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Effect of Feeding of Various Minerals, Vitamins and Probiotic for Enhancing the Performance of Sheep and Goats

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A B S T R A C T

Ruminants are herbivorous, forgot fermentors. Goats and sheep are small ruminant animals. The ideal nutrition program supports optimum production, is efficient and economical, and minimizes related problems. Mineral, vitamins are vital nutrient for growth, reproduction and production sheep and goats.

Introduction

Nutrition exerts a huge influence on flock reproduction, milk production, and lamb and kid growth; 1) late-gestation and lactation are the most critical periods for ewe and doe nutrition, with lactation placing the highest nutritional demands on ewes/does; 2) nutrition level largely determines growth rate in lambs and kids (Ben Salem & Smith, 2008). Lambs and kids with higher growth potential have higher nutritional needs, especially with regard to protein and 3) animals receiving inadequate diets are more prone to disease and will fail to reach their genetic potential. The ideal nutrition program supports optimum production, is efficient and economical, and minimizes related problems. Although cattle, sheep and goats are all ruminants, they have some significant differences in their nutrient and feeding considerations;

Goats and sheep will graze grass and browse forbs (weeds and wild flowers) and brush closer than other herbivores and thus require more intense grazing management.

Goats tend to browse vegetation of higher quality than do cattle.

Sheep are fairly selective feeders, preferring grasses/pastures and forbs; goats, on the other hand, are mainly browsers, preferring shrubs and forbs.

Goats and sheep "sort" grain mixes, selectively choosing preferred ingredients, and therefore should be fed pelletized or textured feeds.

Goats like to eat with their heads up and will select portions with higher nutrient content.

Sheep are very sensitive to copper (Cu) toxicity, whereas goats can consume two to three times the Cu level that sheep can, with no ill effects.

Goats, on the other hand, are very sensitive to phosphorus (P) levels (do not exceed 0.40 % on the feed tag; 0.35 % is ideal). Sheep have a similar P requirement to goats but are less sensitive to higher levels.

Sheep and goats require nutrients for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk and hair. The groups of nutrients that are essential for these small ruminants are water, energy, protein, minerals and vitamins. Many factors affect the nutritional requirements of sheep and goats, including maintenance, growth, pregnancy, lactation, fibre production, activity, and environment. As the productivity of sheep and goats is increased through selection and crossbreeding with animals having a higher production potential, nutritional requirements will also increase. Therefore, the more productive sheep and goats should be fed high quality feed, especially weaned animals being prepared for market, young replacement females and females in late gestation and early lactation. Ewes and does feeding twins or triplets have greater nutritional requirements than ewes or does feeding a single offspring.

Minerals and vitamins for sheep and goats

In order to understand the fundamentals of small ruminant nutrition, we must know the role of minerals and vitamins in addition to energy and protein, essential for growth, production, and reproduction. There are many minerals that are required in the diet of sheep and goats. These are usually divided into macro-minerals (calcium, phosphorus, sodium, potassium, magnesium, sulphur and chlorine) and micro or trace minerals (iron, iodine, copper, zinc, molybdenum, manganese, cobalt, selenium). Macro-minerals are required in larger amounts than trace minerals, with that requirement expressed as a percent of the diet, or as grams per head per day (Fontenot *et al.,* 1989). Some of these are already in sufficient quantity in forages, so supplementation is not needed. Others may not be present in adequate amounts, so must be supplemented. Plant content of mineral elements is dependent upon the interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate (Khan *et al.,* 2006). Young and alkaline soils tend to be more abundant in most trace elements than the older, more acid, coarse, sandy soils. Practical determination of animal's mineral status is often very difficult. Blood analysis is a poor indication of mineral status for many of the minerals.

