

A highly bioavailable monovalent source of copper has shown superior pig performance compared to traditional copper products.



Achieving performance, health, and sustainability – copper source matters



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AXEL MINETTO and DR ALESSANDRA MONTEIRO* report trials that show a monovalent source of copper has shown improved pig performance, and a strong antibacterial effect, with reduced fecal excretion.

Copper (Cu) is an essential micro mineral for pigs, involved in iron transport and metabolism, hematopoiesis, bone formation, and immune function. Cu can also enhance antioxidant capacity. The minimum requirement for Cu by growing-finishing pigs (11-135kg body weight, BW) is 3.0-5.0 mg/kg (NRC, 2012), but supplementing diets with pharmacological doses of Cu (125-250 mg/kg per diet) improves growth performance and reduces the prevalence of diarrhea in weaner pigs. This is why copper has long been used all around the world in pig diets at high dietary levels, much higher than the pig requirements. Since the very first studies, the focus was on its growth enhancing effect at supra-nutritional levels. This positive effect on performance has been consistently reported for almost a century now. However, the mode of action is still under discussion. The positive effect of copper on intestinal health and fecal score remains one of the main hypotheses.

Historical review of copper's uses

Archaeology revealed that the Egyptians were using copper to clean wounds as early as 2400 BC. Two millennia later the Greek doctor Hippocrates was still recommending to use it to treat injuries.

In the 18th century, the British Navy began sheathing the hulls of their ships in copper to prevent the build-up of algae and barnacles. Later during the 19th century, a copper liquid mixture, known as the 'Bordeaux mixture', was used to protect French grapes from fungus. Since then, antimicrobial properties of copper and its ability to fight pathogens have been confirmed by modern science.

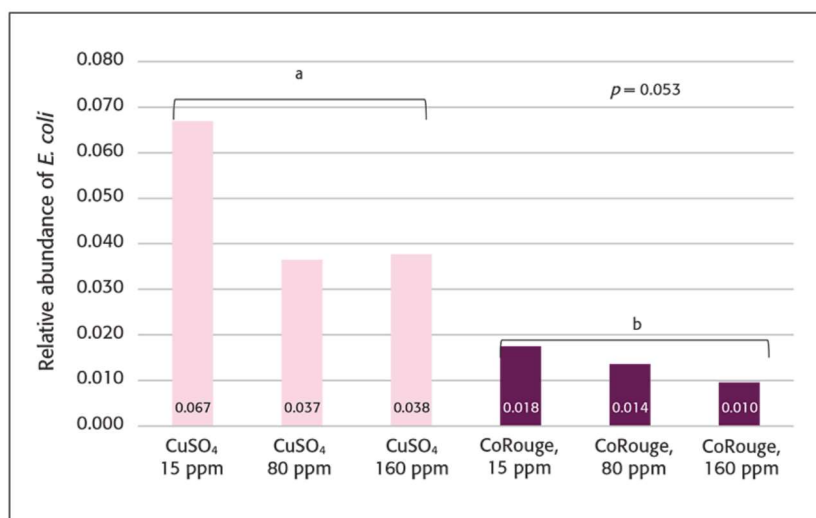
Regarding feed industry, the significance of copper (mainly as copper sulphate - CuSO_4) in growth and development of rats and swine was first reported in 1928 by teams of the Iowa State University. Many other research projects, conducted mostly in the UK and the US, between the 50s and the 80s, repeatedly confirmed the evidence of the positive effect of feeding high dietary copper (100-250 ppm) on weight gain and feed efficiency on piglets and fattening pigs. Conclusions from extensive research on copper doses conducted in the 70s and 80s supported a maximal response when pigs were fed at levels around 250 ppm Cu.

A consistent response of pigs to copper supplementation

A remarkable comprehensive analysis of literature performed by Rosen and Roberts in 1996 demonstrated a maximum response at 200 ppm Cu for weight gain, feed conversion rate and feed intake. They also identified that the response to copper was related to the performance of the control group and the duration of feeding in the experiment.

