

agriculture & rural development Department: agriculture & rural development PROVINCE OF KWAZULU-NATAL

# DAIRYING IN KWAZULU-NATAL

# Mineral & Vitamin Nutrition Of Dairy Cattle

R M Bredon & T J Dugmore Cedara Agricultural Development Institute

#### MINERALS

# INTRODUCTION

Twenty-one minerals are considered to be nutritionally essential, or probably essential, to the animal. Depending on the quantities required by the animal, they can be grouped into major minerals and trace (minor) elements. Of the major minerals the most important are calcium, phosphorus, sodium, chlorine, potassium, sulphur and magnesium. The important trace elements are copper, cobalt, iron, iodine, zinc, manganese and selenium. Most of the major minerals and trace elements are widely distributed in the herbage and the other feeds eaten by the animal, and occur in sufficient quantities to meet animal requirements. Balanced commercial feeds usually contain sufficient minerals to meet the needs of dairy cows under normal conditions.

However, the possibility of clinical, or more likely subclinical, mineral deficiencies may occur even if conditions deviate from the "typical". Clear-cut and well-defined symptoms can usually be observed if an animal suffers from a clinical deficiency of a mineral. On the other hand, subclinical deficiencies could adversely affect the rate of growth and the level of production without causing obvious deficiency symptoms. Apart from actual mineral deficiencies, mineral imbalances may also occur. These imbalances, through interaction, can induce deficiencies by the formation of insoluble compounds which cannot be utilized by the animal.

Mineral deficiencies, and in some cases imbalances, cause metabolic disturbances and can produce specific deficiency diseases. Fertility, and hence calving percentage, can be affected. Milk production is obviously dependent on the health and the well-being of the dairy cow and any metabolic disturbance will affect milk production.

Slow-growing and low-producing animals will not require the same amounts of minerals as high producers. Therefore deficiencies which are subclinical in low producers, often become clinical in high-producing animals. Often the farmer is unaware of the existence of mineral deficiencies, and it is not easy, nor is it always possible, to diagnose a deficiency of any particular mineral. Improved live-mass gains or increased milk production in apparently healthy animals often have been demonstrated when their feeds were supplemented with minerals. These responses

occurred when no evidence of a deficiency existed but, judging by the beneficial effect of mineral supplementation, there must have been a subclinical deficiency.

So far, the emphasis has been on mineral deficiencies, but it must not be forgotten that an excess of some minerals can also have a disastrous effect on the animal. There are well-known areas in the world where cattle cannot be kept because of a high selenium concentration in the soil, and hence in the herbage, which is toxic to the animal. An excess of molybdenum, as a result of over-application to a pasture, can render the pasture unusable for many years. An induced copper deficiency is caused by excessive soil molybdenum. Excesses of copper, iodine or fluorine can also be very toxic to animals. The problem is very complex, and if considerable care is not exercised when supplementing feeds with minerals, especially trace elements, more harm than good can result.

The interactions between individual minerals will be discussed in groups rather than separately. Those minerals, major and trace, which are problematic in KwaZulu-Natal, and elsewhere in South Africa, are discussed in this guide. Calcium, phosphorus, magnesium and salt (sodium and chlorine) are deficient under specific conditions in KwaZulu-Natal. Of the trace minerals there is a confirmed iodine shortage in the KwaZulu-Natal Midlands and there are known to be incidences of copper and selenium deficiencies, and possibly of zinc.

The mineral requirements of different classes of dairy animals will be found in the KwaZulu-Natal Dairy Leaflet 5.12 and licks recommended for different pastures in the Appendix Tables to this leaflet.

# CALCIUM (Ca) AND PHOSPHORUS (P)

The dairy cow is more likely to suffer from a lack of both calcium and phosphorus than from a lack of any other mineral with the possible exception of salt. Strong homeostatic mechanisms exist which regulate the absorption of calcium, *i.e.* only sufficient is absorbed to meet the animal's requirements. The high-producing dairy cow is unable to obtain her calcium and, to a lesser extent, her phosphorus requirements from dietary sources in early lactation. This may be due to a low absorption capability carried forward from the dry period, especially if high levels were fed during the latter stages of the dry period. The skeleton (bones) provides a substantial reserve of Ca which the cow is able to utilize to meet her requirements.

Two aspects must be considered when discussing these two minerals, *viz*. deficiencies, and the ratio of calcium to phosphorus in the diet.

Half of the dry mass of the skeleton and the teeth is made up of calcium and phosphorus in the ratio of approximately 2 to 1. Blood also contains these minerals; there is about 10 mg of calcium and 15 mg of phosphorus in each 100 ml of blood. Milk contains approximately 9 g of Ca and 7 g P per litre.

Although there is only a small amount of calcium (only 1% of the total calcium) in the soft tissues of animals, it is essential for blood clotting, control of the heartbeat, membrane permeability and as a co-factor in many enzymatic reactions. Phosphorus is a structural part of several body proteins, phospholipids and nucleic acids. It is implicated in carbohydrate metabolism, forming compounds with certain metabolic products. These phosphorus compounds take part in the storage and release of energy for muscular work and for maintaining body temperature.

# DEFICIENCY SYMPTOMS

Decreased growth, unthriftiness, decreased milk production, poor conception and pica (depraved appetite) are the general symptoms of calcium and phosphorus deficiency. A young animal in advanced stages of deficiency develops rickets (bones bend under the weight of the animal and, owing to the pull of muscles, they become deformed), while older animals develop osteomalacia (the same condition as rickets, but because adult bones are solid they fracture instead of bending). In both cases, the unequal deposition of calcium and phosphorus which takes place makes the symptoms very characteristic. The ends of long bones become thicker and the middle becomes thinner. The animals suffer from stiffness of the joints and develop lameness.

