

Mineral supplements – the KISS principle

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Summary

- Minerals are vital for life. Most minerals have more than one function in the body and contribute to the body's structure, cellular processes, and the immune system.
- The vast majority of the 25 minerals required are provided by the diet.
- Of the 7 macro minerals (i.e. required in large amounts) required, only 2 are deficient when the majority of the diet is pasture (magnesium and calcium). Sodium can be deficient when more than one third of the diet is a low sodium feed (e.g. cereal grains) and dietary phosphorus can become inadequate in cows grazing fodder beet.
- Of the 18 trace elements (i.e. required in very small amounts) essential for life, only 5 are likely to be deficient in pasture-based systems (i.e. cobalt, copper, iodine, selenium, zinc).
- Magnesium and the 5 scarce trace elements should be supplemented during the 2-4 weeks before calving and for 4 months after calving. Calcium should be provided to cows in the colostrum herd, but there is unlikely to be a benefit of continued supplementation to milking cows unless the herd is experiencing downer cows.
- Concepts like the dietary cation-anion difference (i.e. DCAD) should be ignored unless a mixed ration is being fed to the springer herd.
- There is virtually no evidence that “organic” trace elements offer any advantage over strategic supplementation with the cheaper “inorganic” elements.
- All sources of trace elements (i.e. pasture, supplementary feeds, water, fertiliser, and mineral supplements) need to be accounted for in dietary plans to avoid the risk of over-supply of any trace element.
- Recommendations for supplementation levels are provided. A trace element strategy should be developed in conjunction with your vet.

Background

It has been known for several hundred years that animals require a dietary source of minerals for optimal body function. For example, it was discovered in the 1780s that canaries reared on cereal grains required ground limestone in their diet to produce healthy

eggs, while, in the 1840s, the requirement for common salt was identified in cattle and it was noted that goitres resulted from a deficiency of dietary iodine. Similarly, the primary metabolic disease associated with mineral deficiency, milk fever, was first recorded in the 1790s in Germany.

Therefore, the concept that an animal requires minerals is centuries old. Despite this, however, there is arguably more confusion today than there was several decades ago around appropriate mineral nutrition for production animals. The purpose of this paper is to highlight the minerals that a dairy cow is likely to require in a pasture-based system, and to propose simple and practical supplementation strategies for optimal health and production.

Introduction to minerals

The subject of mineral nutrition has evolved over the last 200 years, and new discoveries continue to be made. It is now known that 25 minerals are essential for life. However, just because minerals are essential for life, does not mean that they should be supplemented in the diet. Many of the 25 minerals are required in such small amounts that a deficiency is almost impossible. For example, arsenic is required for the production of enzymes and may even be involved in the protection of animals against bacteria. However, there has never been a reported deficiency and there is no requirement for supplementation. In fact, arsenic is more widely known as a poison, and supplementation, even in small amounts, is likely to cause death. ***There are many minerals that are essential for life in such small amounts (e.g. silver, nickel, molybdenum, tin, vanadium, silicon) that one can almost be certain that they will not be deficient under any normal circumstances.***

Minerals essential for life are generally divided into two categories: macro minerals and micro or trace minerals (also known as trace elements).

- The term **macro mineral** refers to minerals that are required in large amounts; requirements are usually referred to in grams (**g**)/cow per day.
- The term **trace element** refers to minerals that are only required in trace amounts; requirements are usually referred to in milligrams (**mg**)/day, mg/kilogram (**kg**), or parts per million (**ppm**).

The macro minerals and trace elements known to be essential for life are presented in Table 1. Of the 25 minerals presented, grazing dairy cows are only likely to be deficient in seven (calcium, magnesium, cobalt, copper, iodine, selenium, and zinc). Cows may also be deficient in sodium and phosphorus when other feeds are consumed (e.g. cereal grains are very low in sodium and fodder beet is low in phosphorus), but are unlikely to be deficient when the diet is primarily grazed pastures. It would be highly unusual for a cow to be deficient in any

of the other minerals or, to look at it another way, for the cow to have a positive production, reproduction, or health response to being supplemented with any of the other minerals.

Table 1. The mineral elements known to be essential for life.

