Copper toxicity in broilers: what is the hidden effect?

Meta-analyses include studies which have been carried out a long time ago, and this is also true for literature reviews concerning the specific use of copper (Cu) as a growth promoter in broilers. But are old experiments still relevant? Could there have been some bias which make the results outdated?

There may have been, in old feed formulas, some ingredients which interfered with the objective of the study.

As an example, we will focus on the interactions between a trace mineral (copper) and a molecule (roxarsone).

by Alessandra Monteiro and Stéphane Durosoy, Animine, France. www.animine.eu

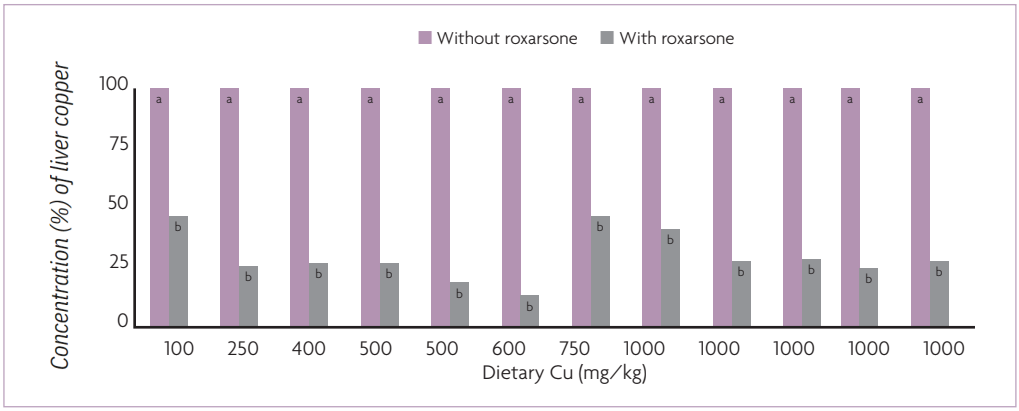


Fig. 2. Reduction (in percentage) of hepatic copper due to roxarsone inclusion in broiler feeds. Differences between with and without roxarsone are P<0.05.

Copper usage as a growth-promoter

Supplementation of copper at high dietary levels to promote the growth of monogastric animals has been popular for decades.

From the 1970s, many studies have been conducted evaluating the effect of Cu addition on broiler performance (Fig. 1).

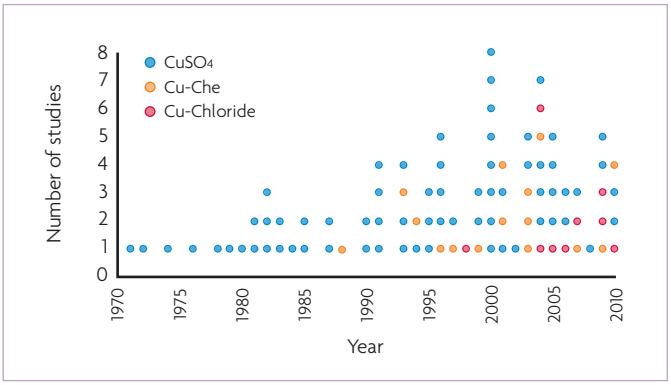
Before the 1990s, most trials evaluated the use of copper sulphate ($CuSO_4$), but the use of other sources has emerged since.

High doses (>100mg Cu/kg in the complete diet) of Cu from CuSO4 result in a linear increase in copper accumulation in the liver of poultry. A study performed at the University of Barcelona compared the effects of high Cu supplementation from CuSO4 or from copper(I) oxide (CoRouge, Animine).

Broilers fed copper sulphate had, after 35 days, the highest liver Cu concentration and impaired growth performance.

It is reported that Cu accumulation in hepatic tissue may initiate oxidative damage, due to the harmful production of free radicals.

Fig. 1. Number of scientific publications on the use of copper as a growth promoter in broilers.



Use of arsenical compounds as feed additives

Arsenic, a chemical element which is highly toxic, is used in many industrial processes, as well as in pharmaceuticals, pesticides, and feed additives.

The use of arsenicals as antimicrobial and anti-cancer agents is well-established.

Organic compounds containing arsenic were first approved in poultry feeds in 1944 by the US Food and Drug Administration (FDA).

The objective was disease prevention, growth promotion, enhanced feed utilisation, and improved meat pigmentation.

Among arsenic compounds used in the feed industry, arsanilic acid, nitrosone, and roxarsone were the most common.

It was estimated that in the late 1990s, roxarsone was used in 70% of broiler feeds in the USA. In 2010, of roughly nine billion chickens raised for human consumption in this country, 88% received roxarsone.

The most common dosage was around 50mg/kg and the lowest level was 23mg/kg. Its use did not require a prescription but was highly effective symbiotically with monensin and salinomycin against the coccidia E. tenella.

