AN OVERVIEW OF VITAMINS AND MINERALS FOR GOATS

Goats have an ability to thrive in the harshest environments. Their high digestive ability enables them to deal with high cellulose/high fibre diets of a very coarse nature. Anatomically goats are similar to other ruminants but with respect to mineral and vitamin requirements very little research has been carried out. That which has occurred has been performed almost by accident using goats as an inexpensive substitute for the cow. There is very little substantial data and very few definitive text books, which is very odd when one considers that there are over 400 million goats worldwide and more goats than sheep in the EU. In fact in some places e.g. The Sudan there are four goats for every person.

Recent surveys show that there are many areas deficient in certain minerals. However, the goat is an intelligent animal and usually manages on free range to eat herbs, weeds and other deep rooted plant material which has relatively high mineral content - free range is very rare though in the U.K. If a goat of say 45kg bodyweight gives 4.5kg of milk per day that is equal to a cow of 500kg giving 50kg (11 + gallons!) No such animal exists. A goat is at least 50% more productive and efficient for its bodyweight than a cow. This means that if a goat is giving its own bodyweight in milk every 10 days, it is therefore utilising vast quantities of vitamins and minerals. At its extreme, a goat has been known to yield consistently 9kg of milk per day, which is equivalent to her own bodyweight every 5 days! A goat also needs more minerals and vitamins for maintenance. With its relatively large digestive system in relation to its body, the work of digestion involves use and loss of large quantities of minerals.

Before we take the minerals and trace elements individually, there is no distinction between the two - it is merely a matter of degree. High levels are called minerals, low levels are called trace elements.

Calcium (Ca) and Phosphorous (P). They are usually considered and always found together, yet they are opposite in effect e.g. excess Ca is equivalent to deficiency in P. They are also interactive with vitamin D as well as iron and copper. 99% is stored in the skeleton and 1% or less is used vitally in enzymatic processes, cell transport, blood clotting etc. The skeleton is the store for both Ca and P and a goat can draw from this reserve in times of deficiency. There is normally a positive calcium balance during pregnancy when the skeleton is added to and a negative balance after kidding where up to 30% of the skeleton may be utilised. A goat requires 1.3g of Ca and 1.0g P for each 1kg of milk: it requires 7.lg Ca and 4.9g P daily for maintenance. If we consider both these figures it is obvious that a Ca:P ratio of 1.4:1 is ideal, suiting both the above. Calcium deficiency manifests itself by rickets, milk fever (especially after kidding). Lack of Vitamin D will also help promote this, since it is required for retention of Ca in the bones. Phosphorous deficiency is more likely, less severe and harder to diagnose. Basically it causes 'poor thrift,' lower milk yields and general lethargy. Ca and P work on the thyroid gland together with Iodine to govern the metabolic rate - i.e. yield appetite, 'rate-of-living'. Very crudely, Ca

acts as a brake and P an accelerator. Unlike cows, goats excrete a large proportion of Ca and P and therefore have a relatively large requirement.

Magnesium (Mg). 70% is found in the bones and teeth, the rest in the blood. Again up to a third can be mobilised at times of need. Some of the functions of Ca depend upon Mg. A daily requirement of 1.2g per day is necessary. The first symptom is the lowering of the milk yield, possibly followed by magnesium tetany and hypomagnesaemia. This is most common when animals are put out on to lush grass in spring when the Mg in the grass is lowest and requirement greatest. It is relatively rare in goats.