The body has a significant storage capability for many of the minerals (for example, the calcium in bone, and iron in the blood). Therefore, until body reserves are depleted, symptoms of deficiency may not be apparent. More involved processes like liver biopsy may be required to determine the mineral status of an animal. Sheep and goats, as small ruminants, can manufacture the B-complex vitamins in their rumens. However, animals who are under a health stress, producing milk at extremely high levels or whose rumen is not functioning may not be able to accommodate their body's need for the B-complex vitamins and supplementation may be required.

Calcium (Ca), Phosphorous (P) and vitamin D

Ca and P are usually considered and always found together, yet they may be considered to be opposite in effect (excess Ca is 'equivalent' to deficiency in P). They are also both interactive with vitamin D as well as iron and copper. 99% is stored in the skeleton and 1% or less is used vitally in blood clotting, membrane permeability, muscle contraction, nerve function, cardiac regulation and enzyme activation. The skeleton is the store for both Ca and P and somewhat surprisingly, the goat can add and draw from this reserve in times of deficiency (Herm *et al.*, 2015). There is normally a positive Ca 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. Sheep and goat requires 1.3g of Ca and 1.0 g P for each 1kg of milk produced. If we consider both these figures it is obvious that a Ca: P ratio of 1.4: 1 is ideal, suiting both the above. Ca 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. Vitamin 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.

80% of the P in the body is found in the bones and teeth. In addition it functions with calcium in bone formation, is essential for cell growth, energy utilization, maintaining acid-base balance, is a component of DNA and is required by rumen microbes for optimal growth and activity. P 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. 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. Deficiency symptoms are uncommon but sheep and goats that are kept indoors in winter etc. are most likely to suffer and therefore need supplementary feeding.

Sodium (Na) and Potassium (K)

1.5 g per day is required, which is equivalent to about 3.5 g of salt (NaCl). Large excesses are detrimental to vitamin A uptake and excess in the diet is excreted in the goat and sheep urine. There are 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 not ideal because the vitamin content will degrade fast in this aggressive environment. It is now recognised that for goats relatively 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, and 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.

Magnesium (Mg) and sulphur (S)

70% is found in the bones and teeth, the rest in the blood. It functions in carbohydrate and fat metabolism and is a catalyst in over 300 enzyme systems. Again up to a third can be mobilised at times of need. 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 (Altura, 1991). This is most common when animals are put out on to lush grass in spring when the Mg content in the grass is at its lowest and requirement greatest. It is relatively rare in goats (Table 1).

Table.1 Requirements of minerals and vitamins for various classes of sheep (based upon the NRC, 1985)

Nutrient	Young Lamb	Mature Ewe	
		Early Pregnancy	Nursing Twins
Calcium, %	0.55	0.25	0.40
Phosphorous, %	0.25	0.20	0.30
Potassium, %	0.60	0.50	0.80
Magnesium, %	0.12	0.12	0.18
Sulfur, %	0.15	0.15	0.25
Sodium, %	0.10	0.10	0.15
Iron, mg/kg DM	40	40	40
Copper, mg/kg DM	10	10	10
Manganese, mg/kg DM	40	40	40
Zinc, mg/kg DM	30	30	30
Selenium, mg/kg DM	0.30	0.30	0.30
Vit A, IU/lb DM	500	1000	1200
Vit D, IU/lb DM	100	100	100
Vit E, IU/lb DM	7	7	7