Rickets and osteomalacia are also associated with vitamin D deficiency, and sometimes a magnesium deficiency. Vitamin D acts as a regulator in the deposition of minerals in bone.

The first symptom of calcium and/or phosphorus deficiency is poor conception. Animals are erratic in coming on heat, the heat is often difficult to detect, and the animals do not conceive. Calcium supplementation of kikuyu pasture, which is low in calcium, has been shown to alleviate infertility problems.

It has also been shown experimentally that a shortage of calcium in the diet can reduce milk production by as much as 4,5 litres per day over the whole of the lactation.

# CALCIUM TO PHOSPHORUS RATIO

In Holland, after the second world war, an attempt was made to restore soil fertility through very high levels of fertilization. This excessive fertilisation resulted in multiple mineral deficiencies and imbalances. The following conditions were found in cattle that were fed diets with unbalanced calcium to phosphorus ratios:

- Cattle, when walking, placed their hind legs unnaturally far forward under the body and when standing, showed sickle hocks. Their walking pattern caused the toes to become too long and the soles of the feet became easily bruised, resulting in the development of dry or purulent corns. Sometimes the inflammation penetrated up to the hoof joints. These were caused by a surplus of phosphorus but a shortage of calcium.
- The legs of cattle showed a rickety appearance. When standing, there was a narrow stance in the hocks; the hocks were too far behind the bodies, with the tails between the hocks which were usually soiled with faeces. The gait of the cattle lacked smoothness and was hesitant. These were caused by a surplus of calcium but a shortage of phosphorus.

Both of these conditions have been observed in KwaZulu-Natal. The symptoms of excess phosphorus but calcium shortage are not uncommon in cattle grazing kikuyu pastures. The addition of feed lime to the mineral lick seems to clear up this condition. It has been observed that the improvement in stance and gait coincides with an improvement in fertility and, in some cases, improved milk production. The British Agricultural Research Council (ARC) recommends a dietary Ca:P ratio of between 2:1 and 1:1. However, it has been shown that as long as the ratio is not more than 3:1 there is no adverse effect on fertility.

Field experience in South Africa showed a considerable increase in foot problems and a decrease of feed intake where the ratio of Ca:P in the ration was less than 1:1.

The type of roughage, and the type of concentrates must be considered when supplementing calcium and phosphorus to achieve a correct ratio in the total ration.

The following are examples of calcium to phosphorus ratios, in typical roughages and concentrates fed to lactating cows:

Bran (Wheaten)	0,1 Ca : 1 P
Maize	> 0,1 Ca : 1 P (0,01 to 0,02% Ca : 0,2% P)
Kikuyu	0,5 to 1 Ca : 1 P
Lucerne	5 to 7 Ca : 1 P
Clover	3 to 4 Ca : 1 P

Typically, roughages in South Africa contain between 1 Ca: 1 P and 1,2 Ca: 1 P; with phosphorus ranging between 0,2% and 0,35% on a dry matter basis.

#### Phosphorus requirements of the lactating cow

The following daily requirements of dietary phosphorus were recommended by the Agricultural Research Council (ARC, 1965):

Maintenance:							2	5,5		grams
Milk production:				1,	75	gra	ums/k	g	of	milk
				(in	ado	ditior	ı to	mai	ntena	ance).
Pregnancy:		4		to	6	mon	ths	2,	, 5	grams
					6	to 7	mon	ths	6,5	grams
	7	to	9	months	10	),5 gr	ams		-	-

Calcium requirements of the lactating cow

It is suggested that the optimum ratio of calcium to phosphorus is between 1,3:1 and 1,5:1. The latter ratio is recommended by the National Research Council (NRC). The requirements for phosphorus can be multiplied by a factor of 1,3 to 1,5 to obtain the amounts of calcium required.

Sources of Calcium and Phosphorus:::

	Calcium* %	Phosphorus* %
Dicalcium phosphate	23,6	17,9
Calcium phosphate	16,0	21,0
Monosodium phosphate	-	17,0
Feed lime	38,0	-
Bone meal (steamed)	21,0	10,0

\*(These are approximate values.)

Commercial mineral supplements sold under various brand names contain varying amounts of different minerals and the labels should be studied to determine the actual content. However, commercial mixed rations do not carry sufficient information for practical ration formulation. Usually only the maxima and minima of mineral constituents are stated. For example the calcium concentration of commercial protein supplements was found to vary from 2 to 5%.

#### DISEASES ASSOCIATED WITH CALCIUM AND PHOSPHORUS DEFICIENCIES

# Milk fever

Milk fever is characterised by symptoms such as muscular spasms, paralysis, and a loss of consciousness leading to coma and death. These conditions are associated with an abrupt drop in the level of calcium in the blood, which is not necessarily caused by a dietary deficiency of calcium. Rather, it is due to the disfunctioning of the parathyroid glands. The efficiency of these glands, which regulate the absorption of calcium through the production of calcitonin, decreases during the dry period of the cow, when her requirements are much less than that normally supplied by the feed during that period. The absorption of dietary calcium and phosphorus during the early stages of lactation is often poor owing to low levels of calcitonin, when the requirement of the cow for these minerals is high, as a result of high milk production.