In this review, frequencies of beneficial responses for supplemented copper (5-250 ppm) were 78% for average weight gain, 64.5% for daily feed intake and 73% for feed conversion ratio. In two-thirds of the experimental groups, both weight gain and feed conversion were improved. In a recent project

Figure 1: *E. coli* reduction in colon according to copper sources and doses.



considering more than 800 articles, reported that copper with zinc was among the most effective alternative to antimicrobial growth promoters for improving average daily gain (ADG), while other alternative categories only reached half or less of this value.

CoRouge the innovative copper source with stronger antimicrobial activity

Absorption of Cu primarily occurs in the small intestine where Cu^+ passes from enterocytes to the interstitial fluids and then to the hepatic portal vein. Absorbed Cu is rapidly deposited in the liver by albumin, and liver concentrations of Cu,

therefore, can be used to assess bioavailability of Cu. However high doses of Cu (150-500 mg Cu/kg) results in an increased Cu accumulation in the liver, which may cause oxidation troubles and reduces performances. In addition, high levels of Cu are known to be oxidative for vitamins, and also cause interactions with phytates for example. This explains why CuSO_4 , the most common source used around the world because of its high solubility and relatively low cost, is now challenged by different sources such as oxides, chlorides, or chelates. These sources are effective at lower dosage and are ►

Figure 2: Pro-inflammatory cytokines and final body weight of pigs fed with different copper sources.

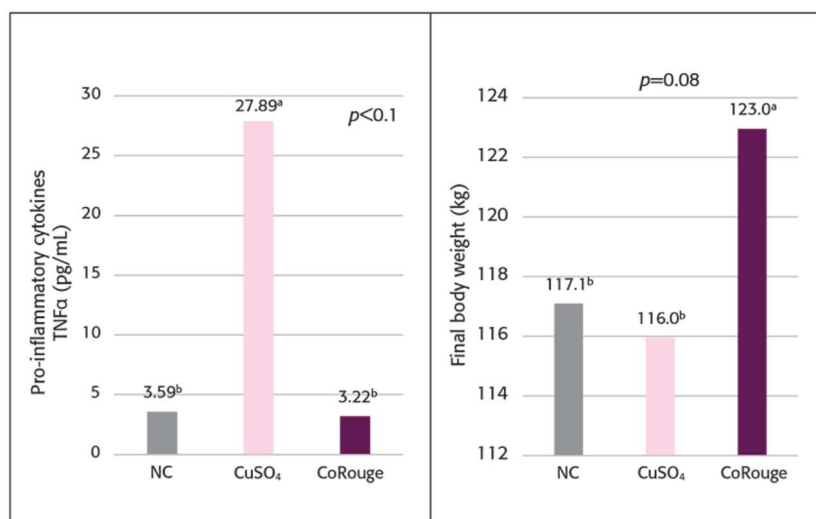
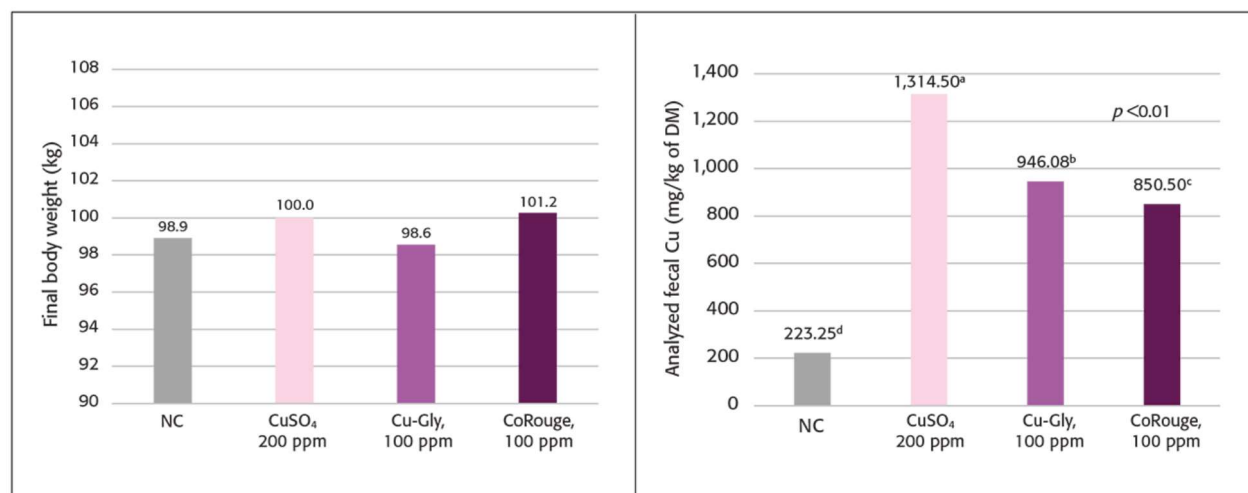