Zinc (Zn). This is found in skin, hair and enzymes. Exact requirements are not known but between 10-60 p.p.m. is considered satisfactory. We do know that 6-7 p.p.m. does cause deficiency with stunted kids that do not thrive. Little Zn is available and must be supplied from the diet. It is not stored in the body as a reservoir. Deficiency symptoms are well documented although the extent and frequency are largely unknown. In Greece a survey of 150 goats showed 2% as having severe Zn deficiency. Zinc has a profound effect on males - much more than females - since it is involved in sperm production and the development of the sex organs. Deficiency symptoms include high bacteria in the mouth with excess saliva, stiffness of the joints and a low male sex drive. In vegetable diets Zn combines with phytic acid to form insoluble salts and becomes unavailable. Dry diets are more likely to cause parakeratosis and wetting of the feed hydrolyses the phytate salts and liberates the Zn. - so wetting of the feed is recommended. Zn deficiency is best spotted by the condition of the coat - there is reduced hair growth, a staring coat and also lameness. Zinc is not very toxic, one would need around 1000 p.p.m. to cause problems. However vast overfeeding or grazing in close proximity to smelting works has given rise to reports of excess, which interferes with iron and copper uptake, in turn giving anaemia. Zn in milk is proportional to feed intake and since goats milk is usually too low in zinc for human requirements, supplementing with Zn is a real benefit, especially when the milk is required for feeding to babies.

Manganese (Mn). Occurs mainly in the liver and is another essential mineral, When fed at 5 p.p.m. in the feed, deficiency symptoms were noted. These included lethargy whereby the goats laid down a lot, they walked poorly and deformities in the forelegs were also noticed. A change in the sex ratio in favour of male twins was reported and a lowering of the reproductive efficiency in the males and a lower conception rate in the females with delayed oestrus observed. A daily requirement of 60-90 p.p,m. in the feed is suggested.

Iodine (I). Low levels are needed daily - this is vitally important since goats can excrete 94% of their daily uptake via the milk, whereas cows lose only 2%. More Iodine in the diet gives directly more in the milk. It is also temperature dependent with six times more Iodine appearing in the milk at 30ºC than at 5ºC. Iodine concentrates in the thyroid gland in the throat and is used in the production of thyroxine - thyroxine sets the pace for the goat's metabolism. Only 0.15mg per day is required but this is essential. The percentage of Iodine available is proportional to its concentration in the soil and not what is growing on it, i.e. the same Iodine percentage occurs in

grass as In deep rooted weeds. Iodine must be fed with care as excess will easily put a goat off its feed. The main deficiency symptom is goitre whereby the thyroid swells in an attempt to work more efficiently with what little Iodine is available. A harsh coat is also common and perhaps the birth of live males, but dead female kids. The female has a larger thyroid gland and a bigger need for thyroxine and therefore Iodine.

Copper (Cu). Can get deficiency even at normal supplies if sulphur and cadmium are present - emissions etc. from factories are the main culprits. Again very small quantities are required and these must be consistently fed to aid digestion and utilise the iron by forming ceruloplasmin etc.Again deficiencies are very noticeable in the coat with 'spectacles' forming around the eyes, especially with dark haired goats. There is Swayback where the back actually does sway and the goat has difficulty walking and 'Teart' areas which cause deficiency by the presence of excess Molybdenum in the feedstuffs which causes poor copper absorption. Cadmium has the same 'blocking' effect as Molybdenum and this has been caused when goatkeepers have put contaminated waste sludge on to their pastures to act as a fertiliser.

Selenium (Se). This element is very toxic in anything other than really minute quantities, but is nonetheless essential. 0.2mg per day is officially recommended. Recent research has shown a link between Vit. E and Selenium in which they act as co-partners in cell metabolism. Deficient areas exist e.g. Lewes in Sussex and most of New Zealand. The symptoms include white muscle disease and stillbirths. Basic feedstuffs are often deficient in Se and have selenium added to compensate. Strangely, weeds and deep-rooted plants have a greater concentration of minerals than grass, yet for Se it is the same for all growth. Therefore the best guarantee for adequate Se is to selenise the soil via a special top-dressing.

Iron (Fe). Most people know that Fe is a component of blood - haemoglobin contains 75% of the total. Some is found in the enzyme systems and iron is fundamental to all tissue. Deficiencies can occur, especially in kids due to low body reserves and exacerbated by the low iron content of goats milk during suckling - a big difference here with cows and sheep milk. For adults a daily intake of 75mg is considered acceptable for lactating goats. Deficiency is relatively rare in farm animals with anaemia being the standard symptom. The diagnosis is not straightforward however since it is usually associated with other mineral imbalance problems. Iron toxicity is very rare because of huge doses needed to cause problems. The Fe in grass and oil meals (100-300mg per kg), in Dicalcium phosphates or limestone (500mg per kg) and cereal grains (30-60mg per kg) should provide enough. Any extra poses no problems·and the Fe content of the milk is NOT dependent upon the diet (which is very different from Iodine).