Reducing the calcium level in the ration during the last three weeks of the dry period seems to stimulate the parathyroid gland to produce calcitonin and consequently decreases the incidence of milk fever by improving calcium absorption. There is considerable evidence that intramuscular injections of vitamin  $D_3$  (0,4g) given 7 days before calving were effective in preventing milk fever. If calving did not take place within the 7 days a second injection was given.

#### Pica (depraved appetite)

This condition occurs in animals deficient in phosphorus. They develop an unspecified craving, and consume foreign material such as soil, flesh, wood or bones.

#### Botulism

This disease occurs when animals deficient in phosphorus start chewing bones infected by this bacterium during the putrefication of flesh that was attached to the bones. The toxin produced by this bacterium is fatal to animals.

# MAGNESIUM (Mg)

Magnesium is a structural part of bone and is closely associated with calcium, phosphorus and vitamin D in bone formation. Magnesium is one of the activators in phosphorus metabolism. It is also involved in carbohydrate metabolism and plays a major role in the neuromuscular functions of the muscles. Although there are reserves of magnesium in bone and soft tissue, the speed of mobilization of these reserves when required, is slow and of little help in an emergency, *e.g.* in cases of grass tetany.

Two types of magnesium deficiency are known in cattle:

- Calves, fed milk only (which is low in magnesium) for a long period, develop skin lesions, nervous muscular irritability and, eventually, convulsions leading to death.
- Older animals develop grass tetany. Grass tetany often occurs in spring when animals are put out on lush young grass after winter feeding, especially if the pasture was heavily fertilized with ammonium sulphate. The symptoms which develop resemble those of milk fever, but the animals show more acute excitability, they stagger (grass tetany) and have convulsions. An injection of a calcium or magnesium salt, such as magnesium sulphate (epsom salts), will result in quick recovery, but if this is not followed by further injections, or oral feeding of magnesium, the tetany will reappear. This is not normally the case with milk fever. Care must be taken when treating these animals because even a needle jab can trigger off convulsions.

Calcium and magnesium salts are interchangeable to a certain extent, and either one can often be of help in the treatment of milk fever and of grass tetany. Large amounts of potassium from herbage, however, can be antagonistic to calcium and magnesium absorption. There is some evidence to suggest that the ionic balance between potassium (K) and calcium plus magnesium is critical and should not exceed 2, *i.e.* K/(Ca + Mg) should be less than or equal to 2. Excessive sodium intake also may cause hypomagnesaemia, because increasing sodium and/or potassium has been shown to decrease the apparent absorption of magnesium from the gastrointestinal tract, and to decrease the blood magnesium concentrations of cows. These effects are particularly pronounced at high potassium intakes.

In sharp contrast to other elements, the magnesium in lush green grass is not readily available to the animal. Many dietary factors have been implicated in impairing the absorption of magnesium, namely, sodium (both deficiencies and excesses), high nitrogen, excessively high calcium, long-chain fatty acids, high rumen pH, low dry-matter content in rumen digesta, and potassium.

Kikuyu pastures which are several years old accumulate considerable amounts of potassium from animal excreta and usually have a low calcium content. It is likely that, in these high potassium, low calcium pastures, there could be a shortage of both calcium and magnesium. The addition of magnesium to the lick could be of advantage, especially during spring. Subclinical deficiencies of magnesium have been demonstrated to cause lowering of milk production, and the addition of magnesium could enhance milk production. It is suggested that the supplementation of 4 to 6 g Mg per day to cows on pasture could be beneficial, *e.g.* 7 to 10 kg magnesium oxide per 100 kg lick fed at the rate of 100 grams per cow per day. Both calcium and magnesium supplementation have been shown to alleviate fertility problems in cattle grazing on kikuyu with high potassium and low calcium-plus-magnesium levels.

Magnesium requirements per cow per day are approximately 9 g for maintenance, and an additional 0,74 g per litre of milk. For a cow yielding 20 litres of milk the total requirement for magnesium therefore would be 24 grams.

# POTASSIUM (K)

Potassium is the third most abundant mineral element in the animal body. It is a major intracellular cation and is involved in the osmotic regulation of tissue fluids and in acid-base balance. An ionic balance exists amongst K, Na, Ca and Mg.

The requirements for K by ruminants is estimated to be between 0,5 and 0,8% of the diet. The potassium requirement appears to be increased by stress. Research has shown that the potassium requirements for heat-stressed dairy cows increases to approximately 1,1%. Levels higher than 1,5% have been associated with decreased dry matter intakes. Grass contains high levels of potassium and deficiencies therefore are uncommon in grazed stock. High potassium levels in well-fertilized pastures can be a problem, especially with regard to Mg absorption. The maximum tolerable level for K is suggested to be 3% of the total dietary dry matter, although surpluses are readily excreted in the urine.

An excess of potassium can aggravate a sodium deficiency, depressing sodium levels by 30 to 60 %. This may be particularly serious on kikuyu pastures, which are inherently low in sodium.

Pastures high in potassium, particularly kikuyu, are a cause for concern in KwaZulu-Natal. Kikuyu pastures containing potassium levels in excess of 5 % have been implicated in cases of bloat and of infertility. Sodium has been shown to reduce the incidence of bloat on kikuyu pastures. It should also be borne in mind that bloat may also be due to high levels of protein in the herbage (in excess of 30% CP/kg DM in some cases). Some cases of infertility have been shown to be reduced by supplementation with calcium and magnesium.

#### SODIUM AND CHLORINE (salt)

#### SODIUM (Na)

Sodium is a major extracelluar cation and plays an active part in regulating the neutrality of blood serum. Considerable amounts of sodium appear in the muscles and it is associated with their contraction.

