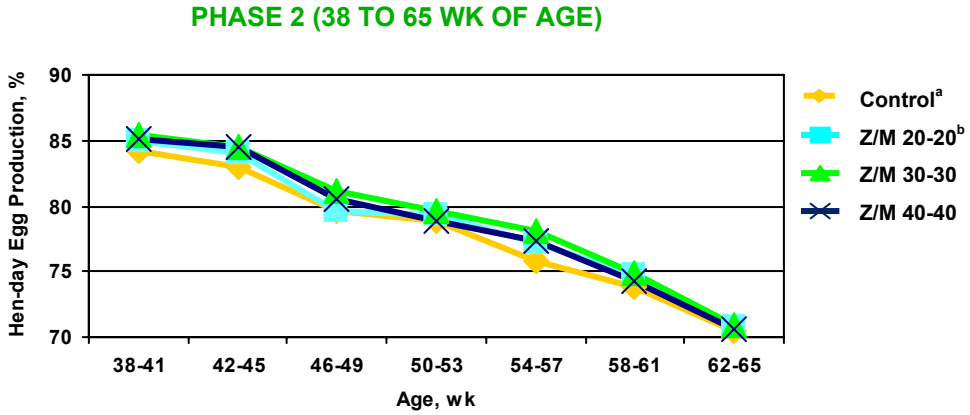
Figure 7. Effect of Zinc and Manganese Complexes on Egg Production



[a] Control = 60 ppm Zn from ZnO and 60 ppm Mn from MnO

[b] Added Zn-Mn (ppm) from Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex

Figure 8. Effect of Zinc and Manganese Complexes on Egg Production



[a] Control = 60 ppm Zn from ZnO and 60 ppm Mn from MnO

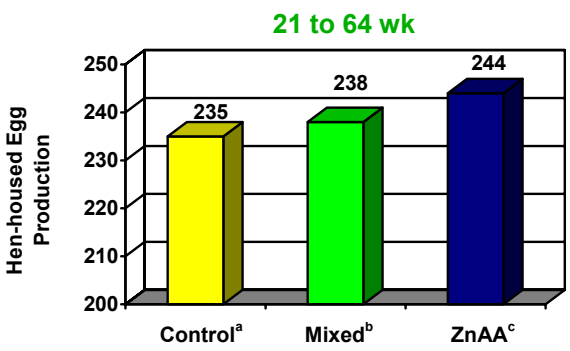
[b] Added Zn-Mn (ppm) from Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex

Commercial Research Trial

Recent research conducted with a large layer operation in the Western U.S. further evaluated the effects of Availa-Zn on layer production. One hundred thirty-five thousand pullets (Isa White) were used to determine the effect of complexed Zn on layer production and egg quality. Feeding 40 ppm Zn from Availa-Zn commenced with the day-old chick and continued through the entire lay cycle. Data reported here are from the onset of lay at 21 wk to molting at 65 wk. Improvements in both the number of eggs per hen housed and feed consumed to produce a dozen eggs were observed (Figure 9 and 10).

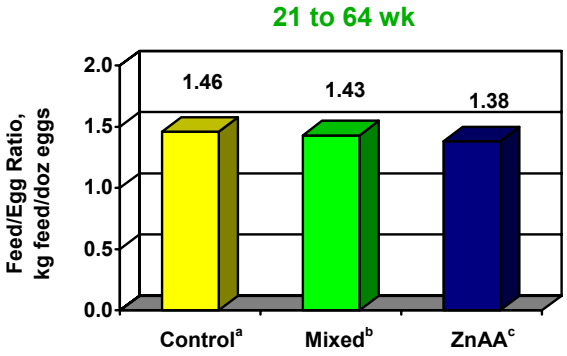
An additional nine salable eggs/hen were produced, for a return on investment of 8:1 (Assumptions: $0.48/doz non-packaged eggs and a feed cost of $0.165/kg). This trial demonstrated a highly profitable outcome from supplementation of AvailaMins.