Cobalt (Co). There is a lot of data on this particular element and it is directly involved in the formation of Vit B12. Sheep have a greater need of Cobalt than cows and goats have 4 times the need of sheep! Deficiency gives off-flavours in the milk, loss of appetite, weakness, emaciation, anaemia, low productivity etc., and the latter symptoms are often categorised as 'pine'. 0.5 mg is required daily and it is most important that it is given on a little and often basis.

Sodium (Na). 1.5g per day is required, which is equivalent to about 3.5g of salt. Large excesses are detrimental to Vit A uptake and excess in the diet is excreted in the urine. There is large differences between goats as to preference to salt and a pure salt lick is the best (and cheapest) option. Salt blocks combined with vitamins are a waste of time because the vitamin content will degrade fast in this environment. It has been reported by McKenzie that all feral goats live near the sea because salt is so important to their existence. This is arrant nonsense since wild goats exist in the centre of Asia 3000 miles from the sea!

Potassium (K). It is now recognised that large quantities of K are needed. It is normally available in feedstuffs containing a high proportion of roughage and should not usually pose a problem. Deficiencies include emaciation, retarded growth, low feed intake with poor milk yields. It is not a toxic element and it is always a wise precaution to incorporate it in feed supplements.

Sulphur (S). It has long been assumed that adequate S is always available. However, it is now apparent that the Sulphur components in need can be easily lost due to their volatile nature. This is particularly true with hay and other fodder crops that have been stored n the sun for long periods. S is required for hair and hoof whereby it forms cross-linking of the keratin and thereby prevents laminitis in hooves and encourages a healthy coat. Specially formulated products with extra Sulphur are now available for Angora and Boer goats who have an additional need for this element.

Vitamin A. Now recognised as very important to all livestock including goats and its primary function is fortifying the outer defences of the skin and mucous membranes against disease. Vit A aids disease resistance and is required for good vision, lactation and reproduction. It is not yellow in colour but the carotenoid pigments found in carrots, maize etc. are bright yellow and contain the precursor to Vitamin A. Carotein is converted in the intestinal wall and this depends upon the thyroid gland. Since the thyroid is very large in the goat, this animal is a very efficient converter of Vit. A - in fact all carotene is converted. This is why goats milk is pure white whereas the milk from cows (relatively inefficient converters) is still yellow with uncoverted carotene present. Deficiency symptoms are rare and include night blindness, poor reproductive performance and metritis. Vitamin A is destroyed by sunlight and therefore old hay is very low in this vitamin so in winter make sure that kale and other feedstuffs high in Vit. A are fed. For the new-born kid the colostrum is very important since they have very small reserves of Vit. A. The Vit. A content of goats milk is proportional to the amount of beta-carotene in the feed.

Vitamin D. Closely connected with Calcium and Phosphorous, Vit. D is required for the deposition and remobilisation of the above into the skeleton. It is the antirachitic (prevents rickets) vitamin and its main source is from sunlight and is formed on the skin. Absorption is through the skin or by simply licking off. Deficiency symptoms are uncommon but goats that are kept indoors in winter etc. are most likely to suffer and therefore need supplementary feeding. Deficiency of Vit. D is a major cause of rickets, bow legs and osteomalacia and whilst it cannot make up for any absolute deficiency in Ca and P, Vit. D will compensate to some extent to help overcome any imbalance between the two. As in cows, there is a high output of Ca & P into the

milk and Vit. D is needed to maintain mobility of these minerals. It has been suggested in France that extra Vit. D is given in the last weeks of pregnancy to prevent hypocalcaemia (milk fever) and this seems very sensible.