Figure 3: Final body weight and fecal copper of pigs fed with different copper sources.

◁ less oxidative to feed ingredients and animal metabolism.

Nutritionists are searching for the best compromise between animal performance, sustainability, and health. To do that, one good choice could be a monovalent copper oxide, known as CoRouge (provided by Animine), recently introduced in Asia, Europe, and Latin America. This new monovalent copper source is non-water soluble and thus less likely able to negatively interact with the release of phytic phosphorus. Also, this source has shown its ability to better control intestinal microbiota at lower level than CuSO₄ (Figure 1).

Reduction of intestinal *E. coli* in piglets using monovalent Cu has led to higher product efficacy in piglet feeding. The use of this source is a viable alternative for pig farmers seeking performance, compliance, and sustainability. On the economic side, trials conducted across Europe with CoRouge resulted in an extra profit (compared to common copper sources) of EUR0.40-1.60 per piglet, depending on the situation.

Copper, when the source matters!

In Europe, copper is only used the first eight weeks after weaning, but in the most of the world copper is used until slaughter. In this case, the choice of the right Cu source seems relevant to achieve performances, health and sustainability. To answer that question, the University of Illinois in collaboration with Animine studied the impact of Cu toxicity on long-term performance. Feeding

250ppm of sulfates (vs. 250ppm of monovalent copper) all along the feeding phases led to the generation of hepatic oxidative stress markers such as malondialdehyde (MDA) and to the secretion of anti-inflammatory cytokines (tumor necrosis factor α - TNF α and interleukin- β - IL- β , Figure 2) in blood at 63 days of age. As a result the supranutritional dose of sulfates negatively impacted performance at the end of the trial compared to the monovalent form, which was less accumulated in liver.

On the same topic, a field trial performed in Australia with growing pigs also showed an improvement on performance when monovalent copper CoRouge was compared to a chelated copper at same level. Monovalent Cu led to higher body weight (101.2 kg) representing 3% improvement compared to the chelated Cu. This higher growth induced a better FCR thanks to an improved daily gain (intake unchanged among treatments). Carcass parameters (hot carcass weight and lean meat deposition %) were also numerically improved in the monovalent Cu group. At the same time, the fecal Cu was significantly reduced when monovalent Cu was used, minimizing the environmental impact.

Conclusion

Copper is an essential trace element for pigs with a confirmed dose response for growth performance. Currently as Cu levels are under regulatory or environmental pressure - the feed industry is forced

to improve its current practices in order to find a compromise between animal performance, health, and sustainability. In this context, finding the right copper source and the right supplemented level, without impacting pig productivity and profitability is compulsory. CoRouge, the only monovalent copper source in the feed market, could be a unique opportunity for swine nutritionists to benefit from a stronger antibacterial activity to sustain technical and economic performance under pressure to reduce copper supplementation levels all around the world. **Ap**

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