Macro Minerals	Trace elements	
Calcium*	Aluminium	Manganese
Chlorine	Arsenic	Molybdenum
Magnesium*	Chromium	Nickel
Phosphorus†	Cobalt*	Rubidium
Potassium	Copper*	Selenium*
Sodium†	Fluorine	Silicon
Sulphur	Iodine*	Tin
	Iron	Vanadium
	Lead	Zinc*

- *mineral is highly likely to be deficient in unsupplemented grazing cows
- †mineral may be deficient in grazing dairy cows

The function of minerals

There are four broad functions for minerals:

- Structural: some minerals are involved in the structural components of body organs and tissues, with the most obvious example being calcium and phosphorus in bones and phosphorus and sulphur in muscle proteins.
- Physiological: some minerals circulate in body fluids and are components of tissues to help maintain the fluid (osmotic) balance, nerve function, and to ensure that the pH (acidity) of blood does not change greatly. Sodium, potassium, and chlorine are often considered of greatest importance, because of their high dietary concentration, almost complete absorption from the digestive tract, and their role in maintaining acid-base balance. This will be discussed further in the dietary cation-anion difference (**DCAD**) section.
- Catalytic: many minerals act to speed up biochemical reactions in the body; such minerals are known as catalysts.
- Regulatory: minerals have been reported to regulate cellular processes, such as tissue repair, and to improve the killing ability of cells of the immune system.

It should be obvious, therefore, that different *minerals are important for almost every aspect of life*.

Mineral deficiencies

A deficiency in any mineral means that the animal does not have enough of the mineral in the right location in the body to function properly; in other words, if the animal is provided with an available form of that mineral, production, reproduction, or health will be improved.

There are **two main types of mineral deficiency**: clinical deficiency and subclinical deficiency.

- **Clinical deficiency**: Clinical conditions are evident (e.g. red coat and scouring from a cow deficient in copper). There will be a positive production or health response to supplementation with one or more minerals. This type of deficiency is more easy to see and correct for.
- **Subclinical deficiency**: No clinical conditions are evident, but production and/or health will respond positively to supplementation with one or more minerals. This type of deficiency is more difficult to detect and may never become clinical. It is to avoid potentially costly subclinical deficiencies that trace element supplementation is recommended. **Unfortunately, it is also in the area of subclinical deficiency that most “muck and magic” products are sold.**

In addition to the two types of deficiencies, mineral deficiencies are also classified on the management/dietary factor that has resulted in their deficiency.

- **Primary deficiency**: A primary (or simple) deficiency occurs when there is not enough of the mineral in the diet. For example, milk fever during the colostrum period is generally a result of too little calcium in the diet.
- **Secondary deficiency**: A secondary deficiency occurs because of the presence or absence of another mineral(s) in the diet. For example, milk fever at calving is often the result of too little magnesium in the diet or iodine deficiency can be the result of compounds in the diet (e.g. in brassica) that prevent the absorption of iodine.

Mineral deficiencies can also result from both Primary and Secondary causes. For example, copper deficiency in unsupplemented grazing dairy cows results from an inadequate intake of copper in spring combined with excessive intake of iron, sulphur, and/or molybdenum. Similarly, grass staggers is usually a result of inadequate magnesium intake, complicated with greater than necessary intakes of both potassium and nitrogen, both of which reduce the absorption of magnesium. This condition is also generally complicated by the weather, with heavy rainfall increasing the stress on the cow and reducing magnesium intake.

It would appear, therefore, that mineral nutrition is extremely complex. However, it does not need to be. With analysis of some blood, liver, pasture and supplementary feed samples at key times, a farmer can understand which minerals are most likely to be deficient in their system and at what time of the year this deficiency is likely to occur. This empowers them to decide on an appropriate management strategy for the farm that removes the risk of a

deficiency reducing production or negatively affecting health or reproduction. ***The simplest strategy is to identify what minerals are likely to be deficient and when, and provide them to the cow.***

Macro minerals

Of the seven macro minerals identified as essential for life, magnesium and calcium, in particular, should be supplemented as an insurance against metabolic diseases, with the requirement for sodium and phosphorus dependent on what other feeds are being consumed by the cows. Potassium, chlorine and sulphur are unlikely to be deficient in the diet of grazing dairy cows.

Magnesium

Magnesium is probably the most important mineral in the diet of the grazing dairy cow. It is essential in almost every biochemical reaction in the body, not to mention its role in nerve and muscle function, and bone development. Normal blood plasma concentrations are 0.75 to 1.1 mmol/L, but this is dependent on cow genetics and the daily intake of magnesium; although there are large amounts of magnesium in the body, it is not available to the cow. The cow effect is also important; some cows seem to function perfectly well at blood magnesium concentrations that would see other cows die. Because of this, it is important when blood testing that at least 10 cows are selected at random to provide a true reflection of the state of the herd.

