Novel trace mineral technology prevents oxidation in premix and feed


Wenbiao Lu


Yinggu Kuang


Manli Liu

WENBIAO LU, YINGGU KUANG and MANLI LIU* present new research that highlights the importance of form of trace minerals in animal diets.

Trace minerals play essential roles in metabolism and are essential for supporting health, immunity, growth and reproduction. Inorganic trace mineral sources (e.g. sulfates and oxides) have been widely used in the livestock industry as a cost-effective solution to meet the trace mineral requirements of animals. However, these traditional mineral sources can have serious negative effects on other nutrients in the diet including enzymes, vitamins and oils, thus deteriorating the overall nutritive value of premixes and final feeds.

Trace minerals accelerate diet rancidity

Due to their oxidative characteristics, trace minerals can accelerate diet rancidity, reducing the shelf-life and palatability of feed which can lead to wastage and reduced feed intake. A study in Asia investigating the effect of various sources of trace minerals on the shelf-life of pig starter diets illustrates this negative effect. Table 1 outlines the variability in rancidity (olfactory assessment) in different rations stored under the same warehouse conditions (32-38.5°C).

The results clearly indicate the strong impact trace minerals can have on diet rancidity. While the diet without added trace minerals was safely stored for 23 days, the addition of traditional inorganic trace minerals shortened shelf-life to 13 days and high copper (Cu 150 ppm) further reduced shelf-life to 7 days. Organic trace minerals still oxidized the diet as rancidity was smelled at Day 9.

The diet containing the coated mineral complex supplementation

Table 1: Trace minerals and diet rancidity.

Dietary treatment	Trace minerals, ppm	No. of days until rancid
Basal diet, 3% soy oil	No added trace minerals	23
+ Inorganic minerals, low copper	Cu 20; Fe 120; Mn 25; Zn 120	13
+ Inorganic minerals, high copper	Cu 150; Fe 150; Mn 45; Zn 150	7
+ Organic trace minerals	Cu 10; Fe 50; Mn 20; Zn 60	9
+ Combo, low copper formulation	30% ITM + 70% OTM	7
+ Coated mineral complex (MinCo)	Cu 66; Fe 70; Mn 20; Zn 60	22

(MinCo) showed very little effect on diet rancidity. This diet was similar to the negative control diet with a longer shelf-life of 22 days.

Trace minerals oxidize vitamins

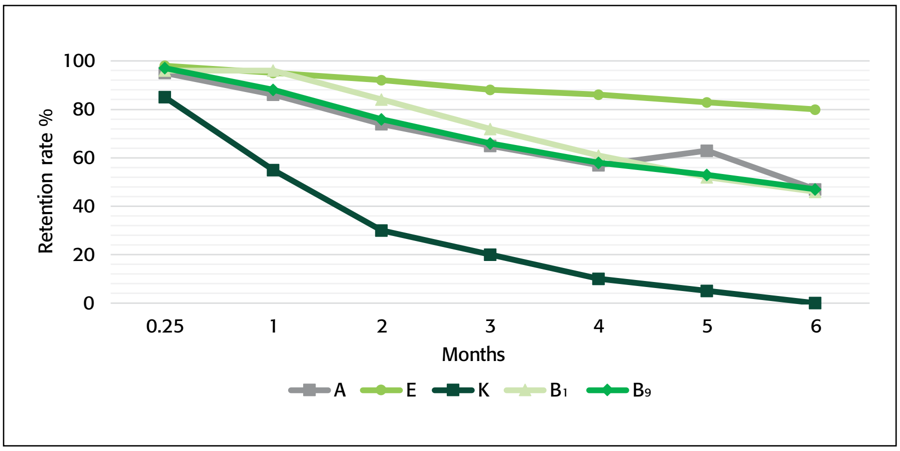
It is common for vitamins and minerals to be premixed and stored separately to avoid chemical reactions and vitamin degradation. Many studies have demonstrated the detrimental effect trace minerals can have on vitamins in a premix. Figure 1 shows a typical study looking at the effect of inorganic trace minerals on the most vulnerable vitamins.