A shortage of sodium adversely affects utilization of both digested proteins and energy, and also prevents reproduction. A shortage of sodium has been associated with cases of bloat on kikuyu pastures that were heavily fertilized with nitrogen. High levels of potassium have been shown to depress the concentration of sodium in plants. Pastures contain several times more potassium than sodium, thus cows on pastures require more salt than do cows on dry feeds or complete feeds. At a given potassium intake level, increasing the sodium intake increases the sodium and decreases the potassium concentrations in the ruminoreticulum digesta. Increased sodium levels have also been shown to be antagonistic to magnesium absorption.

#### CHLORINE (C1)

The chlorides of the blood, consisting mainly of sodium chlorides, make up more than half of the acidic ions. Consequently the chlorides have a principal effect on the acid-base relationship. Chlorine is connected with the formation of hydrochloric acid, an acidic secretion in the abomasum of ruminants. Both sodium and chlorine are contained in the salt which is fed to animals as a very important part of the mineral supplement. The ratio of sodium to chlorine in salt is 1:1,6.

#### Salt

Salt deficiency in cattle results in lack of appetite, rapid loss of weight and a decline in milk production. Animals show unco-ordinated movements, a stiff walk, they shiver and are weak. Complete collapse and death is known to occur in high-producing cows. Calves, in addition to the general unthrifty condition, develop harsh coats.

The salt deficiency becomes more pronounced during hot weather because of the loss of salt in perspiration. Kikuyu, paspalum, sorghum, maize, tall fescue, lucerne and red clover are natrophobic (accumulate sodium in the roots and not in the stem and leaf) plants and animals grazing these plants require greater salt supplementation than is required for other plant species.

The recommended quantities of sodium to be fed are 8,5 g for maintenance of a 500 kg cow plus 0,63 g for the production of each litre of milk. This, allowing for salt impurities, is equivalent to approximately 20 to 25 g of salt for maintenance plus 1,6 g per litre of milk. Chlorine is more abundant in feeds than is sodium and there is no evidence of a chlorine shortage in dairy rations. Consequently, the extent of supplementation must be based on sodium. Only a small amount of the required sodium will be met from the ration, therefore most of it should be supplied as salt. Provided that cows receive enough water, they have considerable tolerance to salt. Consequently a small excess of salt, especially in summer, might be of advantage.

#### SULPHUR (S)

Sulphur occurs in the animal's body mainly in the sulphur containing proteins, that is, proteins which have the amino acids cystine and methionine as part of their molecular structure. Some "B" vitamins and the hormone insulin, also contain sulphur. A deficiency of sulphur is seldom a problem if protein levels in the rations are high.

Sulphur is the most important mineral for the proper development and maintenance of ruminal microflora, because it may limit the synthesis of both cystine and methionine which are essential for the synthesis of microbial body-proteins.

Symptoms of sulphur deficiency are not very specific and are not easy to diagnose. Lower dry matter intake, loss of weight, slow growth of wool in sheep, and sometimes death, are the symptoms of a deficiency of this element. There is also a reduction in the microflora population resulting in poor utilization of cellulose and poor protein synthesis.

The optimum level of sulphur in the ration should be between 0,16 and 0,24% of sulphur. An excess of sulphur, on the other hand, can be a factor contributing to copper deficiency, especially if the ration has a high molybdenum content.

#### IODINE (I)

lodine is found only in minute amounts in the animal's body (less than 0,000 04%) but it is essential for normal development. Half of the total amount of iodine is present in the thyroid gland and is essential for the formation of thyroxine which is a secretion of this gland. A lack of this secretion lowers basal metabolism and the thyroid gland then fails to control the rate of body metabolism. The animal body tries to increase secretion of this gland by enlarging it. This enlargement is called a goitre.

lodine deficiency occurs in areas where the water and feed are deficient in iodine. Goitrogenic (producing goitre) feeds such as brassicas (*e.g.* rape, kale, turnips, cabbage) will aggravate a

deficiency. Star grass and clover can cause an indirect iodine deficiency through the production of cyanogens.

In calves, deficiency symptoms are stunted growth, an enlarged thyroid gland, apathy, blindness, hairlessness and a harsh coat. Calves born to cows suffering from iodine deficiency will have enlarged thyroid glands. If dissection of a full-term calf, either born dead or which dies soon after birth, reveals a thyroid with a mass of over 8 g, then an iodine deficiency is indicated. A thyroid mass of over 20 g in calves is not uncommon in KwaZulu-Natal.

In cows, an iodine deficiency results in retained placentas and also impairs reproductive performance. Any one, or more, of the following symptoms occuring in cows can indicate an iodine deficiency (infertility usually occurs at early stages of a deficiency):

- arrested foetal development at any stage of pregnancy leading to death of the foetus
- abortions
- stillbirths
- the birth of a hairless calf
- irregular or suppressed oestrus.

In bulls, symptoms are a decline in sexual vigour, and a deterioration in semen quality.

In iodine deficient areas such as the KwaZulu-Natal Midlands, the supplementation of 120 mg/kg of iodine in the lick seems to be required. It has been observed that, when only 90 mg/kg was present in the lick, the occasional calf was stillborn and had an enlarged thyroid gland. These cases seemed to disappear when the amount of iodine in the lick was increased from 90 mg/kg to 120 mg/kg.

