

# COPPER SUPPLEMENTATION

## 2. From heifers to milking cows

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Copper supplementation in dairy farms remains a challenge, as cases of deficiencies and intoxications are still reported in several countries. Therefore, it is important to know how copper metabolism changes during the life of animals, from heifers to milking cows. It is also important to know the external factors that modify Cu metabolism in ruminants.

Copper (Cu) is an essential structural component of more than 300 enzymes. These enzymes are necessary for ATP and melatonin synthesis, maintenance of adequate antioxidative status (cytochrome oxidase, superoxide dismutase, tyrosinase, and lysyl oxidase) and also for the formation of keratin and connective tissue.

Even if copper requirements are well known, Cu is the most common trace mineral (TM) deficiency in ruminants due to the interaction with some antagonists including sulfur (S), molybdenum (Mo) and iron (Fe) that influence its kinetics and uptake. This deficiency is characterised by low body weight, loss of hair pigmentation, reproductive cycle abnormalities (anestrus, embryonic loss, polycystic ovaries), and greater incidence of diseases due to depressed immune function.

To avoid potential negative effects of a poorly mineral-balanced diet, cattle feeds are often supplemented with Cu, and other TM, without taking into account the native mineral content in forages. This situation leads to over-supplementation of Cu, and Cu chronic poisoning (CCP). One explanation for this is that ruminants have a reduced ability to increase biliary and urinary excretion of Cu, coupled with a small margin between deficiency and toxic concentrations.

### Is Copper Chronic Poisoning a frequent pathology?

Most UK dairy farms are overfeeding Cu between two and three times the recommended dietary concentration of 11mg/kg DM. In addition, around 38% of cattle at slaughter have liver Cu concentrations that are either very high or toxic.

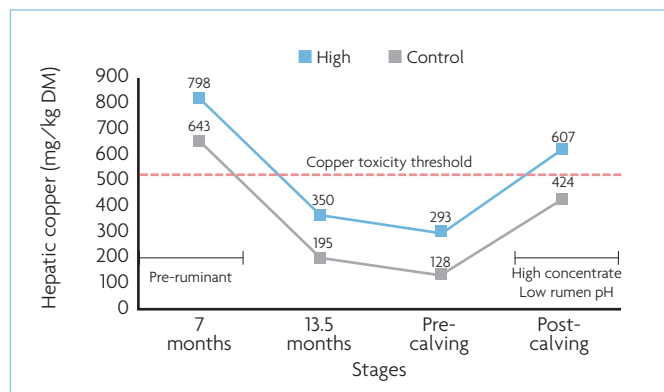
The mechanism of CCP involves long-term ingestion of dietary Cu above the recommended dietary concentration but still below the level that would lead to immediate toxicity.

In this situation, copper-binding proteins become saturated and inefficient in aggregating Cu within the lysosomes of hepatocytes. Copper is released from necrotic hepatocytes into the bloodstream when Cu stores are overloaded.

**Table 1. Fertility performance of heifers that received a Control (15ppm) dose of Cu, and the ones that received a High (30ppm) dose of Cu.**

Fertility indicator	Control <sup>1</sup>	High
Onset oestrus (days)	359	299
Services/conception	1.4	1.9
Pregnancy at 1st service (%)	59.4	46.9
Pregnancy at 1st and 2nd service	96.9	75.0

<sup>1</sup>Treatments: Control; 15mg total Cu/kg DM, High; 30mg total Cu/kg DM



**Fig. 1. Hepatic Copper concentrations (mg/kg DM) in cows supplemented with a Control vs High diet (15 and 30ppm of Cu respectively).**

This phenomenon is accelerated with a stressful event, such as transport, calving, or ingestion of hepatotoxic plants.

Unbound Cu acts as an oxidising agent resulting in damaging the cellular membrane of erythrocytes which leads to a hemolytic crisis. In the absence of mortality, there may be negative effects of CCP on the health and performance of dairy cattle and heifers.

