Comparison of SQM trace minerals with inorganic trace minerals on performance and bioavailability as influenced by an antagonist.

The optimum value of trace minerals is how well they can serve their biological function in an animal's body. For trace minerals to keep an animal in good health and performing to their genetic potential, they have to be available for absorption in the small intestines. There are a multitude of compounds and factors that will interact with individual trace minerals that have the potential to reduce their bioavailability or make them completely inert. The true value of organic trace minerals is to protect these highly necessary nutrients from negative factors in the diets and water animals consume. The purpose of this research study was to formulate diets with common feedstuffs that would contain unknown antagonists at unknown levels and compare it to a purified diet containing minimal antagonist. Then a known antagonist was included across all diets to measure trace mineral bioavailability and influence on performance as affected by trace mineral source (inorganic sulfates versus SQM polysaccharide protected).

Materials and methods

Three trials were conducted in this study to measure performance impact, bioavailability (as measured by digestibility) and net mineral retention.

Performance study

A 42-d performance study was conducted utilizing 1920 Straight Run Broiler chicks in 64 pens containing 30 chick/pen. Each pen contained 1 water fountain and a 50 lb capacity feed tube. Pen density provided 0.67 ft^2 per bird initially. Bird weight was measured at the midpoint of the study (21 days) and completion (42 days). Feed efficiency was calculated based on total pen bird weight and total feed intake throughout the 42 day study. Birds were monitored daily for morbidity and mortality.

Diets (which were used in all three studies) were formulated to contain 20% crude protein, 5.0% fat, 0.9% calcium, 0.45% phosphorus, 1.0% digestible lysine, and 0.48% digestible methionine. The normal diet (Corn/Soy) in these trials was formulated using ground corn and soybean meal (47.5% CP) as the base with the remainder of the diet containing soybean oil, limestone, dical, salt, choline chloride, vitamins, Na bicarb, lysine, DL-methionine and selenium nitrate. The purified (Purified) diet contained corn starch and egg white as the base with limestone, dical, choline chloride, vitamins, Dynamate, sand, potassium bicarbonate, solka-flock fiber and selenium nitrate. The trace minerals of interest in the study were zinc, copper and manganese which were provided by either inorganic sulfate sources or SQM polysaccharide protected sources. Each of these sources was added to provide 40 ppm zinc, 25 ppm copper and 40 ppm manganese. As a known antagonist (A), cottonseed hulls were used and incorporated into the diets at 7% replacing primarily corn or corn starch.

Bioavailability study

The Corn/Soy dietary treatment were used to determine bioavailability (4 males/trt and 4 females/trt; 8 bird/dietary treatment) and placed in individual single bird pens for total fecal collection. Birds were fasted for over 20 hours (having water access for 16 hours). After fasting, birds were fed 30 ml of each test diet containing Cr_2O_3 (as an indigestible marker) via a gavage tube. Fecal material was collected and analyzed for mineral content. Ratio of marker to mineral content in the feed was compared to fecal material to determine bioavailability.

Net absorption study

Due to unforeseen problems with the purified diet, a follow-up study was conducted with individual pen/dietary treatment to determine total body net retention of the trace minerals. Sixty-four additional chicks (8 bird/pen; 1 pen/dietary treatment) were obtained and grown out on the remaining diets from the original performance study. At 37 days, all birds were sacrificed and cremated. Ash samples were then analyzed for mineral content and total mineral retained was determined. These values were then used in combination with pen feed intake to determine net absorption/retention during the grow out.

Statistical analysis was conducted using NCSS ANOVA with treatment and two-way interactions evaluated for statistical significance.

Results and discussion

Table 1. Influence of mineral source and an antagonist on broiler performance

Diet[f]	Bird weight, lb	Feed efficiency	Mortality, %
Inorganic	4.262	1.732[a]	4.16[e]
SQM	4.344	1.686[b]	3.73[d]
Inorganic w/A	4.415	1.720[a]	2.49[c]
SQM w/A	4.432	1.680[b]	2.49[c]

[a,b] $P < 0.01$

[c,d,e] $P < 0.05$

[f] Diets formulated for 40 ppm Zn, 20 ppm, Cu, 40 ppm Mn; Inorganic diet used 100% sulfate sources, SQM diet used 100% organic sources; A = antagonist (cottonseed hulls).

In the performance study, the birds fed the purified diet were unable to obtain enough nutrients from the diet to provided normal growth and health for the entire 42 days of the study. Therefore, the purified diet factor in the performance study was removed. It was subsequently hypothesized that there was an electrolyte deficiency that had manifested itself. The third study (Net absorption) evaluated this limitation.

Table 1 shows the results of the grow out performance study. Final weight of the birds was not significantly affected by treatments. The birds receiving SQM trace minerals had significantly better feed efficiency ($P < 0.01$) than birds consuming the inorganic sources, by nearly 2.5% in all cases. There was an interaction in the influence of trace mineral source on mortality. Birds receiving diets not containing an antagonist had significantly ($P < 0.05$) reduced mortality when SQM was in the diet compared to the inorganic sources. Diets containing the antagonist were not influenced by trace mineral source.