Figure 9. Effect of Availa-Zn on Egg Production Ratio



[a] 66 ppm Zn from ZnO
[b] One-half fed control and one-half fed ZnAA from hatch; all fed control during lay
[c] Control plus 40 ppm Zn from Availa®Zn zinc amino acid complex fed from hatch

Figure 10. Effect of Availa-Zn on Feed /Egg Ratio



[a] 66 ppm Zn from ZnO
[b] One-half fed control and one-half fed ZnAA from hatch; all fed control during lay
[c] Control plus 40 ppm Zn from Availa®Zn zinc amino acid complex fed from hatch

Egg Production Conclusions and Feeding Directions

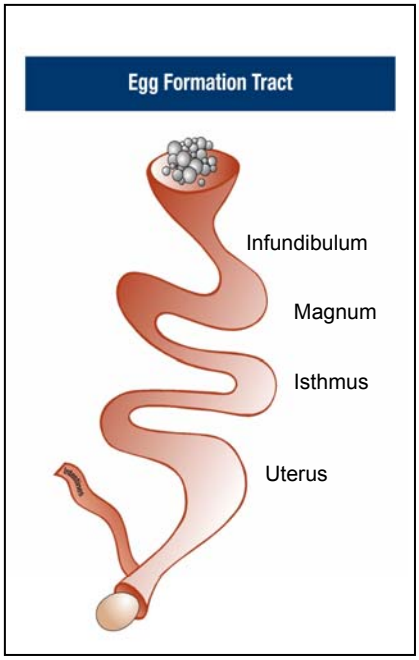
Addition of AvailaMins to layer diets improved egg production and feed conversion when compared to many types of inorganic trace minerals. These results indicate that Availa®ZMC should be added to commercial layer diets to improve egg production, egg quality and layer performance. Availa-ZMC should be fed continuously from day-old chick through the end of lay cycle to ensure optimal responses. Feed at a rate of 1 kg/ton of complete ration to provide 40 ppm Zn from Availa-Zn, 40 ppm Mn from Availa-Mn and 7.5 ppm Cu from Availa-Cu.

Layers and Immunity

It has long been demonstrated that trace minerals play important roles in immune function. Zinc plays a very important role in maintaining epithelial and endothelial tissue integrity and repair. Epithelial tissue (skin) is the first line of defense from disease attack or trauma. Maintaining good skin strength and rapid wound healing will help reduce the incidence of skin scratches and lesions that lead to infections and diseases such as cellulitis. Endothelial tissue is found in the respiratory tract, gut lining and egg formation tract tissue such as the infundibulum, magnum, isthmus and uterus (Figure 11). Maintenance of healthy endothelium will result in higher egg production, better quality egg production and greater persistency of lay. Improved endothelial tissue in the lungs and pulmonary system may also help resist respiratory diseases and problems due to ascites.

Zinc, manganese and copper are all involved in the synthesis of crucial enzymes needed for immune response. Super oxide dismutase, a free radical scavenger enzyme helps maintain cellular integrity and minimize damage from oxidative disease challenge. Further, zinc and manganese are involved in the phagocytic response (macrophage production) to infections such as *E. coli* and salmonella.

