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Copper hydroxychloride as a beneficial tool for broiler production

As consumers demand a transition away from the use of sub-therapeutic antibiotics in broiler production, companies need to explore antibiotic alternatives for the maintenance of broiler health and performance.

Where permitted, supplementing copper above the nutritional requirement of the bird, has been demonstrated to improve broiler performance (Miles, 1998). When fed at nutritional levels (~10mg/kg), copper has both structural and catalytic functions in multiple enzyme systems integral to energy metabolism, tissue growth, red blood cell formation, oxidative defence and immunocompetence (Arias and Koutsos, 2006).

Maintaining copper homeostasis

Since copper is essential for growth and metabolism, biological mechanisms for maintaining copper homeostasis are highly conserved, from simple bacteria to complex vertebrates. These include a multitude of transporters, chaperones, and export and sequestration proteins (Leeson, 2009).

In high copper environments, such as the intestinal lumen of animals fed high copper diets, organisms must upregulate the expression of copper export transporters (Osman and Cavet, 2008). These transporters require significant energy (ATP) to pump copper out of the cell against its concentration gradient. It is possible that the bacteriostatic properties of copper are a result of the diversion of energy away from reproduction/colony growth to maintain copper homeostasis. When a microbe does not have sufficient energy to maintain safe intracellular copper concentrations, the build-up of ionised copper can cause lethal oxidative damage to its cellular membranes and genetic material.

When dietary copper is plentiful, animals downregulate the expression of copper transporter proteins (Osman and Cavet, 2008). Furthermore, the digestion and absorption of other nutrients results in the concentration of copper in digesta as it transits the gastrointestinal tract (GIT). As a result, feeding high copper diets can establish a two to three times higher copper concentration in the distal GIT, creating an unfavourable environment for pathogen proliferation. Limiting proliferation reduces the risk of subclinical performance loss.

Both *in vitro* and *in vivo* experiments have been conducted to determine the effects of high copper concentrations on bacterial proliferation (Klasing *et al*., 2013) and broiler growth performance (Moore *et al*., 2016).

The first experiments determined the minimum inhibitory concentration (MIC) of copper against common broiler pathogens. A follow-up experiment was conducted to assess how well these bacteria proliferate when using intestinal contents for growth media collected from broilers fed 150mg/kg copper. The final set of three experiments measured the growth performance of broilers fed 275mg/kg copper and exposed to a necrotic enteritis (NE) challenge model, as compared to bacitracin methylene disalicylate (BMD), a commonly used antibiotic growth promoter.

Effect of copper on bacterial growth

MICs of copper against several pathogenic bacteria and a protozoa were determined *in vitro* in two experiments

Table 1: Minimum inhibitory concentration of different copper sources *in vivo*.

MIC, mg/kg Cu	*E. coli*	*C. perfringens*	*S. gallinarum*	*S. enteritidis*	*S. typhimurium*	*L. plantarum*
Experiment 1						
Cu sulphate	600	>600	600	600	ND	ND
Cu hydroxychloride	400	600	600	400	ND	ND
Experiment 2						
Cu hydroxychloride	250 to 500	ND	ND	500 to 750	500 to 750	500 to 750

**ND: Not determined; Cu hydroxychloride = IntelliBond® C, Micronutrients, Indianapolis, IN.*

Table 2: Relative bacterial growth in digesta collected from chickens fed 0 or 150mg/kg Cu from various sources.

Cu source*	*E. coli*	*C. perfringens*	*S. gallinarum*	*S. enteritidis*	*Eimeria* (% viable)
0 added Cu	1,0[a]	1,0[b]	1,0	1,0	79
Cu sulphate	0,47[b]	0,88[b]	1,12	0,93	76
Cu hydroxychloride	0,31[c]	0,78[bc]	1,18	0,90	75
Organic Cu	0,33[c]	0,75[c]	1,09	1,11	81
P-value	0,001	0,015	0,20	0,33	0,51

**Cu hydroxychloride = IntelliBond® C; Organic Cu = AvailaCu*