Vitamin E. As discussed it is tied up with Selenium as a co-partner, but there are still some doubts as to its exact function. It is known to be concerned with the cell nucleus, the development of the foetus and the performance of the males. It is an antioxidant, facilitating absorption, storage and protection of Vit. A. Vit. E is found in oil meals and bran - however, if goats be persuaded to eat cod liver oil, recent evidence shows that deficiency symptoms are CREATED by forming gut conditions favourable to the destruction of both Vit. E and Selenium. The method of storage of feedstuffs is very important as the concentration of Vit. E is dependent upon it. Basic feedstuffs can easily be made to be very deficient simply by bad storage conditions. Goats transfer Vit. E into the milk more readily than cows and should therefore receive daily adequate supplies of this vitamin to ensure milk quality. Apart from white muscle disease and muscular dystrophy, lack of Vit. E also causes sterility in males. Note that kids have no reserves of fat soluble vitamins (A,D & E) and sudden death of kids less than 2 weeks old is often due to lack of Vit. E in particular. This is normally overcome by feeding colostrum but the Vit. E content is affected by the nutrition of the dam during pregnancy. With kids there is degeneration of muscle including the heart, whereas in older animals it will manifest itself as stiffness of the limbs.

The B Vitamins. Goats along with other ruminants are blessed with bacteria that live in the rumen and synthesise the B vitamins. Therefore it has been suggested that supplementation is not necessary, but there are several reasons for Vit. B inclusion:

a) inhibition of synthesis of certain B Vitamins by substances in feedstuffs occurs, especially with high starch compounds.

b) parasites in the gut totally remove certain B vitamins.

c) some B vitamins cannot be synthesised in sufficient quantities to meet demand - especially with heavy milkers and the shortfall must be provided via the feed.

Vitamin B1 (Thiamin). Conventional feedstuffs contain fairly constant amounts of B1 and the higher the amount fed the lower the amount synthesised. However diets with high carbohydrate content increase the requirement of B1 which is one reason why straight grain diets should not be fed since they act as Vit. BI antagonists, There is a relationship between Vit B1 deficiency and disease resistance and deficiency causes damage to the central nervous system (polioencephalomacia and cerebrocorticalnecrosis - PEM and CCN). This is exhibited by collapse, twitching etc. and the only cure is Vit B1 injection. 50-60mg per day is the recommended daily intake. Vit. B1 is also used as a preventative for acetonaemia.

Nicotinamide - a member of the B group vitamins. Recent evidence again shows limited synthesis and the majority of the vitamin is derived from the feed intake. Supplementation

improves milk production and butterfat levels. There is good evidence that Nicotinamide present in cereals is 'bound' i.e. not available and therefore must be added by supplementation in the diet.

Pantothenic acid - another B group member. In high cellulose diets e.g. where hay comprises a large percentage, the biosynthesis of Pantothenic acid is impaired. It is found in fresh vegetables and, in milk, bound to the proteins. It serves an important function in the formation of enzymes and certain antibodies, and since recent evidence has shown that deficiency can occur, it is always best to incorporate it in the feed via supplementation on a daily basis.

Vitamin B12 (Cyanocobalamin), Directly associated with Cobalt, Vit. B12 has a Cobalt nucleus in a highly complex molecule. Large excesses of Cobalt in the gut will result in analogues of Vit B12 being formed these are identical to the natural vitamin except for a slight molecular variation. These analogues surprisingly have zero vitamin activity, despite being 99+% identical to the original and will cause Vit B12 deficiency symptoms (outlined under Cobalt). Obviously, administering even more Cobalt is NOT the answer as this creates further problems and the best solution is to ensure a low daily dose of Cobalt is provided and in the case of B12 deficiency, an injection of this vitamin, whilst the gut flora returns to a normal healthy state.

Much more research is needed in this vital science - virtually no data is available to goatkeepers with respect to Vitamin C, Vitamin K, Biotin, Folic Acid as well as other trace elements such as Fluorine, Chromium etc. - and what about amino acids, enzymes, fatty acids etc. etc.? Only time and continued research will enable us to understand more fully the requirements of the goat and thus be able to cater adequately for her needs.