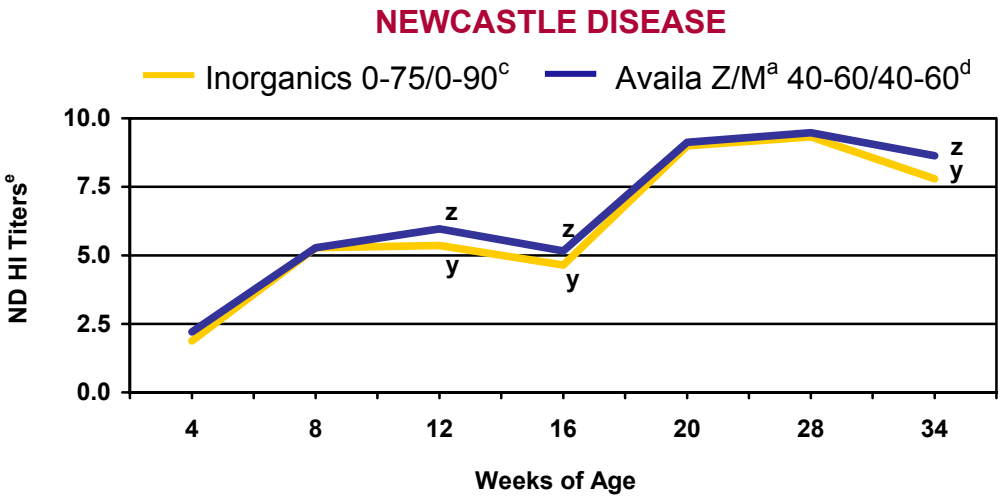
Figure 11. Egg Formation



Antibody Titer Research

Research recently completed at Khon Kaen University evaluated the antibody titer response to poultry supplemented with AvailaMins. As predicted, hens supplemented with trace minerals complexed to individual amino acids demonstrated improved ($P < 0.05$) antibody titer production in response to vaccinations to three common avian diseases, Newcastle Disease, Infectious Bursal Disease and Infectious Bronchitis (Figure 12, 13 and 14). Improving vaccine efficacy (building higher antibody titers) through nutritional supplementation of AvailaMins has very positive implications for improving flock disease resistance and overall health.

Figure 12. Effect of Complexed Zinc and Manganese[a] on Broiler Breeders[b] Humoral Response (antibody titers)



[a] Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex

[b] Cobb 500 genetic line; treatments applied from hatch

[c] 75 ppm Zn from ZnO and 90 ppm Mn from $MnSO_4$

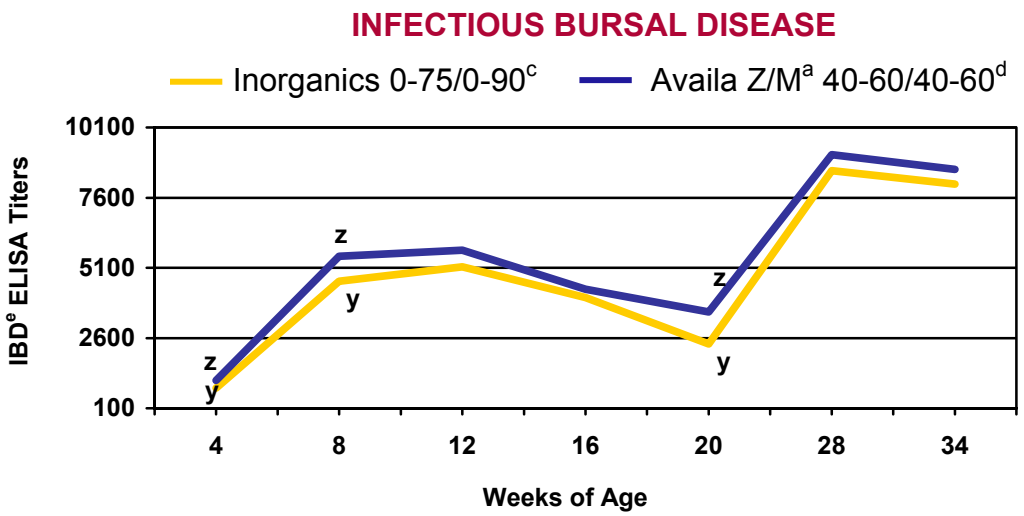
[d] 40 ppm Zn from Availa-Zn + 60 ppm Zn from ZnO and 40 ppm Mn from Availa-Mn + 60 ppm Mn from $MnSO_4$

[e] ND = Newcastle disease; HI = hemagglutination inhibition; Vaccination schedule: 7, 24, 56, 84, 106, 140 and 196 days of age and every 56 days thereafter

[yz] Within a week, means lacking a common superscript letter differ ($P < 0.05$)

Khajarern et al., 2002. Poultry Sci. 81:(In press)

Figure 13. Effect of Complexed Zinc and Manganese[a] on Broiler Breeders[b] Humoral Response (antibody titers)