Table.2 List of feed additives used for feeding in sheep and goats

S. No.	Feed additive	Benefits of feeding
1.	*Aspergillus oryzae* (Yeast)	Stimulate fibre-digesting bacteria, stabilize rumen pH, and reduce heat stress
2.	Calcium propionate	Increase blood glucose and calcium levels
3.	Protected Choline	A methyl donor used to minimize fatty liver formation and to improve fat mobilization
4.	Enzymes	Increase fibre digestibility by reducing fibre (cellulase and xylanase enzymes) and DM intake
5.	Magnesium Oxide	Alkalinizer (raising rumen pH) and increases uptake of blood metabolites by the mammary gland, raising fat test
6.	Methionine Hydroxy Analog	Minimize fatty liver formation, control ketosis, and improve milk fat test
7.	Probiotics	Produce metabolic compounds that destroy undesirable organisms. Probiotics provide enzymes improving nutrient availability, or detoxify harmful metabolites
8.	Propylene Glycol	Used as a source of blood glucose, to stimulate an insulin response, and to reduce fat mobilization
9.	Sodium Bentonite	Clay mineral used as a binder, which shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported
10.	Sodium Bicarbonate / Sodium Sesquicarbonate (Buffer)	Increase dry matter intake and stabilize rumen pH
11.	Yucca Extract	Decrease urea nitrogen in plasma and milk by binding ammonia to the glycofraction extract of Yucca shidigera plant, improving nitrogen efficiency in ruminant animals
12.	Zinc Methionine	To improve immune response, harden hooves, and lower somatic cell counts

Table.3 List of commercially available feed additives used for feeding in sheep and goats

Sr. No.	Feed additive (trade name)	Contain	Benefits of feeding
1.	Goat SHAG	Combination of probiotics, electrolytes, vitamin and mineral pack.	Improve growth rate and milk production.
2.	Secret Shake	Combination of Proteins, Spray Dried Egg Product, Amino Acids, Carbohydrates, and Electrolytes in a highly digestible palatable form.	To pull weight without losing shape and bloom.
3.	Sheep and Goat Nutri-Drench	High energy source containing high vitamins, minerals, amino acids and glucose.	These nutrients support life and are needed quickly to restore a non-functioning immune system. Support for multiple birth and disease, increase milk production, stimulate appetite, energy burst for weak newborn kids.
4.	Full Stream for Goats and Lambs	Calcium	A topdress feed supplement for goat and lamb wethers, designed to increase absorption of calcium in animals prone to urinary calculi.
5.	Duramax" with Oxy-gen for Goats	High potent vitamin and mineral mobility package	Better nutrient absorption through the digestive system.

Two amino acids (methionine, cysteine) and two B-vitamins (biotin, thiamine) contain S. S also functions in maintaining bone, cartilage, tendon and blood vessel integrity (contained in chondroitin) (Noronha, 2002). Rumen microbes are capable of synthesizing the entire S containing compounds from inorganic sulphur. High S levels in the diet partially inhibit the use of Cu and Mo.

Copper (Cu) and zinc (Zn)

Cu is involved in haemoglobin formation, enzyme systems, nervous and immune system function (Chia *et al.*, 1992). Cu interacts with Fe, Zn, S and Mo in antagonistic relationships. Cadmium also has the same 'blocking' effect as molybdenum and this has occurred when goat keepers have put contaminated waste sludge on to their pastures to act as a fertiliser. Sheep are very susceptible to Cu poisoning as dietary Cu levels approach or exceed 20 ppm. Very small quantities of Cu are required and these must be consistently fed to aid digestion and utilise the Fe by forming ceruloplasmin etc. Again deficiencies are very noticeable in the coat with 'spectacles' forming around the eyes, especially noticeable with dark wool type sheep and haired goats (Clauss *et al.*, 2007). More serious Cu deficiencies can be seen with the appearance of 'Swayback' where the back actually does sway and the goat has difficulty walking. Cu deficiency caused by the presence of excess Mo in the soil which prevents the Cu being absorbed. Mineral mixes or trace mineral salt formulated for cattle or horses should not be fed to sheep because they are too high in Cu and sheep accumulate Cu in the liver more easily than other livestock species. If sheep mineral contains Cu don’t feed a trace-mineralized salt containing Cu. Cu poisoning also may result from low intakes of Mo, S, Zn and Ca. Stressful situations such as handling, strenuous exercise, transporting, a declining

nutritional state and weather can cause a sudden release of the stored Cu into the blood, and cause toxicity.