Although magnesium deficiency is usually associated with grass staggers (or grass tetany), which is the clinical manifestation of the deficiency, subclinical magnesium deficiency will cause milk fever (a clinical deficiency of calcium) in calving cows, and low milk production when cows are in established lactation. Research in New Zealand in the 1970s highlighted a staggering reduction in the incidence of milk fever when cows were supplemented with magnesium before calving: milk fever declined from approximately 15%/year to less than 5%/year when pre-calving magnesium supplementation was introduced at No. 2 Dairy in 1979. Similarly, a review of the world literature identified magnesium as the most important mineral in the pre-calving diet for milk fever prevention.

Considering magnesium's role in most body functions, the limited amount of magnesium in pasture, and the negative effect of potassium and nitrogen on the ruminal absorption of magnesium, ***it is recommended that cows are supplemented with 20 g magnesium/cow per day from about two to three weeks before calving until four months after calving.*** This is equivalent to 40 g magnesium oxide, 200 g magnesium sulphate, or 140 g magnesium chloride/cow each day, or any combination of the three. There has been very little research undertaken on chelated forms of magnesium (i.e. magnesium bound to an amino acid). However, although the magnesium is probably absorbed more quickly and may be excreted

more slowly from the body, the amount of magnesium supplied by these products is unlikely to protect a dairy cow during early lactation. Their use in horses and beef cattle is probably effective.

Calcium

Adult animals absorb as much calcium from their diet as they need to maintain blood calcium at 2.2 to 2.5 mmol/L. As calcium is very important to smooth muscle function and to the functioning of cells, the body strives to maintain this blood calcium concentration through increasing calcium absorption from the intestine when dietary calcium concentration is low, and through bone resorption, where necessary. However, the ability of the intestine and bone to increase the amount of calcium provided for body processes is slow and can often take days. This has important implications for the calving cow, who must double or treble her supply of calcium in the space of one or two days.

A deficiency in blood calcium results in milk fever, which usually occurs around calving as the calcium requirement for colostrum production increases suddenly (there is 2 g calcium in each litre of colostrum). This is a complex metabolic disorder that will be discussed later. However, dietary calcium can contribute to this disorder in two ways:

- Too much calcium in the diet prior to calving reduces the proportion of dietary calcium that is being absorbed. This means that when a cow calves and requires large quantities of calcium for colostrum production, she is unable to absorb sufficient calcium from her diet to maintain smooth muscle function. That said, it is difficult to get dietary calcium to a sufficiently low level before calving to increase calcium absorption.
- A deficiency of dietary calcium during early lactation, particularly, during the colostrum period, will contribute to milk fever, as the cow will not have enough dietary calcium to absorb to compensate for what is being secreted in colostrum, irrespective of absorption efficiency.

Results from research undertaken in New Zealand indicate that supplementing cows with calcium during the colostrum period will reduce the risk of milk fever after calving. Those experiments also highlighted no advantage to supplementing cows with calcium after they had left the colostrum herd (i.e. after 4 days), unless milk fever is occurring in the milking herd. If milk fever is occurring in cows in established lactation, the milking herd should also be supplemented with calcium.

During the colostrum period, **cows can be supplemented with up to 300 g of limeflour/cow each day**. This can be dusted on pasture or provided to the herd mixed with molasses as a lick. Lower levels of calcium supplementation (~100 g limeflour/cow per day) can be

supplied to cows via in-shed feeding systems during the colostrum period. However, this may not be sufficient calcium to prevent milk fever, particularly in “at risk” cows (i.e. old, Jersey/cross-bred, cows greater than BCS 5.5).

During lactation, there is unlikely to be a benefit to supplementing cows with calcium unless they are consuming large amounts of low calcium feeds (e.g. maize silage, cereal grains). If cows are being supplemented with more than 5 kg DM of a grain-based concentrate, then supplementation with **150 g limeflour/cow per day is recommended**.

Phosphorus

Because of the use of phosphorus fertilisers to maximise pasture production, phosphorus deficiency is very unlikely on dairy farms, even when large amounts of grain-based concentrates or by-products are being fed. The exception to this appears to be in some herds grazing fodder beet during the winter.