However, using new coated mineral technology could reduce the impact of vitamin oxidation, allowing safe mineral addition in the premix. HPLC analysis (Figure 2) demonstrates a significant sparing effect of the oxidation of Vitamins A, D3 and E in the presence of the coated mineral complex. This opens the door to streamlining premix operations while maximising investment in vitamins.

Trace minerals impact enzymes

Approximately 70% of global monogastric feeds contain exogenous phytase to increase the digestibility of phosphorous in the diet, thus reducing phosphorous excretion.

Figure 1: Loss of vitamin activity in vitamin and mineral premix.

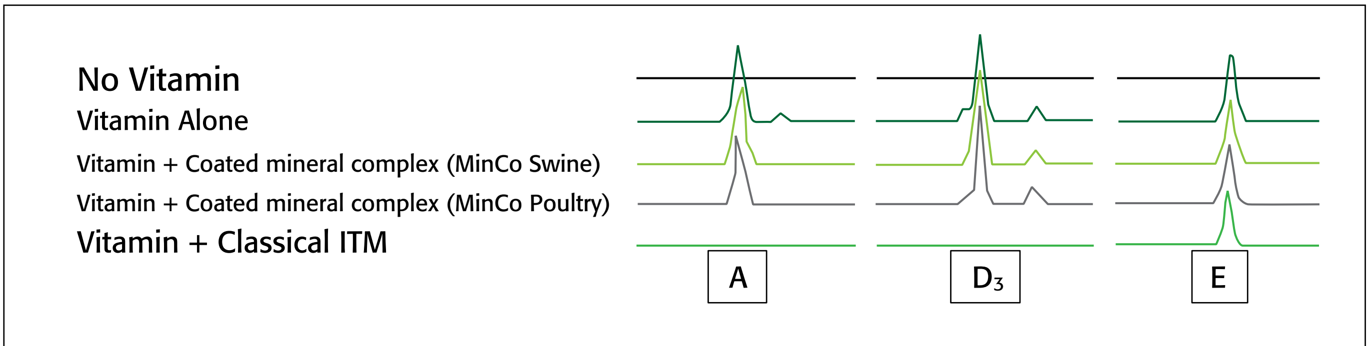


Modified from Coelho. M. 13th Annual Florida Ruminant Nutrition Symposium, 2001

Some producers add phytase and other enzymes into mineral premixes. Santos *et al*. (2015) assessed *in vitro* interaction between inorganic and organic chelated sources of Fe and Zn with three commercially available phytase preparations and confirmed significant phytase inhibition concluded that all forms of trace minerals significantly deteriorated phytase activity (Figure 3).

The authors recently tested the effect of mineral sources on enzyme retention in broiler diets in Thailand. A corn-soybean meal diet was prepared as crumble, using traditional inorganic trace minerals (sulfate) at Ross recommended dosages (in mg/kg Fe 40, Cu 15, Zn 100, Mn 100, Se 0.3 as selenite and I 1.0 as KI) in comparison with organic trace minerals (in mg/kg Fe 20 as sulfate; Cu 5, Zn 40, Mn 30, as chelate with methionine, Se 0.3 as OH-SeMet and I 1.0 as KI). Both phytase and xylanase were added at recommended dosages and the feed samples were analyzed. The results (Table 2) show the activity loss of both enzymes during the 21 ▷

Figure 2: HPLC chromatography of Vitamins A, D3 and E retention after mixed with trace minerals in aqueous solution



◁ days of storage was largely affected by mineral form. This highlights the opportunity for the industry to maximize the efficacy of enzymes included in premixes or feed by presenting trace minerals in a coated mineral complex.

Dietary oils are an important component in feeds. Oils, especially those high in unsaturated fatty acids, are subject to oxidation, which not only reduces their nutritive value, but also shortens the shelf-life of final diets.