Zn is important in stress management, immune response, enzyme systems and protein synthesis. Exact requirements are not known but between 10-60 ppm (mg/kg DM) is considered satisfactory. Level below 6-7 ppm does cause deficiency with stunted kids and lambs that do not thrive (Kirchgessner *et al.,* 1981). Little Zn is available and must be supplied from the diet since it is not stored in the body as a reservoir. Zn 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 for males is recommended. Zn deficiency is best spotted by the condition of the coat - there is reduced hair growth, a staring coat and also lameness. Zn is not very toxic; one would need around 1000 ppm to cause problems.

Manganese (Mn)

Occurs mainly in the liver (cofactor in several enzyme systems) and is another essential mineral, when fed at 5 ppm in the feed, deficiency symptoms were noted. These included lethargy whereby goats would lay down a lot, walk poorly and deformities in the forelegs were also noticed (Chia *et al.,* 1992). 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 ppm in the feed is generally suggested as being ideal (Kirchgessner *et al.,* 1981).

Iodine (I) and Cobalt (Co)

I is primarily involved in the thyroid hormones that regulate rate of metabolism. Deficiency usually is not a problem except with goitrogenic forages or feedstuffs like turnips, kale, rape, white clovers (Merck, 1986). Low levels are needed daily and are vitally important since goats and sheep can excrete 94% of their daily uptake via the milk, whereas cows lose only 2%. More I in the diet give directly more in the milk. It is also temperature dependent with six times more I appearing in the milk at 30ºC than at 5ºC. I concentrate in the thyroid gland in the throat and is used in the production of thyroxine hormone. Only 0.15 mg per day is required but this is essential. The percentage of I available is proportional to its concentration in the soil and not what is growing on it (the same I percentage occurs in grass as in deep rooted weeds). 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 a greater need for I.

Sheep have a greater need of Co than cows and goats have 4 times the need of sheep. Co is directly involved in the formation of vitamin B_{12} (Arinola *et al.,* 2008). Deficiency gives off-flavours in the milk, loss of appetite, weakness, emaciation, anaemia, low productivity etc., and the latter symptoms are often categorised under the generic term 'pine'. 0.5 mg is required daily and it is most important that it is given on a daily basis.

Iron (Fe)

Fe involved in cellular respiration and oxygen transport via haemoglobin. Additionally, some is found in the enzyme systems and Fe

is fundamental to all living tissue. Deficiencies can occur, especially in kids and lamb due to low body reserves and exacerbated by the low Fe content of goats milk during suckling (a big difference here with cows and sheep milk). For adults a daily intake of 75 mg is considered acceptable for lactating goats. Deficiency is relatively rare in farm animals with anaemia being the standard symptom. Fe toxicity is very rare because of huge doses needed to cause problems (Youdim *et al.,* 1989). 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 (very different from I).

Selenium (Se) and vitamin E

Se is very toxic in anything other than really minute quantities, but is nonetheless essential. 0.2 mg per day is officially recommended. Basic feedstuffs are often deficient in Se and many have Se rich compounds 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 (Combs Jr, 1981). Therefore the best guarantee for adequate Se is to 'Selenise' the soil via a special Se rich top-dressing.

Vitamin E is tied up with Se 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 vitamin A. vitamin E is found in oil meals and bran, however, if goats can 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 vitamin E and Se. The method of storage of feedstuffs is very important as the concentration of vitamin E is dependent upon it: basic feedstuffs can easily be made to be very deficient simply by bad storage conditions. Apart from white muscle disease and muscular dystrophy, lack of vitamin E also causes sterility in males. Note that kids have no reserves of fat soluble vitamins (A, D and E) and sudden death of kids less than 2 weeks old is often due to lack of vitamin E in particular. This is normally overcome by feeding colostrum but the vitamin E content is also 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 (Combs Jr, 1981).