In some situations, cows grazing fodder beet get milk fever close to calving and do not respond well to calcium supplementation. In these situations, the milk fever is often complicated by a phosphorus deficiency. This is best overcome by supplementing with **up to 50 g of dicalcium phosphate/cow per day while cows are on fodder beet**.

Surplus dietary phosphorus can also cause milk fever by interfering with the hormones that control calcium absorption. For this reason, care must be taken when offering feeds like palm kernel extract or maize gluten to dairy cows in the weeks before calving. These feeds should be limited to less than 30% of the diet of the springer cow where possible.

Sodium

Sodium is rarely deficient in pasture-based diets, but can become deficient when large amounts of grain or maize silage are fed. Deficiencies in sodium lead to poor milk production and loss of live weight, with most severe symptoms of clinical deficiency usually being a cow licking and chewing stones, gates, etc. (i.e. a depraved appetite). If cows are being supplemented with more than 5 kg DM of a grain-based concentrate or maize silage, then **supplementation with 40 g salt/cow per day** is recommended.

Trace minerals

Of the 18 trace elements identified as essential for life, only five of them are likely to be deficient and recommended for supplementation in grazing dairy cows except in unusual circumstances; these are copper, cobalt, selenium, iodine, and zinc. These trace elements

can be supplied to cows in a variety of ways, depending on the trace element. All of the trace elements can be supplied to the cow via water fortification systems (e.g. dosatron) or through fortified supplementary feeds in the milking shed. Copper and cobalt concentrations in pasture can be increased through fertiliser application, but this method is less accurate in its daily provision of minerals than direct supplementation to the animal. Iodine is absorbed extremely well through the skin and, so, can be applied topically to the cows flank. This is a particularly effective way of supplementing iodine to cows grazing brassica crops. Copper, selenium and iodine can be injected. Irrespective of the means of supplementation, cows should be supplemented with trace elements for the 2-4 weeks before calving until 4 months post-calving. This period encompasses:

- the calving period, when the immune system, which is greatly influenced by trace element status, is under pressure
- peak lactation, when the cow has greatest need for trace elements that influence energy metabolism
- the reproduction period, when trace elements are essential for good reproductive function
- the climatic stressers of spring.

Supplementation during the rest of the lactation is unlikely to be beneficial, except in unusual circumstances. In all situations, you should work with your vet to devise the most appropriate trace element supplementation strategy for your herd.

Technically, the actual requirement for trace elements relates to how much the cow is producing and, therefore, how much the cow is eating. However, mineral supplementation of dairy cows is not an exact science (e.g. the amount of minerals received from the base diet is not known, in herds fed a fixed amount of supplement, each cow gets the same access to minerals, irrespective of production capacity, etc.). Therefore, to simplify management, recommendations are based on requirements/cow per day (Table 2).

Copper

Copper deficiency is common in grazing dairy cows because copper concentrations are generally low in pasture (6-10 mg/kg DM), the absorption of available copper is low (3-5%), and concentrations of sulphur and iron are high, particularly in spring with soil contamination of the pasture/crop; furthermore, the concentration of molybdenum can also be high. These three elements form insoluble complexes with copper in the rumen and render it unavailable for absorption.

Most farmers recognise copper deficiency as a real threat to cow health and productivity and supplement, either as copper needles, copper injections, soluble copper in the water, or fortified supplements in the shed. All of these strategies are effective.

If we consider that cows are unlikely to be receiving much more than 100 mg copper/day from their unsupplemented diet in early lactation and factor in the secondary deficiency factors mentioned previously, **dairy cows should be supplemented with 200-300 mg/day of copper**. This can be provided in multiple ways, as discussed previously, but probably most important to note is that *there is very little evidence to suggest that the more expensive “organic” forms of copper are more effective than copper oxide needles or copper sulphate*. Recommendations are, therefore, to supply cows with 1-2 g copper sulphate/cow per day during early lactation (in water or in supplementary feed), a 20 g bullet of copper oxide, or the product recommended level of injectable copper.

It is important to note that this is the total requirement for supplementary copper. Of all the mineral elements provided, **copper is the most likely to become toxic**, particularly in Jersey cows or crossbred cows with a high proportion of Jersey genetics. Therefore, if copper is being supplied in feed (e.g. palm kernel extract), via naturally high water concentrations, or indirectly through fertiliser application, it is important to account for these other sources of copper before deciding on the most effective supplementary feeding strategy.