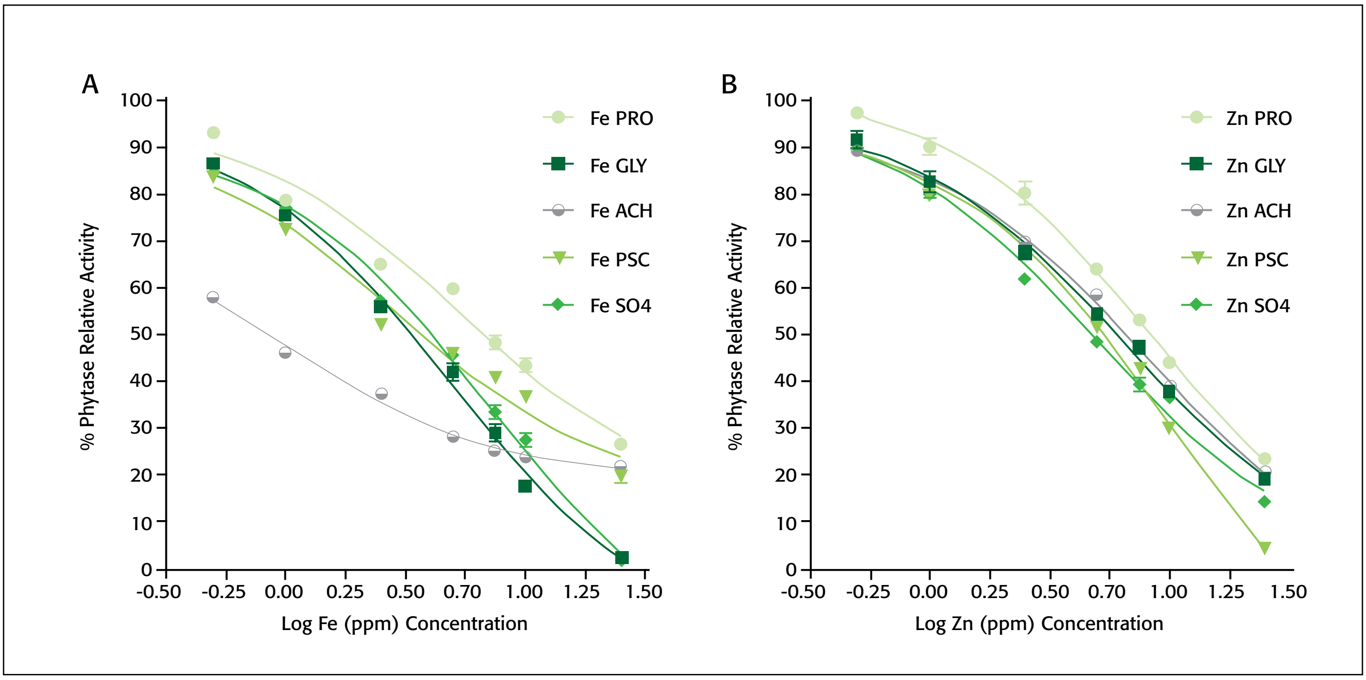
The authors conducted a series of in vitro studies to investigate the interactions between trace minerals and oils. Traditional inorganic trace minerals (sulfate), organic minerals (methionine chelate) and a coated mineral complex (MinCo) were mixed with corn, soybean meal and fresh soy oil. The samples were placed in an acceleration chamber with continuous stirring at 50°C at 75% humidity. Oil saponification and peroxide value of the extracted oil were determined (Fig. 4).

The highest level of oxidation was observed in the sample containing inorganic trace minerals, peaking at 72 hours after mixing. The second highest level was observed with the organic/inorganic trace mineral combination, peaking at 7 days.

Table 2: The impact of trace mineral form on enzyme retention in broiler diets.

	Fresh diets	Stored for 21 days	Loss, %
Xylanase activity, VU/kg feed			
Inorganic (sulfate)	2,303	1,920	- 16.6
Organic (Amino acid)	2,144	1,977	- 7.8
Coated mineral complex (MinCo)	2,351	2,198	-6.5
Phytase activity, FTU/kg feed			
Inorganic (Sulfate)	922	764	- 17.1
Organic (Amino acid)	948	600	- 36.7
Coated mineral complex (MinCo)	883	786	-11.0

Figure 3: Phytase activity when mixed with various forms of iron (left) and zinc (right).