To achieve 120 mg/kg iodine in the lick, 15,6 g potassium iodide or 20,2 g potassium iodate must be added to 100 kg lick, or per 20 kg salt which will be mixed in the lick. Potassium iodate has the advantage over potassium iodide in that it has greater stability. The aforementioned amounts can be dissolved in approximately 1 litre water and sprayed over the salt, which must be spread out. The best spray to use is a hand mist spray of the type sold in garden shops. It is critically important that the iodine be thoroughly dispersed throughout the lick mix, because iodine in large quantities is extremely toxic. Just about the only way of thoroughly mixing the very small quantities of potassium iodate or iodide required, is the method of dissolving and spraying over salt, described above. Alternatively, commercial iodine pre-mixes are available which contain small amounts of iodine in a carrier and can be conveniently mixed into a lick. The amount of iodine per package of pre-mix should be checked, and the appropriate amount mixed per bag of salt before mixing in the remainder of the ingredients. For example, 25 g of iodine per package would mean that, with a mix containing approximately 20% salt, one package of pre-mix per 42 kg salt would yield a final mix of 120 mg/kg iodine as follows:-

20% 120 mg/kg iodine is wanted the final mix containing of in salt. Therefore. 120) iodine salt. (100 20 600 mg/kg of wanted Х = in Now, 1 000 000 g salt must contain 600 g iodine, and 1 pack pre-mix contains 25 g iodine. Therefore:  $(1\ 000\ 000\ x\ 25)$ ,  $(600\ x\ 1000) = 42$  kg salt per pack pre-mix.

OR

50 / 42 = 1,2 packs pre-mix per 50 kg salt.

lodine requirements for growing animals are 0,12 mg/kg dry matter of the diet and for pregnant and lactating cows the concentration of iodine should be 0,8 mg/kg dry matter of feed.

### MANGANESE (Mn)

Although manganese deficiencies rarely occur in ruminants, they can cause many problems, because manganese is associated with tissue respiration and affects both growth and reproduction. It stabilizes calcium and phosphorus metabolism and therefore has an influence on bone formation. It also affects the function of the endocrine organs, enhances fat utilization in the body and counteracts fatty degeneration of the liver.

Heat cycles in cows and heifers are difficult to detect (silent heat) and conception is poor. A deficiency of manganese in pregnant cows causes weak legs in newly born calves.

High calcium and low phosphorus levels in the ration seem to increase the requirement for manganese.

Manganese deficiencies have been identified in the Highveld, KwaZulu-Natal, Cape Coastal areas, Western Cape, Northern Cape and southern Namibia. The recommended dietary allowance for manganese is 40 mg/kg dry matter (DM).

# ZINC (Zn)

Zinc is a structural component of various enzymes. Some play a part in digestion and some act as activators to other enzymes. Zinc also intensifies the effect of insulin by protecting it from decomposition by insulinase, and influences the reproductive system. Most of the zinc in an animal's body is contained in the skin, hair and wool.

A deficiency causes parakeratosis. This disease is manifested by slow growth, skin lesions and hair loss. Cattle can develop spots on the tender parts of the skin, not unlike those occurring during photosensitization. Other symptoms of zinc deficiency in ruminants are inflamed membranes of the nose and mouth. The reproductive efficiency of males is lowered. Hair loss in cattle has been observed. Excessive calcium in the diet can affect absorption of zinc, but, in general, deficiency in ruminants is rare.

Ruminants can tolerate high levels of zinc, although feeding an excess of zinc (500 mg/kg DM) can produce toxicity, the symptoms of which are sluggishness, loss of appetite and diarrhoea. Zinc deficiencies have been identified in most of the regions of South Africa.

The recommended dietary allowance for zinc is 40 mg/kg DM.

#### COPPER AND MOLYBDENUM

#### COPPER (Cu)

Copper, apart from being a catalyst necessary for the absorption of iron into haemoglobin, participates in the processes of pigmentation and keratinization of hair. It is a structural component of certain proteins and an activator of various enzymes. It is also essential for the proper development and function of rumen micro-organisms.

Any or several of the following symptoms are common when the diet of cattle is deficient in copper:

- rapid loss in livemass
- anaemia
- abnormal appetite
- hair discoloration
- diarrhoea
- unco-ordinated movements
- bone malformation
- osteomalacia
- often, a pacing gait
- fertility is also affected, a lack of sexual activity is common, and abortions and retained placentas often result.

In recent years molybdenum has often been applied to soils to stimulate the growth of plants. This creates the danger of a physiological copper deficiency which occurs if an excess of molybdenum is applied, for example, in seed maize production in the Greytown area of KwaZulu-Natal.

Excessive copper can be toxic to the animal. It accumulates in the liver for a time, and then large quantities are released into the blood-stream, causing a haemolytic crisis associated with jaundice and liver necrosis and, eventually, death. Cattle can tolerate diets containing 100 parts per million in the dry matter, but larger amounts can only be tolerated for a short period of time. Sheep and milk-fed calves are far more susceptible to copper toxicity than are adult cattle.

The copper requirement of the mature cow is about 100 mg copper per day. The dietary concentration of copper should be about 10 mg Cu/kg of dry matter.

In cases of suspected deficiency the inclusion of 0,25 to 0,5% of copper sulphate in the mineral lick is advisable.

# MOLYBDENUM (Mo)

Molybdenum is a structural component of the enzyme nitrate reductase, which reduces non-toxic nitrates to toxic nitrites.

An excess of molybdenum will cause accumulation of nitrites in the rumen, with resulting toxicity.

The other adverse effects of excessive molybdenum such as its antagonistic effect on copper assimilation, by the formation of insoluble compounds of copper-molybdenum sulphate, is well known. The formation of these insoluble compounds induces a physiological copper deficiency.