[a] Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex

[b] Cobb 500 genetic line; treatments applied from hatch

[c] 75 ppm Zn from ZnO and 90 ppm Mn from $MnSO_4$

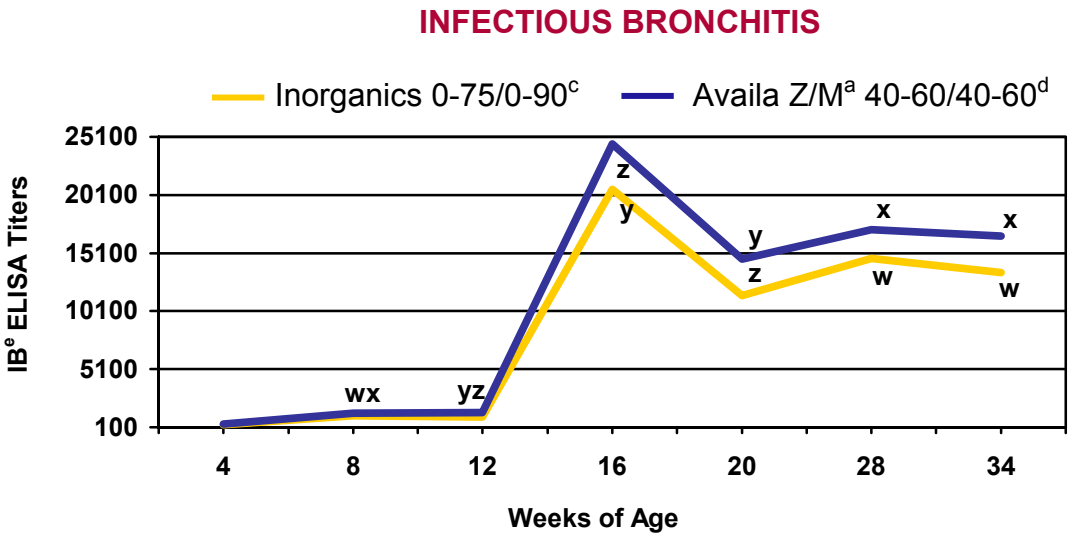
[d] 40 ppm Zn from Availa-Zn + 60 ppm Zn from ZnO and 40 ppm Mn from Availa-Mn + 60 ppm Mn from $MnSO_4$

[e] IBD = infectious bursal disease; Vaccination schedule: 18, 28 and 140 days of age

[yz] Within a week, means lacking a common superscript letter differ ($P < 0.05$)

Khajarern et al., 2002. Poultry Sci. 81:(In press)

Figure 14. Effect of Complexed Zinc and Manganese[a] on Broiler Breeders[b] Humoral Response (antibody titers)



[a] Availa®Zn zinc amino acid complex and Availa®Mn manganese amino acid complex

[b] Cobb 500 genetic line; treatments applied from hatch

[c] 75 ppm Zn from ZnO and 90 ppm Mn from $MnSO_4$

[d] 40 ppm Zn from Availa-Zn + 60 ppm Zn from ZnO and 40 ppm Mn from Availa-Mn + 60 ppm Mn from $MnSO_4$

[e] IB = infectious bronchitis; Vaccination schedule: 7, 24, 56, 84, 106, 140 and 196 days of age and every 56 days thereafter

[wx] Within a week, means lacking a common superscript letter differ ($P < 0.10$)

[yz] Within a week, means lacking a common superscript letter differ ($P < 0.05$)

Khajarern et al., 2002. Poultry Sci. 81:(In press)

Coccidiosis Challenge Research

Coccidiosis is a constant problem that reduces flock health and profitability. Because of the role of zinc and manganese in the immune response and maintenance of endothelial tissue (gut lining and gut lesion healing from a cocci challenge), experiments were conducted to measure the effects of a deliberate coccidiosis infection and a subsequent natural infection, via contaminated litter challenge. The birds supplemented with Availa-Zn showed significant improvements in final body weight, feed conversion and reduced mortality (Table 7).