* PRO: proteinate; GLY, glycinate; ACH, amino acid chelate; PSC, polysaccharide complex (extracted from Santos et al., 2015).

Table 3: Mineral excretion levels in native chickens at ages Days 28 and 70.

	Age Day 28			Age Day 70		
	Control	Coated	Δ, %	Control	Coated	Δ, %
Cu, ppm	32±1.1	24±1.3	25.0	31±1	22±1	29.0
Fe, ppm	1,266±71	1,141±70	9.9	1,194±67	1,070±66	10.4
Mn, ppm	497±34	345±15	30.6	468±32	324±14	30.8
Zn, ppm	287±26	254±7	11.5	270±25	238±15	11.8

Note: Control as inorganic trace minerals at NRC (1994) levels; Coated: mineral complex (MinCo).

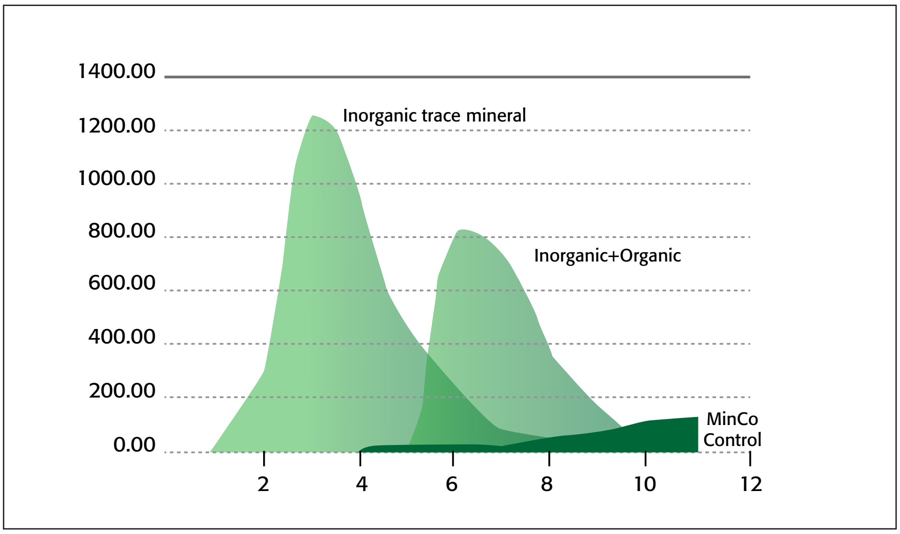
In contrast, the coated mineral complex (MinCo) treatment behaved similarly to the control sample, no significant oxidation of fats in the feed was observed during the 12 days. The lower levels of oxidation support better stability of oil in animal diets and prolonged shelf-life.

Trace mineral impact on environment

Traditional inorganic trace minerals are biologically inefficient and typically require high supplementation levels to meet animal requirements. Wide-spread use has led to high excretion levels and environmental pollution.

A recent trial compared the effect of mineral form on excretion levels in native chickens. The birds were given NRC levels of copper, iron, manganese and zinc in either inorganic or coated mineral complex form (Table 3). Mineral excretion levels were substantially lower in the birds fed on the coated mineral complex treatment, namely Copper by 25-29%, Iron 10%, Manganese 30% and Zinc 11.5%.

Figure 4: Oxidation of oil in feed. Peroxide value, meq/kg.



Conclusion

Providing adequate mineral nutrition is paramount to healthy performance. However, the oxidative effects of trace minerals can severely impact other ingredients, thus impacting overall premix or feed quality and ultimately, animal performance. Coated mineral technology offers the potential to reduce interactions with vitamins, enzymes and oils in premixes and feeds, preserving the quality and palatability of premixes and final feeds whilst extending their shelf-life. AF

*Wenbiao Lu, Sales & Marketing Director, and Yinggu Kuang, President, both with Syno Biotech, China; and Manli Liu (m.liu@synobiotech.com), Technical Consultant, Syno International, Singapore. References are available on request to the corresponding author.