MINERAL ANALYSIS: BLOOD VS LIVER SAMPLES

Farmers are usually well aware of the potential negative effects they can expect from trace mineral deficiencies or toxicity. One example is Selenium deficiency which is linked to White Muscle disease and infertility.

Trace mineral deficiencies are often blamed for poor animal production, although several other factors can influence production, like an energy shortage in the feed, or the presence of parasites or liver fluke.

Unfortunately clinical signs associated with mineral deficiencies can be slow to develop. Therefore deficiencies should be confirmed by an analytical verification and a nutritionist should recommend the levels of additional supplementation. Analysis reflecting the mineral status will be of little value if broader health and production problems on the farm are not addressed as well.

Historically testing has been performed on feed or dietary components (for example grazing) to ensure adequate mineral levels in the diet. However, feed analysis does not identify the bioavailability of these minerals. The availability and absorption of minerals are also influenced by the presence of other minerals; some minerals compete with each other and may prevent the absorption of another.

In theory it would then be more reliable to do analysis on the minerals that ended up in the body or a marker or enzyme that indicates the mineral status.

A variety of samples from live animals can be tested for minerals. The most common samples are blood and serum, other samples include liver biopsies, urine, hair and milk. Milk is not typically used to evaluate the mineral status of an animal, because mineral levels can vary through and across lactation and can also be affected by disease. Hydration has a significant effect on urinary mineral content, making it a poor sample for mineral status evaluation.

Biochemical analysis is conducted on tissue with the assumption that the mineral activity reflects the status of the mineral at the functional site. This is not always true because factors interacting with metabolism of minerals differ from site to site. Sites of sampling are usually chosen because of convenience, rather than choosing the site with the highest mineral activity. Interpretations of results are usually based on experience rather than on proven evidence.

The rate of change of mineral levels in tissue or body fluid after increasing mineral intake varies tremendously between minerals. Some elements like Cu, Se and Vitamin B12 which is stored in the liver follow a positive linear increase (within limits) with an increase in mineral intake, making tissue concentration ideal to use. But such a linear accumulation can't be measured with Ca and P which is stored in bone. Minerals like Pb, Zn and Mg are also stored in bone with excessive intakes, but can only be released when Ca and P are mobilised.

In case of toxic intakes of minerals, the high levels won't reflect in tissue until some threshold value is reached, where-upon it increases dramatically.

Phosphorus (P)
P intake is reflected in the P concentration in plasma/serum, but not necessarily the P status. There are also many factors that can affect the plasma/serum P concentrations:

- Elevated stress from infections and exercise
- Age, first lactation cows have higher P levels than older cows
- Serum levels increase as milk yield decreases
- Serum P levels increase for two hours after feeding, then decrease
- A Ca deficiency can cause high P concentrations
- Site of Sample collection (jugular vein have lower P concentration than mammary gland and coccygeal)

Mineral composition of bone is not really affected by low intake of P or Ca, and bone ash analyses provide low or no indication of Ca or P status. But rib bone P (mg P/cm³) reflected the dietary P intake in a study done by Karn (2001), whereas the liver, kidney, heart and muscle P concentrations didn't. But P concentration in rib bone must be evaluated with the factors above and accuracy of measurement isn't reliable.

**Calcium (Ca)**

The mechanism of absorption and mobilization of Ca makes it unreliable to use bone alone to estimate the Ca status of an animal. Hormonal changes for example after calving, increase Ca demand, this increase Ca mobilisation from bone. The essential change is a reduction in the total bone mineral content with little change in bone mineral composition.

**Copper (Cu)**

For ruminants liver Cu levels increase linearly with Cu intake and is a good measurement, but this is not the case in monogastric animals or hindgut fermenters. Because the liver is a storage organ, Cu levels show the level of depletion rather than deficiency. Serum levels increases slowly with higher intake only up to a certain level and remain constant except when high Molebdenum levels are present. (High Mo levels causes above normal Cu concentrations, but this Cu is unavailable to the animal)

**Selenium (Se)**

Selenium is one of the few elements where liver and whole blood tissue is positively correlated with intake.