### The danger of over-supplementing copper in early life

A project led by Harper Adams University aimed to determine the long-term effects of over-supplementing Cu during rearing and lactation on the performance, health and fertility of dairy cattle. Heifers were evaluated from 4-22 months of age. Two treatments were compared: 15ppm/kg DM of total Cu (Control) vs. 30ppm/kg DM (High).

#### Elevated hepatic copper concentrations and liver damage

Liver Cu concentration varies during the life of animals, according to internal and external factors. As explained before, the increase in liver Cu concentration can cause damage in this organ. This effect can be assessed by measuring the concentration of the enzyme glutamate dehydrogenase (GLDH).

Heifers that received high Cu dose had higher hepatic Cu concentrations throughout the duration of the study (Fig. 1). High hepatic Cu concentrations at seven months of age were associated with high serum concentrations of GLDH indicative that heifers on both treatments were subject to considerable liver damage at the beginning of the study.

For both groups of heifers on High and Control, lower hepatic Cu concentrations were observed during the pre-calving period.

This decrease was associated with a decline in GLDH values to within their normal range. However, during post-calving, Cu concentration increased mainly due to the increase of starch and concentrates in the diet of milking cows. This situation decreased rumen pH, leading to an increase in Cu absorption and bioavailability (see previous article 'Copper metabolism: The unknown consequence of SARA').

### Impaired reproduction performances

This study showed that feeding high amounts of Cu reduces the reproduction performances of the heifers.

As presented in Table 1, days to oestrus were earlier with high Cu, the conception rate lower and services per conception higher with high Cu feeding. It is well known that fertility in ruminants is highly dependent on their nutritional status.

Trace minerals, and Cu mainly, are involved not only in the synthesis of reproductive hormones but also in the improvement of the uterine micro-environment for embryonic implantation, foetal growth and development.

There is also no doubt that maternal nutrition affects offspring performance and can affect the health and productive life of descendants.

However, supplementation of trace elements in excess of requirements may cause subclinical toxicities or mineral imbalances and result in impaired reproductive performance.

The findings of Olsen et al. (1999) support these statements as they stipulated that supplementing cows with a high amount of copper decreased the number of non-pregnant cows compared to the control group (14% vs 0%).

### Reduced milk yield and negative energy balance

In the same study, supplementing heifers with High dietary Cu concentrations during the rearing phase and first 14 weeks of first lactation decreased early lactation performance.

Overfeeding Cu (30ppm) during the early stages of life made heifers gain more daily weight, reaching the first service heavier.

After calving, the High Cu group had a more pronounced negative energy balance than heifers receiving 15ppm of Cu. Indeed, higher BHB in the blood were observed for the High Cu group reflecting a greater mobilisation of body fat tissue and numerically less milk produced (High Cu: 32.0kg/cow/d vs Control: 33.1kg/cow/d).

### How should heifers be supplemented with Cu?

In the first months of calves' life, Cu supplementation should be closely monitored.

At this stage, these animals are physiologically monogastric (pre-ruminants), as their rumen is not completely functional yet, which makes them less susceptible to interaction between copper and its antagonists. Thus, Cu is more bioavailable for calves than for adult cattle. The main objective of a good Cu supplementation is to avoid over-supplementing Cu during the growth period.

Therefore, we need to evaluate the native Cu content in every feedstuff distributed to the heifers including the mineral feed, boluses, drench, etc. Today, it is possible to have a precise mineral supplementation, with a handheld analytical tool that uses XRF technology (X-Ray fluorescence) to instantly analyse mineral content in forages. This tool, named AniGun, also measures the concentration of Cu antagonists such as molybdenum, sulfur and iron, making the recommendation of Cu dose even more precise. In addition, supplementing a stable source of Cu (CoRouge) should help to reach the requirements of heifers, reducing the interaction with antagonists in the rumen, and leading to greater bioavailability.





### Take home message

Over-supplementing heifers with high levels of Cu impairs fertility and affects negatively their productive performance as future dairy cows. Cu supplementation should be very precise to avoid not only low performances but also rejection of the soils and pollution of the environment.

It is then recommended to know the native amount of Cu in the basal diet, to supplement with a stable source of Cu, and ensure proper rumen conditions.


This article is part of a series on copper in ruminants.

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