Table 7. Effect of Complexed Zinc During an *E. maxima* Coccidiosis Challenge[a]

Parameters	Control	ZnAA[b]
Final body weight, kg	2.55[y]	2.60[z]
Adjusted feed conversion	1.99[y]	1.96[z]
Intestinal lesion scores[c]	2.00	1.66
Mortality, %	10.82[y]	7.65[z]

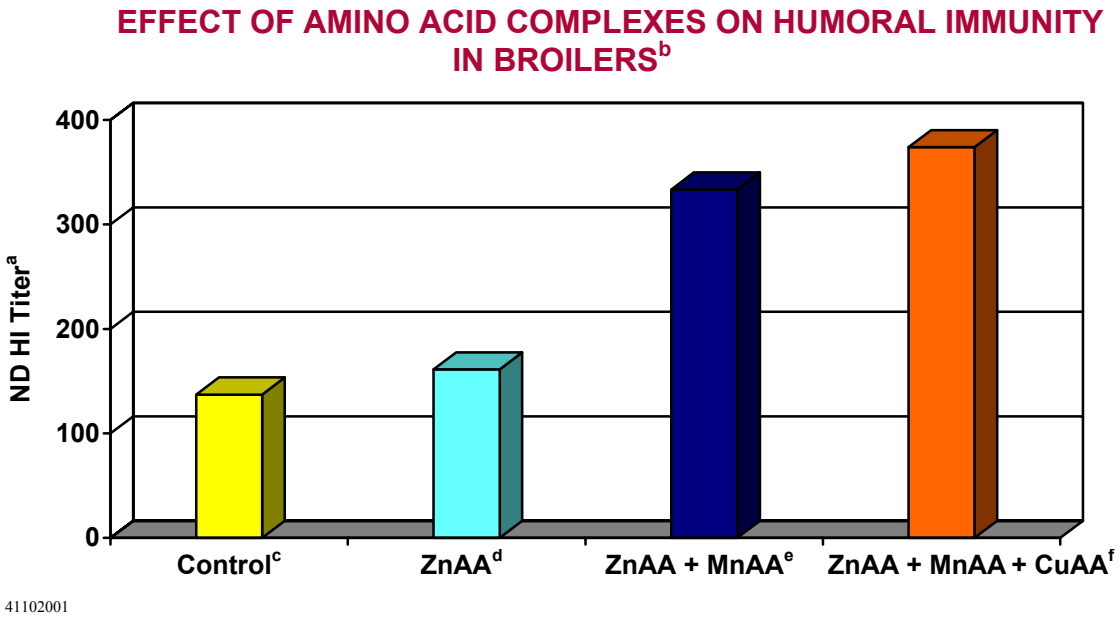
[a] Only two of four treatments are discussed here
[b] Availa®Zn zinc amino acid complex (40 ppm added Zn)
[c] Number of lesions greater than 6 mm
[yz] Within a row, means lacking a common superscript letter differ ($P < 0.05$)

The Case for Complexed Copper

The nutritional requirement of copper for layers is unknown. Typically copper is supplemented at 8 to 25 ppm in layer diets. However, it is important to know that zinc, calcium and iron can reduce copper availability. Layer diets contain high levels of calcium, which acts as an antagonist to copper. Providing a more bioavailable form of copper in the layer diets will be beneficial and assure proper copper status in the bird.

Many of the copper dependent enzymes affect the immune system. Research conducted in broilers showed that feeding diets supplemented with zinc, manganese and copper complexes increased ND titers above titers of broilers fed inorganic trace minerals or diets supplemented with zinc and manganese complexes (Figure 15). Copper also is important for enzymes that are necessary to increase structural strength and elasticity of connective tissue such as the eggshell membrane and blood vessels, and increase bone strength. These components are critical to maximize egg production. Providing copper in a highly bioavailable, amino acid complex form is an excellent way of ensuring maximum layer performance.

