Microflora modulation by monovalent copper and fat digestibility

In animal feed, fat and oil are important sources of energy. They have to be absorbed and metabolised to be efficiently used by the host, driving the energy to body weight gain.

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As fat sources represent an important cost in formulation, some feed additives were developed to enhance fat digestion and improve performance. Monovalent copper is one of them with a specific mode of action now well described.

Absorption of lipids

The first and limiting step of lipid absorption is the emulsification process, which happens thanks to the bile salts action. They coat the fatty acid, decreasing the size of fat globule and providing more surface area for lipase action. Thanks to their action, the lipase can transform the fat globule into micelles which can be easily absorbed in the intestine.

Bile acids (BA) are synthesised from cholesterol in the liver (primary BA), conjugated to glycine or taurine (conjugated BA) and stored in the gallbladder to be released in the intestine.

In their conjugated form, they are efficient emulsifiers improving lipid digestion. However, they can be deconjugated by the gut microbiota via the enzyme bile salt hydrolase (BSH), and also be converted into secondary BA by the 7a-dehydroxylation.

These enzymatic reactions done by the microbiota are not profitable for the animal metabolism: deconjugated BA are not efficient to emulsify fat; secondary BA can be toxic to the body if in high concentrations. The ideal condition to promote lipid absorption is to limit the action of bacterial BSH enzyme.

Microbial bile salt hydrolyse and fat digestibility

Compelling evidence has shown that inhibition of BSH activity should enhance weight gain by altering the bile acids pool, host signalling and lipid metabolism.

The ability of growth promoter molecules, such as antibiotics, in promoting growth is highly correlated with the decrease in BSH activity.

This mode of action has been shown for many antibiotics growth promoter (salinomycin, avilamycin, bacitracin, monensine, tylosin) and was associated to the reduction of intestinal BSH producers. Lactobacillus species is the major producers of this intestinal enzyme, but Clostridium, Listeria, and Staphylococcus are also identified as BSH producers.

Recently, it has been demonstrated that some specific minerals sources (for example, copper, zinc and manganese) also have an impact on the activity of BSH by two mechanisms: an indirect inhibition by microbiota modulation, similar to antibiotics; and a direct inhibition of BSH enzyme through an interaction on its active site.

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Fig. 1. Live weight at slaughter.

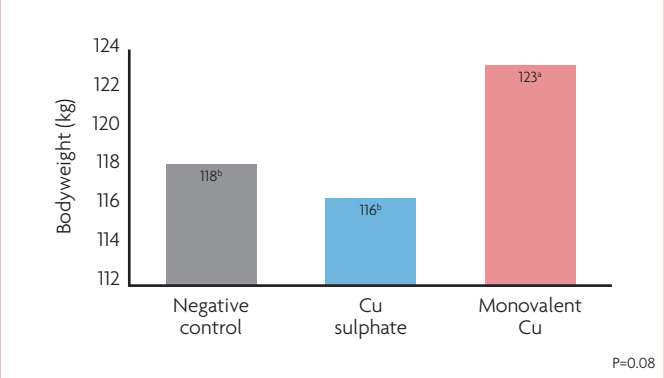
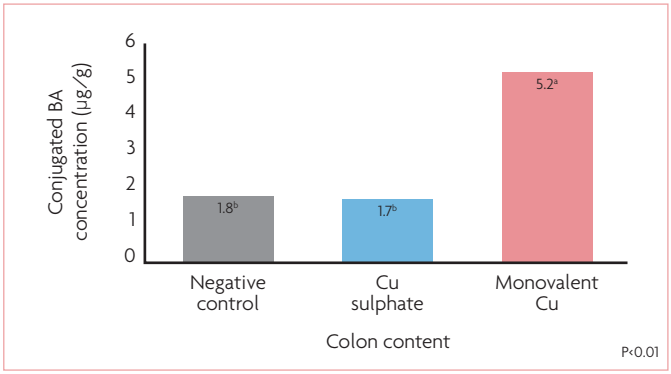


Fig. 2. Primary conjugated bile acids content measured in the colon.



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Among these minerals, Cu compounds have the highest inhibition capacity, but few studies associated their growth promoter capacity to the BSH activity.

Monovalent copper, bile acid metabolism and growth

High dietary levels of Cu have been used for a long time to promote the growth of monogastric animals.

There are no doubts about the efficacy of Cu in promoting growth, but its mode of action is still under debate. One of possible mechanisms is the inhibition of BSH activity, which has an effect on the dietary utilisation and metabolism of lipid. This would render available more energy to the animal.

A recent study conducted by Animine in the USA (at the University of Illinois) has shown that growing pigs fed 250ppm of Cu (from monovalent copper) had a higher body weight compared to a group fed 250ppm of Cu sulphate (divalent copper).

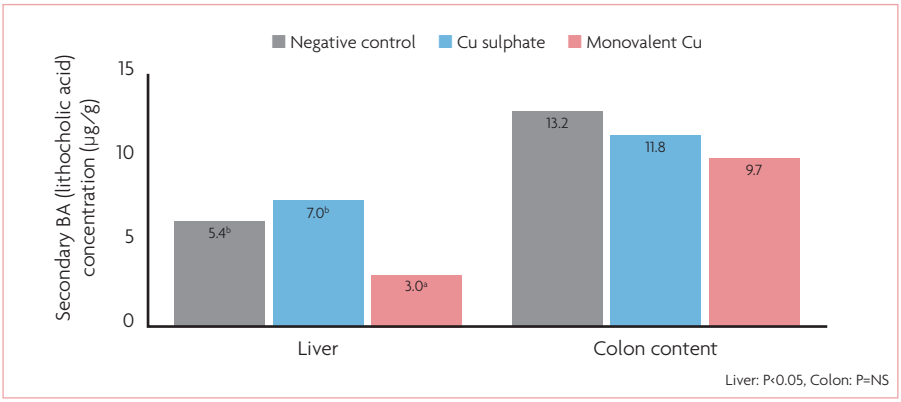
One of possible explanations for this huge effect on performance is the effect of Cu on BSH activity.

Indeed, in this trial was showed that pigs fed monovalent Cu had higher concentration of conjugated BA in the intestine (showing a lower deamination activity of BSH) than Cu sulphate group.

Monovalent Cu group also presented significatively lower concentrations of secondary BA in liver and numerically (-18%) in colon content.

One of possible explanations for the difference between Cu sources would be related to their ionic form. In vitro studies have shown the potency of monovalent copper (Cu+) over divalent Cu (Cu+2) in inhibiting gram-positive and gram-negative bacteria. This would suggest that monovalent Cu would have an indirect effect on BSH activity by reducing BSH-producer bacteria more than divalent Cu.

Fig. 3. Secondary bile acids content.



Conclusion

For years, the use of monovalent copper (CoRouge) in monogastric consistently resulted in higher body weight. Recent scientific investigations revealed that higher amounts of conjugated bile acids produced by a healthy liver are only part of the explanation.

Indeed, the unique ability of monovalent copper to modulate microflora also reduce bacterial deconjugation of bile acids and provides a higher fat emulsification capacity. This results in a better fat digestion and utilisation, providing more energy to improve performance. ■