Diarrhoea, emaciation, black hair turning grey, swollen vulva, weakness from exertion, and stiffness are known symptoms.

No deficiency of molybdenum under natural grazing conditions has yet been recorded.

The molybdenum requirements of grazing livestock are estimated to be 1 mg/kg DM, or less.

# **IRON AND COBALT**

These trace elements have one thing in common: their deficiency, apart from any other specific symptoms, will cause anaemia. Iron is a structural part of haemoglobin (red blood cells) while cobalt is necessary for synthesis of vitamin B<sub>12</sub>, a deficiency of which causes pernicious anaemia.

#### IRON (Fe)

Iron deficiency causes anaemia which is characterized by the general appearance of malnutrition, and the very unpronounced, and fewer, blood vessels in the whites of the eyes. Generally speaking, only calves fed for a long time on large quantities of milk are liable to develop anaemia because milk is a poor source of iron. The food eaten by ruminants weaned from milk is abundant in iron, consequently the anaemia caused by iron deficiency is not likely to occur.

Dietary allowances for cattle are 30 mg Fe/kg DM for dry stock and 40 mg Fe/kg DM for pregnant and lactating cows.

# COBALT (Co)

Cobalt is a structural part of vitamin B<sub>12</sub> and a lack of cobalt renders it impossible for the ruminal microflora to synthesise vitamin B<sub>12</sub>. The ruminal microflora require cobalt to be supplied on a continuous basis and therefore it is pointless to inject cobalt.

The symptoms of a cobalt deficiency are:

- unthrifty condition
- lack of appetite
- muscular unco-ordination and anaemia.

No direct evidence of any cobalt deficiency has been found in KwaZulu-Natal, but the suspicion exists that a sub-clinical deficiency could occur after a prolonged period of heavy rainfall.

Cobalt in excessive amounts can be toxic and under practical conditions the daily intake of 220 to 275 mg of cobalt per 100 kg live-mass will produce toxicity symptoms within 4 to 30 days. The symptoms of toxicity are:

- reduced feed intake
- loss of live-mass
- emaciation
- anaemia
- elevated liver cobalt
- respiratory distress and excess salivation.

A dietary concentration of 0,1 mg Co/kg dry matter should meet cattle requirements for cobalt. In cobalt-deficient areas, the addition of 50 to 60 grams cobalt sulphate per 100 kg salt normally should be sufficient to correct the deficiency.

# SELENIUM (Se)

Only recently has attention been paid to animal requirements for selenium. Until 1957, selenium was not considered to be essential for animal health and was known to be very toxic in areas where the grazing contained more than three parts per million (3 mg/kg DM). However, over the last 20 years it has been found to be an essential trace mineral. Diets deficient in selenium caused liver necrosis in rats, muscular dystrophy in calves and lambs ("white muscle" disease in calves and "stiff lamb" disease in sheep), scouring in calves in some areas, and delayed clearing of the afterbirth in cows. Selenium is involved in the mammalian antioxidant defence system, playing a stimulatory role in the immune response and thereby improving disease resistance.

Selenium behaves in a similar manner to vitamin E. It appears that in dairy cows an adequate intake of selenium can compensate for an inadequate intake of vitamin E and *vice versa*. The symptoms of deficiency are not necessarily caused by a dietary deficiency of selenium. Selenium, however, cannot take over all of the functions of this vitamin, but the level of vitamin E in the diet will affect the animal's response to the feeding of selenium.

High dietary concentrations of sulphur, as well as the heavy metals such as arsenic, mercury, silver, copper and cadmium have been shown to reduce the availability of selenium. Fertilization of the soil with elemental sulphur or superphosphate could induce clinical selenium deficiencies in animals in areas where marginal deficiencies exist.

Generally speaking, a range of from 0,1 to 0,5 mg/kg Se in dry matter in the diet is acceptable to the animal. Diets with less than 0,1 mg/kg would be likely to cause deficiency while those with more than 5,0 mg/kg would be likely to be toxic. Because of the very real danger of toxicity, selenium is very seldom added to animal diets or to mineral mixtures; in some countries it is illegal to do so. Selenium therefore should be used only where it is almost certainly deficient, and only under expert guidance because of the very real dangers of toxicity. The delayed clearing of the afterbirth, a symptom of a selenium deficiency, with resultant metritis can often be avoided through the injection of 50 mg of sodium selenite 20 to 21 days before calving.

#### SUMMARY

Minerals are essential to animal health and production. Most minerals are present in the feed in sufficient quantities to supply the animal's requirements. The general deficiency of both phosphorus and calcium is a well-established fact in this country. In fact, most of the pioneering work on phosphorus and calcium nutition was done in South Africa. Consequently, phosphorus and calcium are usually supplied as supplements.

Deficiencies of other minerals do not normally occur, or do not cause clinically recognizable symptoms, except in certain areas, or only when a very limited variety of food is fed to the animal. This does not mean that sub-clinical deficiencies do not occur, but our present knowledge of these is very limited or non-existent. Appendix Tables 2 to 4 have been designed to give a number of alternative mixes for specific roughage combinations and Appendix Table 1 for different sources of major minerals. This appendix should be studied and the mix chosen which fits both the roughages fed and the sources of minerals which are available.

It will be noted that all of these mixes contain a proportion of commercial mineral sources. The reason for this is that, with our present limited knowledge of trace mineral deficiencies, it is desirable to include a small proportion of these minerals which are most conveniently supplied

by commercial mixes containing trace minerals in proportions that are assumed to be correct in the light of present knowledge.