Cobalt

Of all the mineral recommendations, cobalt is probably the most contentious in New Zealand. The primary reason for supplementing cows with cobalt is to ensure that adequate vitamin B12 is produced by the rumen microorganisms. The requirement for cobalt to achieve this aim is very small and easily met by the diet. Therefore, one could argue that there is no need to supplement with dietary cobalt.

However, there are other properties of cobalt that are poorly understood, but important to grazing dairy cows. For example, dietary cobalt concentrations three-fold greater than those required to maintain vitamin B12 concentration have been reported to enhance the digestion of fibrous feeds, an important consideration, obviously, for cows grazing fresh pasture. Therefore, the current recommendation from DairyNZ is to **supplement cows with 8-10 mg of cobalt/day**. This is equivalent to 40-50 mg cobalt sulphate/cow per day or 5 g cobalt sulphate per 100 cows.

The mechanisms behind the improvement in fibre digestion through greater supply of cobalt to the ruminal microorganisms are poorly understood. However, because cobalt is required in such small amounts anyway, the cost of insuring against inefficient fibre digestion by ensuring adequate supply of cobalt to the rumen microorganisms is financially insignificant.

Selenium

Selenium is yet another trace element that most New Zealand dairy farmers recognise must be supplemented. In general, selenium concentrations in pastures tend to be very low (approximately 25% of requirements), are not sufficiently increased through fertiliser applications to meet animal requirements and, so, supplementation is recommended.

The actual requirement for selenium is difficult to predict, because many of its immunological functions are in conjunction with vitamin E, which is available in very large quantities in fresh forages. However, the general feeling globally is that by supplying **3-5 mg/day of supplemental selenium**, cow requirements will be met.

There is evidence that the availability of organic selenium is better than that provided by sodium selenate or selenite. However, “organic” sources of selenium tend to be much more expensive and are not likely to provide any benefit beyond the recommendations of 3-5 mg/cow per day of selenium from the inorganic sources (i.e. 10 mg sodium selenate/cow per day).

Although unlikely, it is important, also, to be aware of selenium toxicity. Cases generally reflect soils that are naturally high in selenium (well aerated or alkaline soils tend to be higher in selenium), the use of selenium fertilisers, or, more often the inclusion of cereal grains, cereal grain by-products (e.g. brewers grains), oilseed by-products (e.g. soybean meal), or all of the above, in conjunction with dietary or water fortification. Before embarking on any trace element supplementation strategy, consult with your vet about the likely pitfalls and advantages of trace element mixtures and practices for your farm.

Iodine

Iodine is important for thyroid function and energy metabolism, including thermoregulation (i.e. the maintenance of core body temperature during winter), the immune system, and it is particularly important for reproduction. However, the requirements for supplementary iodine are poorly understood. In the first instance, iodine concentrations in pasture vary considerably and herbage tests are, for the most part, useless. Secondly, the requirement for iodine is dependent on the metabolic state of the cow and the presence of goitrogens in the diet (especially, when brassicas are being fed), and, thirdly, the requirement for additional supplementation depends on whether cows are being teat sprayed with an iodine-based teat spray.

It is possible that teat spraying provides the cow with sufficient iodine to meet her daily requirement. Certainly, milk iodine concentrations from cows teat-sprayed with iodine-based teat sprays indicate a high iodine status; however, it is not clear whether this iodine in

milk is a result of a direct transfer of the iodine into the mammary gland or whether it has entered the mammary gland via the blood.

Because of this, and, because one of the most important times for iodine supplementation in the South Island is during winter, when the cows are grazing brassica crops, supplementation with iodine is recommended through the dry period and for approximately four months post-calving. Brassica crops contain compounds that render dietary iodine unavailable to the cow and because they are high in water, fortification of the water with iodine is an ineffective way of supplying iodine to cows. Iodine is absorbed through the skin. Therefore, an effective way of supplying iodine would be to spray iodine (7 ml of a 5% tincture of iodine) on the flank or rump of the cows (i.e. where the skin is tightest) once a week when they have been offered a new break of crop.

Although it is difficult to provide a definitive recommendation for iodine, DairyNZ recommends **supplementing cows with approximately 10 mg iodine/cow per day** for approximately 4 months post-calving.

Zinc

Zinc is an important trace element for skin and hoof development, the functioning of the immune system, not to mention the cellular metabolism of carbohydrates and proteins. In fact, zinc is almost a macro mineral, being required in very large quantities relative to the other trace minerals.