Figure 1 shows the influence of trace mineral source and an antagonist on individual mineral bioavailability. Zinc bioavailability was significantly ($P < 0.01$) improved when the zinc was protected by the SQM technology in all diets compared to zinc sulfate. There was a tendency ($P < 0.12$) for an interaction between trace mineral source and inclusion of an antagonist where the antagonist reduced zinc bioavailability from the sulfate source by nearly 30% whereas it had no effect on zinc bioavailability more than the SQM. This tendency would indicate that in the presence of an antagonist one might expect to see approximately a 155% improvement in zinc bioavailability by feeding SQM zinc compared to zinc sulfate. The bars in the middle of Figure 2 show the bioavailability of copper. It was expected that the antagonist would have the same influence on copper that it had on zinc. This turned out not to be the case. The results of this study indicated that copper protected by SQM technology was significantly ($P<0.01$) more bioavailable than copper sulfate regardless of the presence of an antagonist. With or without the antagonist copper bioavailability was nearly two-fold greater with SQM. One hypothesis is that the cottonseed hulls do not interact with copper to the same extent that they do with zinc (ie. binding to reduce availability), and that something that was inherent in the Corn/Soy diet was an antagonist to copper. Manganese bioavailability was not significantly influenced by diet or antagonist. This somewhat supports the hypothesis that cottonseed hulls maybe an antagonist specific to zinc.

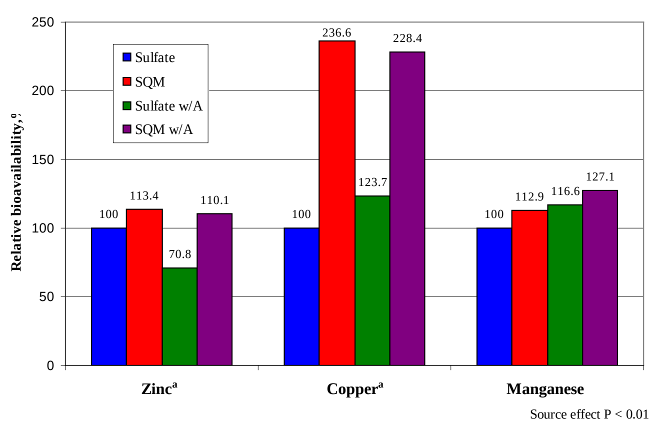

Figure 1. Influence of source and antagonist on trace mineral bioavailability.

Table 2. Influence of diet, mineral source and antagonist on net mineral retention in growing broilers

Mineral	Diet[c]		Source		Antagonist		SE
	Corn/Soy	Purified	Inorganic	SQM	None	With	
	--------------------------% of intake--------------------------						
Zinc	47.07	49.82	40.79[a]	56.10[b]	49.96	46.93	4.15
Copper	19.46	19.79	18.58	20.67	20.58	18.66	1.87
Manganese	37.08	46.14	41.04	42.17	41.70	41.52	2.74

[a,b] P<0.06

[C] Diets formulated for 40 ppm Zn, 20 ppm, Cu, 40 ppm Mn; Inorganic diet used 100% sulfate sources, SQM diet used 100% organic sources; A = antagonist (cottonseed hulls).

Table 2 shows the results of the net mineral retention study. Due to the size and scope of this final study, a robust statistical analysis could not be conducted, but a valid main effect means could be tested. Total body net retention of individual trace minerals would indicate what storage capacity might be, but would not be an indicator of total mineral that had been absorbed and used by the bird. Any mineral that had served its function during the study would tend to be excreted; so it would have been absorbed, used and then discarded. These results would be indicative of how body stores could be filled and the status of the animal would be for any potential challenge to growth or health. As expected net retention in birds on the Purified diet was numerically greater than birds consuming the Corn/Soy diet, due to total fewer unknown antagonists. The influence of source was significantly ($P < 0.06$) greater for SQM zinc retention than for zinc from the sulfate source. This difference was over 30% greater for the SQM. Both copper and manganese net retention was numerically superior for the SQM source, but did not achieve statistical significance. The mean influence of the antagonist (cottonseed hulls) was not statistically significant for any of the minerals on a net retention basis but did show the same overall trend of reduced total retention.

Implications

The overall implication of this trial and these studies is that there are factors in feed that will reduce overall bioavailability of trace minerals. Some of these antagonists have been identified but possibly they do not influence all minerals to the same extent. Other antagonists are still unknown and potentially could reduce overall mineral nutrition without visual indicators. This would be the case for an improvement in feed efficiency with no change in growth rate. The addition of zinc, copper and manganese protected with the SQM protection technology to animal's diets will help to avoid putting those animals into potential situations where a demand for a specific trace mineral cannot be met by body stores.

Study location

This study was conducted at the VDRC Private Research Facility, Harrisonburg, VA