Salt is the only other mineral which, invariably, must be supplied in addition to calcium and phosphorus, because all of the roughages normally fed in this country are deficient in salt.

High-producing animals have a much higher requirement for minerals than do low producers. Thus it is invariably the high-producers that are the first to show signs of mineral deficiencies or imbalances. Therefore, it is the high producers which should be watched for deficiency symptoms.

Most mineral deficiencies, or imbalances, affect fertility, often producing specific symptoms.

Only by trying supplementation with specific minerals, and by observing animal response can one be certain of the existence of a deficiency or imbalance. Laboratory-determined imbalances in blood, liver and kidney samples can give a good indication of deficiencies, but these analyses are expensive, and, more important, with the exception of blood samples, for practical purposes, are impossible in the producing animal. Blood samples (blood profiles) on their own (except in the case of very few minerals) are difficult, if not impossible, to interpret because of a lack of knowledge about interactions.

As the general levels of dairy production per cow rise, it is likely that mineral deficiencies will become more common and, if manifested by clinical symptoms, easier to diagnose. Nevertheless, even if subclinical deficiencies are suspected, the indiscriminate supplementation of feeds with minerals must be avoided, because raising mineral levels can cause not only toxicity (in excess), but also the antagonistic effect of some minerals on others, can create imbalances and induce physiological deficiencies.

If a deficiency is suspected, then expert advice should be sought and if the deficiency is confirmed, the suspected mineral can be added to the diet. In the author's opinion, if the mixes as detailed in Appendix Tables 2 to 4 are fed, the only other mineral likely to be deficient is iodine, but others, as discussed under the individual minerals, may be deficient in some situations.

#### METHODS OF SUPPLEMENTING CATTLE WITH MINERALS

There are six common methods of supplementing cattle with minerals:

- offering free choice, individual mineral sources in a cafeteria system
- offering a mixture of minerals as a lick
- supplementing with minerals mixed with concentrates
- feeding a mixture of minerals individually to cows
- injections or oral dosing
- slow-releasing bullets or soluble inpregnated glass.

But these systems can be incorrectly applied.

# Free choice of individual minerals in a cafetaria system

This system is based on the assumption that animals themselves instinctively know which minerals they need, and that they will consume

the required quantity. This theory has been disproved. Some cows will take several times the quantity of minerals taken by other cows. If they followed their requirements, individual intakes would be similar. Cows tend to eat the most palatable minerals rather than the required minerals.

It is also known that when deficient, cows can develop a perverted appetite for minerals, which can persist for the remainder of their lives.

#### Licks

This method must be used where no individual control is possible. The criticisms of this method are:

- individual animals vary considerably in their intake of the mixture
- the mixture becomes unpalatable after being exposed to dew or rain
- if the lick troughs are too small, bullying will occur, resulting in the prevention of free access to the lick for some animals

#### Minerals mixed in concentrates

It is impossible to supply accurately the required quantities of minerals by mixing them in a standard concentrate. This is because the amount of concentrates given to individual cows varies with some cows not receiving any concentrates and thus minerals. At lower levels of production, the cow becomes more dependent on the roughages as its mineral source. Cows receiving no concentrates are entirely dependent on the roughages to meet their mineral requirements. The roughage can be, and generally is, deficient in some minerals. This means that, whatever the level of minerals in concentrates, some cows will be overfed minerals while others are underfed, because the minerals supplied are balanced for an average production at an average concentrate supplementation level.

Individual supplementation of cattle

An estimate is made of the average production that can be expected from roughages alone. A mineral mix is made up to balance the deficiencies in the roughages and this is fed to the individual cows in measured or weighed amounts. In practice a tablespoon which holds about 50 g is a practical tool for mineral supplementation. One to three or more spoonsful of the supplement would be fed daily, either alone or on top of the cows concentrates. The requirements for production above that obtained from the roughages are added to the concentrates.

The advantages of this system are that the stockman knows that each cow gets her requirements and is not dependent on her appetite for minerals or on her rank in the pecking order. Furthermore, cows getting little or no concentrates will still receive minerals and cows getting a lot of concentrates need not be overfed minerals. The mineral content of the concentrate can thus be adjusted for production needs and no attempt need be made to make up roughage deficiencies. This method is the method of choice for supplementation of macrominerals such as salt, calcium, phosphorus and magnesium *etc*. Specific micro-mineral deficiencies can be individually catered for by injections or by slow-releasing bullets.

# Injections and oral dosing

Oral dosing, or drenching, of animals with mineral solutions or pastes of the required minerals has the advantage that all animals receive known amounts of the required mineral at known intervals. This type of treatment could prove unsatisfactory where labour costs are high and the animals must be handled frequently, specifically for treatment. Certain of the disadvantages associated with the use of licks or oral drenches can be overcome by the use of injectable organic compounds of the minerals. Such complexes are more expensive, but when injected intramuscularly, are absorbed slowly into the tissues and provide protection against a dietary deficiency of the injected element for lengthy periods.

#### Bullets and soluble glass

Heavy pellets (bullets) of the mineral, or soluble glass which has the specific mineral impregnated into it, are useful in supplying specific minerals, or minerals which need to be supplied continuously, for lengthy periods. These lodge in the reticulo-rumen of sheep and cattle and yield a steady supply of the mineral to the animal for periods of months or even years.

#### VITAMINS

Vitamins are complex organic compounds that function as parts of enzyme systems essential for the transformation of energy and regulation of body metababolism, and are required in minute amounts for normal growth, production, reproduction and/or health.