Vitamin A

Vitamin A is recognised as very important to all livestock including sheep and goats and its primary function is fortifying the outer defences of the skin and mucous membranes against disease. Vitamin 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 known as Carotene. Carotene 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 vitamin A; in fact all carotene is converted: this is why goat's milk is pure white whereas the milk from cows (relatively inefficient converters) is still yellow with unconverted carotene present.

Vitamin A can be stored in the liver for two or three months after sheep and goats have been eating green forage for several months. Consequently, when animals are eating fresh pasture, or fresh or well-made hay, no supplemental vitamins are needed. 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. For the new-born kid and lamb the colostrum is very important since they have very small reserves of vitamin A. It is worth noting that the vitamin A content of goat milk is directly proportional to the amount of beta-carotene occurring in the feed.

Vitamin B-complex

Sheep and goat 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 vitamin B inclusion:

Inhibition of synthesis of certain B vitamins by substances in feedstuffs occurs, especially those with high starch levels.

Parasites in the gut totally remove certain B vitamins.

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.

Conventional feedstuffs contain fairly constant amounts of vitamin B_1 and the higher the amount fed the lower the amount synthesised. However diets with high carbohydrate content increase the requirement of vitamin B_1 which is one reason why straight grain diets should not be fed since they act as vitamin B_1 antagonists. There is a relationship between vitamin B1 deficiency and disease resistance and deficiency causes damage to the central nervous system (polioencephalomacia and cerebrocorticalnecrosis). This is exhibited by collapse, twitching etc. and the only cure is vitamin B_1 injection. 50-60 mg per day is the recommended daily intake. Vitamin B_1 is also used as a preventative for acetonaemia. Nicotinamide, also a member of the B group vitamins. Recent evidence again shows limited synthesis and the majority of the vitamin is derived from the goat's 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.

In high cellulose diets (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 B_{12} is directly associated with Co. Large excesses of Co in the gut will result in analogues of vitamin B_{12} 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 vitamin B_{12} deficiency symptoms. Obviously, administering even more Co is not the answer as this creates further problems and the best solution is to ensure a low daily dose of Co is provided and in the case of vitamin B_{12} deficiency, an injection of this vitamin, whilst the gut flora returns to a normal healthy state.

Choosing a mineral and vitamin supplement

There are a variety of salt and mineral mixes commercially available that are specifically formulated for sheep. These mixes range from trace mineralized salt to salt-free minerals to mineral mixes that contain vitamins. When

you feed a complete trace mineral mix containing salt, no other source of salt should be available to your sheep. Some commercial mineral mixes also contain vitamins A, D and E. If you buy a mineral mix with added vitamins, choose the one containing the highest level of vitamin A (up to 500,000 IU). Adding specific minerals like Ca is also a way of incorporating minerals into the diet in some circumstances (adding limestone or calcium carbonate is an inexpensive way to supply the Ca required by lambs fed high grain diets or ewes fed green feed or grass hay as roughage). Minerals can also be supplied in a custom mineral mix that is specifically designed to meet the mineral requirements of your sheep based on an analysis of your home grown feeds. When the nutrient content of your home grown feeds changes, so must the minerals supplied in your custom mineral mix.

Feed additives for sheep and goats

Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as rumen pH shift, growth, or metabolic modifier. Several feed additives contain nutrients such as sodium in sodium bicarbonate, or protein in yeast culture. Feed additives are not a requirement or guarantee for high productivity or profitability. Most sheep and goat producers will use very few, if any, feed additives. However, feed additives are heavily marketed and producers should be aware of what they are, what claims are made for individual feed additives and which work and which do not.

In conclusion, supplementation of micronutrients and feed additives in diets of sheep and goats enhanced body weight gain, and productive and reproductive performance of sheep and goats.

Balanced feeding and nutritional supplement such as minerals, vitamins and probiotics are important ways to enhance health and prevent disease in small ruminant animals and also enhances reproduction and production performance in sheep and goats.

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