**Cobalt (Co)**

It is difficult to measure the Co status of animals. Concentration in the liver does respond to dietary changes, but isn't a very sensitive indicator of Co status. The serum level of vitamin B12 can be used to determine the Co status, but lab to lab variation make diagnosis unreliable. Another option is to measure vitamin B12 in milk, this method has less analytical problems. Therefore the Co concentration of the diet is valuable in the interpretation of an animal's Co status.

**Iodine (I)**

Liver Iodine levels don't correlate with intake levels, but the concentration in milk increase linear with intake. T3 and T4 levels can be measured for an indication of Iodine concentration. The weight of a fresh thyroid gland can also be used to indicate the iodine status of the animals.

**Iron (Fe)**

Both blood and liver analysis give a reasonable indication of Fe intake of an animal.

**Lead (Pb)**

Both Liver and kidneys must be analysed to diagnose Pb toxicity, the concentration in the liver and kidney varies with acuteness of toxicity.

**Manganese (Mn)**

Mn levels in blood, bone, hair and liver decline only slightly in animals with a deficiency; Mn concentration is so low in the body that it makes it difficult to measure it accurately. Liver analysis is most frequently used because it contains the highest Mn concentration, but it shows little deviation with change of Mn intake. The most reliable way to measure Mn is the diet itself.

**Zinc (Zn)**

Analysis of Zn concentration of tissue is a very inaccurate indication of the Zn status of an animal. Symptoms of Zn deficiency shows long before they can be
detected in tissue (blood/liver). Factors like stress and microbial infection have a big influence on Zn levels in tissue.

**Table 2:** Useful analyses in predicting mineral status of livestock (Adapted from Judson & McFarlane, 1998) (Most of these measurements do not necessarily have a high reliability)

<table>
<thead>
<tr>
<th>Element</th>
<th>Liver</th>
<th>Blood/Plasma</th>
<th>Bone (Rib)</th>
<th>Milk</th>
<th>Kidney</th>
<th>Feaces</th>
<th>Feed/Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>Ca</td>
<td>Ca*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ca¹</td>
</tr>
<tr>
<td>Mg</td>
<td>Mg¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>P</td>
<td>P¹</td>
<td>P²</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co</td>
<td>B12</td>
<td>B12, MMA</td>
<td>B12</td>
<td></td>
<td></td>
<td></td>
<td>Co¹</td>
</tr>
<tr>
<td>Cu</td>
<td>Cu¹</td>
<td>Cu</td>
<td>Cu</td>
<td>Cu²</td>
<td>Cu²</td>
<td>Cu²</td>
<td>Cu, Mo, S, Fe, Zn</td>
</tr>
<tr>
<td>Fe</td>
<td>Fe¹</td>
<td>Hb¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>T4, T3¹</td>
<td>I¹</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td></td>
<td></td>
<td></td>
<td>Mn²</td>
<td>Mn¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Se</td>
<td>Se¹</td>
<td>Se¹, Gx</td>
<td>Se</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>Zn²</td>
<td></td>
<td></td>
<td>Zn²</td>
<td>Zn¹</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pb</td>
<td>Pb¹</td>
<td></td>
<td></td>
<td>Pb¹</td>
<td>Pb</td>
<td>Pb</td>
<td>Pb</td>
</tr>
</tbody>
</table>

*per volume bone; **at low dietary levels
MMA = methyl malonic acid; Cp = caeruloplasmin; Hb = haemoglobin;
T4 T3 = tetra- & tri-iodothyronine; GPx = glutathione peroxidase
¹ Most accurate method of analysis highlighted in blue

**References:**

- Van Ryssen, J.B.J., 2003. Predicting the mineral status of livestock from laboratory analyses. UP-Nutrilab Information Day on Laboratory analyses on feeds and animal tissues.