#### **GENERAL CONSIDERATIONS**

Vitamins A,D,K, E, C and the B Group are essential to animal health. A considerable variety of these, namely all the B vitamins and vitamin K, can be synthesized by the ruminal microflora. A deficiency of vitamin B<sub>12</sub> can occur, but only if cobalt is lacking. All green feeds are rich in vitamin C and in carotene, the latter being the provitamin (precurser) to vitamin A. Vitamin E occurs in most feeds, and it has been shown that a deficiency is most unlikely to occur unless the diet is short in selenium. Vitamin C deficiency has never been demonstrated in ruminants.

Vitamin deficiencies in cattle are rare and supplementation is only required in certain specific circumstances.

#### VITAMIN A

This vitamin has two primary functions in the animal body. First, it is essential for the maintenance of the epithelium, which forms the protective membranes in the respiratory and digestive tracts, and the lining of the eyes. If this vitamin is deficient, the epithelium becomes keratinized and cracks occur, giving easy access to bacteria and viruses, resulting in infectious diseases. Second, vitamin A plays an important role in the chemical processes which occur in the eye and are essential for vision. This vitamin combines with proteins in the retina of the eye

and forms the pigment called visual purple. These cells, together with the lens pigment, are responsible for vision in dim light. During this process, some of the vitamin A is excreted and has to be replenished from the blood, if normal vision is to be maintained. Vitamin A deficiency, in addition to causing malfunction in the processes referred to above, also will cause changes in bone structure and will affect reproduction by interfering with the production of sperm in males, and by causing resorption of the foetus in females.

Carotene is converted with varying efficiency to vitamin A by the animal body. Adult cattle are much better converters than are calves, and Holstein-Frieslands are better converters than are Jerseys. Cattle have the ability to store vitamin A. Adult cattle can store enough for up to three months. On green feeds, which are usually rich in vitamin A, cattle are unlikely to suffer a vitamin A deficiency. In cows, such a deficiency may occur only towards the end of winter, and then only if no green forage is available at that time. Under these circumstances, it might be advisable, towards the end of winter, to inject cows with one to two million international units of vitamin A, followed by a second injection a month later. Younger animals should be injected with smaller quantities, depending on the size of the animal.

The symptoms of vitamin A deficiency are scouring, low resistance to bacterial infection, stiffness of joints and unco-ordinated movements, lesions around the eyes and dull watery eyes followed by night blindness at more advanced stages. The fertility of cows is always affected. A shortened period of gestation, a high incidence of retained placentas, stillbirths and abortions are common symptoms. Often calves are born blind and their movements are unco-ordinated.

# VITAMIN D

Vitamin D occurs in plant material in the form of a provitamin which is converted in the animal body, when exposed to sunlight, to vitamin D. Adult cattle, unless stall fed, will not be vitamin D deficient. Calves, when kept for long periods under cover without being allowed exposure to the sun, can develop rickets. The symptoms are the same as those observed in cases of calcium and phosphorus deficiencies. Supplementation of the diet of calves with halibut or cod-liver oil will prevent rickets.

#### VITAMIN E

Vitamin E, apart from its other minor functions, has very strong antioxidant properties and is involved in the mammalian antioxidant defence system where it stimulates the immune response, thereby bringing about disease resistance.

For certain purposes, the antioxidant functions of vitamin E can be performed by other antioxidants. Selenium for example, which is present in glutathiozone peroxidase, decomposes peroxides, which are toxic. This is one of the reasons for the interaction between vitamin E and selenium, and in many cases either selenium or vitamin E can correct dietary deficiencies. For example, it has been shown that the occurrence of muscular dystrophies (myopathinies, white muscle disease) in cattle can be prevented by administering traces of either selenium or vitamin E. Where, however, animals are getting a diet rich in unsaturated fatty acids (for example, cod liver oil fed to calves) the addition of selenium to the diet will not help muscular dystrophy, but the addition of vitamin E will be effective. Vitamin E, on the other hand, will not be effective in cases where the selenium content of the diet is high (above 0,08%). In herds where the incidence of retained placenta is high, injecting each cow with selenium 21 to 25 days before calving is effective in reducing the incidence of retained placenta, in such cases vitamin E has no effect.

The exact interrelationship between vitamin E and selenium is not yet clear. However, a shortage of vitamin E is unlikely to occur, because green roughages are sources of this vitamin. Maize is a poor source, but wheat by-products (especially wheat germ) are excellent sources, of this vitamin.

### **REFERENCES**:

ARC, 1965. *The nutrient requirements of farm livestock. No. 2. Ruminants.* London: Agricultural Research Council.

ARC, 1980. *The nutrient requirements of ruminant livestock*. Farnham Royal: Commonwealth Agricultural Bureaux.

GRACE, N.D., 1983. *The mineral requirements of grazing ruminants.* (Occasional Publication No. 9): New Zealand Society of Animal Production.

MAFF, DAFS, DANI, UKASTA, BVA, 1984. Mineral, trace element and vitamin allowances for ruminant livestock, in: *Recent advances in animal nutrition*, edited by Haresign W. & Cole, D.J.A.

McDOWELL, C.R., CONRAD, J.K., ELLIS, G.L. & LOOSLI, J.K., 1983. *Minerals for grazing ruminants in Tropical Regions.* University of Gainesville: Florida.

NRC, 1971. *Nutrient requirements of dairy cattle,*. 5th ed. Washington D.C: National Academy of Sciences.

NRC, 1978. *Nutritional requirements of dairy cattle*, 5th rev. ed. Washington D.C: National Academy of Sciences.