Figure 15. Zinc, Manganese and Copper Amino Acid Complexes Improve Broiler ND Titer[a]



[a] ND = Newcastle disease; HI = hemagglutination inhibition
[b] 42 days of age
[c] Control = 100 ppm Zn as $ZnSO_4$, 120 ppm Mn as MnO, 15 ppm Cu as $CuSO_4$, all treatments iso-mineral
[d] ZnAA was 40 ppm Zn from Availa®Zn zinc amino acid complex
[e] MnAA was 40 ppm Mn from Availa®Mn manganese amino acid complex
[f] CuAA was 10 ppm Cu from Availa®Cu copper amino acid complex
Personal Communication, Dr. H. Shieh, National Chung-Hsing University, Taiwan

Conclusion

AvailaMins provide essential trace minerals to improve poultry immune response and function. Feeding strategies to build poultry immune systems and improve disease resistance are of growing importance. AvailaMins also improve layer performance resulting in more eggs/hen, less reject eggs, improved egg quality and improved feed to egg conversion. These benefits support AvailaMins as a profitable inclusion in layer diets.

Bibliography

Caine, W., M. McFall, B. Miller, D. Onderka, R. Kirkwood, S. Jaikaran, and T. Fakler. 2001. Intestinal development of weaned pigs from zinc amino acid complex supplemented gestating sows. Banff Pork Seminar, Vol. 12.

Cousins, R.J., and J.M. Hempe. 1990. Zinc. pp. 251-260 in Present Knowledge in Nutrition. M.L. Brown, ed. International Life Sciences Institute Nutrition Foundation, Washington, D.C.

Cromwell, G.L. 1997. Handbook of Copper Compounds and Applications. pp. 177-202.

Dardenne, M. and J.M. Bach. 1993. Rationale for the mechanism of zinc interaction in the immune system. In: Nutrient Modulation of the Immune Response. S. Cunningham-Rundles, Ed. Marcel Dekker Inc., New York, pp. 501-509.

Downs, K.M., J.B. Hess, K.S. Macklin, and R.A. Norton. 2000. Dietary zinc complexes and vitamin E for reducing cellulitis incidence in broilers. J. Appl. Poultry Res. 9:319.

Fakler, T.M., C.J. Rapp, T.L. Ward, and A.B. Johnson. 2002. The effect of complexed trace minerals on sperm quality. Proc. Amer. Assoc. Swine Vet. (in press)

Fakler, T.M., T.L. Ward, and H.J. Kuhl. 2002. Zinc amino acid complexes (Availa®Zn) improve layer production and egg quality. Poultry Sci. 81:(in press)

Guo, Y.M., personal communication. Effects of supplemental inorganic and organic zinc to the basal diet of laying hens. China Agricultural University, Beijing.

Hess, J.B., S.F. Bilgili, A.M. Parson, and K.M. Downs. 2001. Influence of complexed zinc products on live performance and carcass grade of broilers. J. Appl. Anim. Res. 19:49.

Hunt, S.M. and J.L. Groff. 1990. Advanced Nutrition and Human Metabolism. West Publishing Co. St. Paul, MN.

Jackson, M.E., C. Zhong and T.M Fakler. The Bioefficacy of Complexed Mineral Products on the Performance of Laying Hens at Three Temperatures. Poultry Sci. 76(Suppl.):18(Abstr.).

Keen, C.L. and S. Zidenberg-Cherr. 1990. Manganese. pp. 279-286 in Present Knowledge in Nutrition. M. L. Brown ed. International Life Sciences Institute Nutrition Foundation, Washington, D.C.

Khajarern, J., S. Khajarern, C.J. Rapp, T.L. Ward, A.B. Johnson, and T.M. Fakler. 2002. Effect of zinc and manganese amino acid complexes (Availa®Z/M) on layer production and egg quality. Poultry Sci. 81:(in press)

Khajarern, J., C. Ratanasethakul, S. Khajarern, A.B. Johnson, T.M. Fakler, and T.L. Ward. 2002. Effect of zinc and manganese amino acid complexes (Availa®Z/M) on broiler breeder production and immunity. Poultry Sci. 81:(in press)

Kidd, M.T., P.R. Ferket, and M.A. Qureshi. 1996. Zinc metabolism with special reference to its role in immunity. World Poultry Sci. J. 52:309.

