

# Mineral availability – the forgotten limiting factor?

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Widespread mineral nutrient depletion occurs in soil from areas where there is high efficiency crop production. Low levels of minerals in soil result in low levels of minerals taken up by cereals that are then used as feed ingredients.

With increasing pressure to maximise production now bioethanol production is in full swing this problem can only get worse.

The intensive production of agricultural crops continues to deplete soil of mineral nutrients.

In intensive cropping regimes standard fertiliser applications of nitrogen, potassium and phosphorous are made, but little is done to maintain trace mineral levels that are also vital for maintaining yields. In the UK for example magnesium deficiency has long been a problem in wheat production.

## Low levels of minerals

The resultant low levels of minerals in the soil inevitably limit the levels of minerals taken up by cereals that are then used as feed ingredients.

Table 1 shows how mineral levels in soils have reduced mineral levels in crops and the animals feeding from them.

Mineral requirements for poultry are dependent on the level of production and for modern strains of birds these require-

**Table 1. Changes in mineral content of different types of vegetable crops (27 varieties), and meat measured between 1940 and 1991.**

Mineral	Vegetable (%)	Meat (%)
Sodium	-49	-30
Potassium	-16	-16
Phosphorous	+9	-28
Magnesium	-24	-10
Calcium	-46	-41
Iron	-27	-54
Copper	-76	-24



**Unique carrier promotes acid activity from feed production to the end of the digestive tract.**

ments are likely to be high. Minerals are added to feed through commercial premixes to compensate for the low levels that are naturally found in cereals.

These minerals are usually in the form of inorganic salts that may not be readily available to the animal. However, inorganic trace minerals are inexpensive so there can be a tendency to over-formulate to ensure a generous safety factor.

Poor bioavailability of inorganic minerals supplied in excess will result in high levels of minerals being excreted into the environment with possible increased water intake and the resultant wetter litter problems.

Increasing the bioavailability of minerals by adding protected acids to premixes can reduce the inclusion of inorganic minerals in poultry feed and reduce the loss to the environment.

It is possible to increase the availability of minerals by maintaining the presence of chelating fatty acids in the intestine. Acid salts are known to be highly soluble compared with simple inorganic oxides and carbonates.

Initial studies in this area were conducted with major minerals such as calcium when looking at skeletal development or egg shell strength but the evidence is clear that natu-

rally occurring mineral/acid complexes can boost the supply of many of the sub-optimal minerals found in commercial animal feeds.

In order for minerals to pass through the lining of the intestinal tract into the blood, the minerals must be soluble. If the minerals are not used immediately, they will either be stored, or they will be excreted.

## Chelated trace minerals

To be transported from the stomach to other parts of the body, the nutrients must either be soluble in water or be combined with other particles such as proteins that are carried in the blood. Nutrients that are stored in the body are typically stored in fat cells, so they must be soluble in fat. Finally to be excreted via the urine, a nutrient must be water soluble.

Several organic acids are known to be extremely efficient for this purpose as they are both hydrophilic and lipophilic, satisfying both main requirements for digestion and metabolism.

Chelated trace minerals are reported to be at least 30% more bioavailable when compared to simple inorganic trace mineral

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salts fed to broilers. This is because chelates easily pass through the intestinal wall into the blood stream. With improved solubility the minerals are transported by passive absorption and there is less risk of mineral interactions.

The overall benefit to the animal is based on the percentage of the mineral in the chelate, the solubility and the bioavailability. In the case of iron, ferrous lactate has high bioavailability.

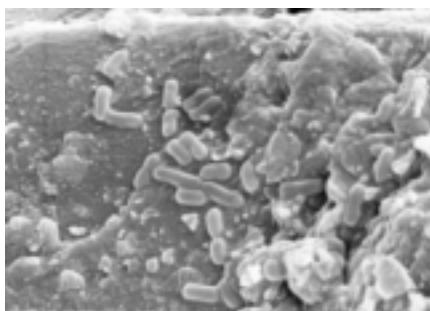
## Chelating agents

Many organic acids that can act as chelating agents including acetic acid, ascorbic acid, citric acid and lactic acid. Lactic and propionic acids are moderate chelators and can be produced in the intestine in significant quantities when conditions are correct.

Lactic acid producing bacteria ferment carbohydrate from the feed to produce lactic and propionic acids.

Growth rates of Lactobacillaceae can be rapid in the anaerobic, high nutrient density mesophilic conditions of the chicken intestine.

However, these bacteria are acidophilic, colonising the upper intestine from the crop, proventriculus and gizzard. Intestinal pH is increased in the duodenum by a combination of bile salts and bicarbonates to enable



**Lactic acid bacteria colonising an acidified mineral carrier.**

enzymatic digestion further down the intestine, and the presence of undigested and poorly soluble calcium carbonate from the feed continues to drive the pH of the intestine and caeca more alkaline further limiting mineral availability.

Simple addition of acids to the feed is inadequate as a means of adjusting intestinal pH due to the natural digestive processes that consume these acids as energy sources.

In cases where liquid or weaker acids are used inclusion rates may be prohibitively expensive. This is because animal feeds have a high buffering capacity and have a tendency to be alkaline in nature.

The change from animal proteins to soya has exacerbated this swing, as soya is twice as buffering as fishmeal, whilst yeast products also push up the buffering capacity.

By providing a protected acidic microenvi-

ronment with a large surface area for colonisation, it is possible to increase the numbers of lactic acid producing bacteria in the gut.

## Lowering the pH balance

Optimising the acid producing gut microflora will lower the pH in the intestine and the increased production of lactic acid will improve the availability of minerals to the animal.

It is therefore possible to increase the bioavailability of minerals by enhancing organic acid production in the intestine.

This has been successfully achieved using a combination of exfoliated minerals and micropearls to provide a slow release of carefully buffered organic acids in the intestine and to provide an ideal mineral base beneficial acidophiles can colonise.

This process is similar to the bead fermentation process used in the microbiological production of other beneficial metabolites but in this case it can be performed in-vivo.

Electron micrographs of the carriers used in Kiotechagil's Salkil have clearly shown the association between the beneficial lactic acid producing bacteria and the carrier matrix.

This is an indirect, safe and effective means of altering intestinal pH, to have a direct impact on nutrient bioavailability, which in turn is vital if we are to optimise breeding, fertility and hatchability. ■