Pasture zinc status is variable and can range from 20-60 mg/kg DM across farms. At the lower end of this scale, cows in early lactation would very likely be deficient in zinc, at least subclinically, while at the upper end, cows would be consuming adequate zinc and would not require supplementation. In addition to this variability, zinc concentrations probably vary within a paddock, as well as from one paddock to the next, making it impossible to predict the daily zinc intake of a grazing cow.

Because of this variability and because the level of zinc supplementation recommended is not likely to cause ill effects, **it is recommended that cows receive between 500 and 750 mg supplementary zinc/cow per day** or approximately 1g zinc oxide or 2-3 g zinc sulphate.

Cereal by-products (e.g. wheat and oat middlings) have very high concentrations of zinc (>150 mg/kg DM) and brewers grains, distillers grains, and palm kernel extract have reasonably high concentrations (>50 mg/kg DM). The zinc content of these supplements must be taken into account in calculating the likely zinc requirements of the herd as, although the recommended supplementary zinc would not make the animal sick, zinc and copper compete with each other for absorption sites in the small intestine and, therefore, high levels of zinc will lead to copper deficiency.

Summary

In summary, dairy cows will very likely benefit from the supplementation of magnesium, copper, cobalt, iodine, selenium, and zinc during the 2-4 weeks before calving and for 4 months after calving. Iodine supplementation is also important during the dry period when cows are on crop, and calcium should be supplemented during the colostrum period. Recommended intakes of trace elements and affordable and practical sources of these trace elements are presented in Table 2.

Table 2. Recommended intakes of trace elements per day, sources of trace elements, and percentage of the desired mineral in the salt.

Trace element	Recommended total intake*, mg/day	Supplementary source	% mineral in the salt‡
Cobalt	10	Cobalt sulphate	25
Copper	350 (250)†	Copper Sulphate	25
		Copper oxide	80
Iodine	10	Potassium iodide	70
Selenium	5	Sodium selenite	46
		Sodium selenate	40
Zinc	750	Zinc sulphate	30
		Zinc oxide	75

*total intake includes intake of trace element from all feeds plus supplementary mineral sources

†Jersey cows are more prone to copper toxicity than Holstein-Friesian cows. Therefore, the recommended dietary intakes of copper are lower.

‡This is the approximate concentration of the desired mineral in the salt. The % of the mineral in the salt will vary with source.

Other trace elements:

Although there are other trace elements essential for life, there is very little evidence that providing cows with supplementary sources of these minerals will improve production, health or reproduction. Farmers should avoid salesmen trying to sell them trace elements that are not listed in Table 2. The return on investment is likely to be negative.

One exception to this may be chromium, a trace element known to have effects on insulin resistance under certain circumstances. An experiment undertaken in Southland identified lower levels of fat in blood in early lactation in cows supplemented with chromium, a longer period of anoestrus, but greater pregnancy rates in the first four weeks of mating. Although

the overall effects appear positive, the relevance of these effects is much less staggering. The reduction in blood fatty acid concentration was very small biologically and unlikely to represent any advantage to the animals. The positive effect on pregnancy rate reflects very poor reproductive performance in the 'Control' cows (39% pregnant in 4 weeks) rather than very good reproductive performance in the chromium-treated cows (50% pregnancy rate in 4 weeks). Further research into the role of chromium in the energy metabolism of grazing cows and, more importantly, grazing cows supplemented with grain-based concentrates, is required before their use could be recommended.

Source of mineral

The choice of a mineral supplement should be determined by cost, while ensuring a reputable source. Mineral supplements tend to be simplistically divided into two types: "organic" or inorganic. "Organic" minerals are so named because the mineral is bound to an amino acid, a small protein, or a carbohydrate (i.e. they are bound to a carbon-based compound) and are also called mineral chelates or chelated minerals. Inorganic mineral compounds are a salt that contains the mineral in question bound to an innocuous 'partner' mineral (e.g. copper sulphate).