Kidd, M.T., M.A. Qureshi, P.R. Ferket, and L.N. Thomas, 1994. Dietary zinc methionine enhances mononuclear-phagocytic function in young turkeys. Biological Trace Element Res. 42:217-229.

Kidd, M., N.B. Anthony, Z. Johnson, and S.R. Lee. 1992. Effect of zinc methionine supplementation on the performance of mature broiler breeders. J. Appl. Poultry Res. 1:207.

Kidd, M.T., N.B. Anthony, L.A. Newberry, and S.R. Lee, 1992. Effect of Supplemental Zinc in Either a Corn-Soybean or a Milo and Corn-Soybean meal diet on the Performance of Young Broiler Breeders and their Progeny. Poultry Science 72:1492-1499.

Kirchgessner, M. and E. Grassman. 1970. The dynamics of copper absorption. In: Trace Element Metabolism in Animals. pp. 277-287.

Mass, J. 1987. Vet Clin. N. Amer. Food Anim. Pract. 3:633-646.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington, DC.

O'Dell, B.L. 1990. Pages 261-267 in Present Knowledge in Nutrition. M.L. Brown, ed. International Life Sciences Institute Nutrition foundation, Washington, D.C.

Puls, R. 1994. Mineral Levels in Animal Health. Diagnostic Data. 2nd Edition. Sherpa International, Clearbrook, BC, Canada.

Prasad, A.S. 1993. Biochemistry of Zinc. Plenum Press, New York.

Rapp, C., M.J. Arce, G.E Avila, A.B. Johnson, T.M. Fakler, and T.L. Ward. 2001. Effect of zinc and manganese amino acid complexes on ascites in broilers. 13th Eur. Symp. Poult. Nutr., Blankenberge, Belgium. pp. 338-339.

Rapp, C., A.B. Johnson, T.M. Fakler, T.L. Ward, and C.L. Quarles. 2001. Effect of zinc source on intestinal lesions and performance of broilers exposed to coccidiosis. 13th Eur. Symp. Poult. Nutr. Blankenberge, Belgium.

Shetlar, M.R. and C.L. Shetlar. 1994. The role of manganese in wound healing. In: Manganese in Health and Disease. Klimis-Tavantzis D.J., Ed. CRC Press, Boca Raton. pp. 145-157.

Swiatkiewicz, S. and J. Koreleski. 2001. The bioavailability of zinc from inorganic and organic sources in broiler chickens as affected by addition of phytase. J. Anim. Feed Sci. 10:317.

Virden, W.S., J.B. Yeatman, S.J. Barber, K.O. Willeford, T.L. Ward, T.M. Fakler, and M.T. Kidd. 2002. Responses of chicks from broiler breeders fed supplemental zinc and manganese: cellular immunity. Poultry Sci. 81:(in press)

Virden, W.S., J.B. Yeatman, S.J. Barber, K.O. Willeford, T.L. Ward, T.M. Fakler, and M.T. Kidd. 2002. Responses of chicks from broiler breeders fed supplemental zinc and manganese from sulfate or amino acid complexed sources: live performance and processing. Poultry Sci. 81:(in press)

Wedekind, K.J., A.E. Horton and D.H. Baker. 1992. Methodolgy for assessing zinc bioavailability:Efficacy estimates for zinc-methionine, zinc sulfate, and zinc oxide. J. Anim. Sci. 70:178

Zinpro Corporation internal research. PARC Institute – skin lesion scores

Zinpro Corporation internal research. PARC Institute – Av-Zn/ZnMeth/$ZnSO_4$ bioavailability

Zinpro Corporation internal research. PARC Institute – Reduction of condemned poultry claws when ZnMet was fed.

Zinpro Corporation internal research. Fourteen trial summary on feeding complexed zinc and manganese to broilers.