Roxarsone was commonly used in most countries outside the EU until recent years. A growing number of studies showed that this derivative of phenylarsonic acid was associated with the contamination of inorganic arsenic in edible poultry products.

In the USA, the industry voluntarily began ceasing its use in 2011, followed by prohibitions in other countries such as Canada, Australia and The Philippines.

In some Asian countries like Vietnam and Indonesia, 3-nitro branded roxarsone was still widely used in 2016, mostly for the pigmentation of broilers. In the case of China, the country only officially banned the use of arsenic-based feed additives in 2019.

Effect of roxarsone on copper metabolism

Several studies have tested the interaction between roxarsone and copper metabolism. They showed a reduction, at least by half, of hepatic Cu in broilers fed with roxarsone (Fig. 2).

The mechanisms by which roxarsone interferes with Cu metabolism may be related to the depressive effect of arsenic on liver copper content, because of chelating characteristics of the nitroso and hydroxyl group of this element via the Baudisch reaction, causing a reaction with copper and formation of a complex that is absorbed, transported and excreted into the urine.

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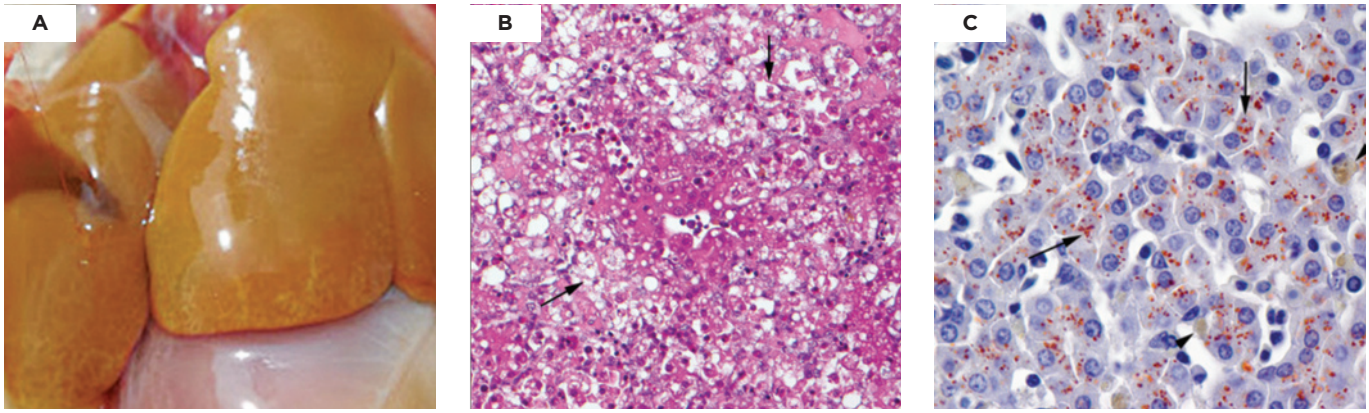

Fig. 3. Diffusely pale and brownish-orange liver with some white linear streaks on the surface in a chick with copper toxicosis (A). Photomicrograph of the liver showing centrilobular degeneration and acute coagulative necrosis of hepatocytes (arrows; B). Photomicrograph of the liver showing abundant accumulation of copper pigment in the cytoplasm of hepatocytes (arrows; C) (Malinak at al. 2014. Avian Diseases 58:642–649).

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Toxicity from copper accumulation in the liver

Several studies have shown that high levels of Cu can induce oxidative damage and immune dysfunction. Cases reported by the University of Georgia (USA) showed that the excess in copper intake caused copper toxicosis in broilers. Most chicks had pale viscera and yellowish to brownish-orange discolouration in the liver (Fig. 3A).

There was mild to moderate centrilobular to diffuse vacuolar degeneration and occasional acute coagulative necrosis of hepatocytes (Fig. 3B), and cells containing golden-brown pigment in the cytoplasm, mild to moderate bile duct hyperplasia in the liver (Fig. 3C).

Conclusions

Most studies from recent decades on the supplementation of copper sources in broiler feeds are outdated as roxarsone was commonly used. This arsenical compound interferes with copper metabolism, inducing less Cu accumulation in the liver and consequently less risk of animal toxicity.

With the ban on roxarsone in the poultry industry, the use of copper sulphate at growth promoting level may increase the risk of copper toxicosis.

The trend in favour of heavier birds at slaughter age exacerbates this risk due to the longer lifespan of animals.

Supplementation with monovalent copper oxide improves weight gain of growing monogastric animals (pigs, broilers) without Cu accumulation in the liver.

CoRouge can be used at a nutritional level to supply highly bioavailable copper, and at supra-nutritional dosages to preserve animal productivity, health and welfare. ■

References are available from the authors on request