There are many claims that "organic" elements are more effective than inorganic elements because of differences in their mode of absorption or differences in how they are used by tissues post-absorption. Although some studies have indicated differences in absorption rate and tissue concentration differences when "organic" and inorganic elements were compared, on a whole the effects are variable and there is little, if any, evidence to suggest that the "organic" elements are cost effective. It appears that **inorganic trace element sources are as effective as their much more expensive "organic" cousins.**

Special topics

Milk fever

Milk fever is a complex disorder with many factors contributing to its occurrence. Jersey cows and fat and thin cows are all prone to milk fever. In addition, milk fever incidence is greatest following heavy rain events and following frosty nights. Therefore, it is particularly difficult to predict when an outbreak of milk fever might occur.

Milk fever is defined by low levels of calcium circulating in blood (i.e. subclinical milk fever is when blood calcium is less than 2.0 mmol/L, with clinical milk fever defined as blood calcium concentrations less than 1.4 mmol/L). On average, farm records indicate 1-2% of "downer cows", while 5% of cows had clinical milk fever and 33% of cows subclinical milk fever in multi-year research databases.

Low blood calcium interferes with smooth muscle function (i.e. rumen motility, uterine contractions) and can lead to difficult calvings, low DM intake, increased mastitis, and poor immune function. It is primarily controlled by supplementing cows with 20-30 g magnesium/cow per day during the 2-4 weeks before calving and supplementing freshly calved cows with limeflour (as discussed earlier).

In recent years, however, there are reports of a different type of milk fever, where cows go down with milk fever symptoms around calving but are quick to rise with calcium treatment. These situations almost always involve cows that are fatter than BCS 5.0 and fed generously during the springing period. It is unclear why this situation causes milk fever, but a quick solution is to provide the cows with 20% less energy than required during the last 2 weeks before calving.

- A cow requires approximately 25% of her mid-lactation live weight in metabolisable energy every day; for example, a 500 kg cow requires 110 MJ ME/cow per day.
- To avoid milk fever, this cow should consume 90 MJ ME/cow per day during the springing period. This is particularly effective in cows at BCS 5.0 or greater.

Dietary Cation-Anion Difference

The dietary cation-anion difference (**DCAD**) refers to a difference in the concentration of particular minerals in the diet. The most important minerals are sodium and potassium (cations) and chlorine and sulphur (anions). These minerals regulate the alkalinity of blood, which, in turn, regulates the absorption of calcium from the intestine and, possibly, the mobilisation of calcium from bone. There is plenty of evidence in housed systems and in systems where cows have been fed fresh pasture, hay, or silage, that when DCAD is reduced to negative values in the weeks before calving, intestinal absorption of calcium is increased.

It is important to note, however, that, for this concept to increase calcium absorption successfully, **the DCAD must be negative**. This is very difficult to achieve in cows being supplemented with pasture or other green forages. Therefore, for the most part, **the DCAD concept is virtually irrelevant in pasture-based systems**. In comparison, in systems where cows are offered a diet consisting of maize silage, brewers grains, molasses, and other low DCAD feed ingredients, a small amount of anionic salts (magnesium sulphate and magnesium chloride) will reduce the DCAD sufficiently to help prevent milk fever.

Some people report reductions in milk fever with very small changes in DCAD. This is unlikely to be an effect of DCAD and, probably, has more to do with the magnesium or sulphur in the anionic salt provided. For the most part, **the DCAD of the diet is not important in pasture-based systems**.

Grass staggers

Grass staggers is a deficiency in blood magnesium concentrations. However, it is rarely caused by a lack of magnesium in the diet. High levels of potassium and nitrogen reduce the absorption of magnesium from the rumen and the efficiency of absorption of magnesium post-ruminally is low. Therefore, well fertilised temperate forages tend to predispose animals to low levels of magnesium absorption. However, staggers tends to be the result of a stressor, such as cold wet weather (which also reduces magnesium intake from pasture) or transporting stock.

The way to reduce the risk of staggers is to supplement cows daily with 20 g magnesium during the main risk period (i.e. from before calving until approximately November).

Conclusions

Twenty five minerals that are essential for life have been identified. However, very few are deficient in the average diet. Magnesium and calcium are the most important macro minerals, although, in particular situations, sodium and phosphorus supplementation should be considered. Five trace elements tend to be deficient in the diet of grazing cows: copper, cobalt, iodine, selenium, and zinc. These should be provided as a supplement from 2-4 weeks before calving until 4 months post-calving.

You must account for all sources of trace elements to ensure cows are not poisoned by oversupply. “Organic” trace elements do not offer an advantage over the less expensive inorganic trace element sources.

If in doubt, consult with your vet on the most appropriate mineral supplementation strategy for your herd.

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