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Boosting Small Ruminant Health and Productivity with Mineral Mixtures

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Background

Small ruminants, particularly sheep and goats, play a critical role in global agriculture, providing meat, milk, and fiber. Their productivity, however, is often hampered by nutritional deficiencies, especially a lack of essential minerals. Unlike large ruminants, small ruminants have specific mineral requirements that may not be adequately met by traditional grazing or forage-based diets. This is where mineral mixtures come in, offering a targeted solution to optimize their health and performance.

Introduction

In small ruminant farming, reproductive efficiency and nutrition are closely linked, with inadequate nutrition negatively impacting reproduction, particularly in females (Wang et al 2023). The capacity for reproduction of semiarid pasture-raised animals may be hindered due to an inadequate diet in the dry season (Kraai et al, 2022). Since grazing is the primary source of nutrition for these animals, the body condition of the flock directly influences its reproductive capacity. Nutritional conditions play a significant role in modulating reproduction in sheep and goats because reproductive activities require both the quality and quantity of nutrients (Blache et al, 2008). The combination of supplementation, grazing, and reproductive management can significantly improve the reproductive performance of sheep and goats (Assan, 2022), especially for female animals like pregnant ewes or dry mated does, if the grass is poor quality. that were up to 29% higher than those of grazing-only groups. Trace elements, like cu and se, are often overlooked in supplements, leading to deficiencies in certain grazing areas (Assan, 2025). Feed blocks supplementing ewes before and during mating can boost conception rates and twinning percentages. The use of blocks as supplements likely resulted in an increase in the amount of nutrients provided, particularly proteins (Chisoro et al, 2020b).

Mineral mixtures are supplemental feed additives containing a blend of essential macro-minerals (like calcium, phosphorus, and magnesium) and micro-minerals (like zinc, copper, selenium, and cobalt). These minerals are vital for various physiological functions in sheep and goats, including:

- **Growth and Development:** Minerals like calcium and phosphorus are crucial for bone formation and skeletal development, especially in young animals.
- **Reproduction:** Minerals such as selenium, zinc, and copper play key roles in reproductive processes, including fertility, conception rates, and reducing the incidence of abortions.
- **Immunity:** Adequate levels of zinc, selenium, and copper are essential for a strong immune system, helping animals resist diseases and infections.
- **Metabolic Functions:** Minerals are involved in numerous enzymatic reactions and metabolic processes that are critical for energy utilization, nutrient metabolism, and overall health.
- **Productivity:** Mineral deficiencies can lead to reduced growth rates, lower milk production, poor wool or fiber quality, and decreased reproductive efficiency, all of which impact profitability.
- Trace minerals are mainly supplemented as inorganic forms i.e. sulfate, oxides and

chlorides in the ration of animals. However, due to high interaction with other dietary nutrients and low bioavailability of inorganic trace elements, organic trace minerals such as proteinates and chelates are used. Organic forms of trace minerals more closely resemble the natural forms that are present in plants. Recently hydroxy sources of trace minerals are introduced and these are more bioavailable than inorganic and comparable to organic source.

- **Zinc**: It is a key component of more than 200 metalloenzymes such as carbonic anhydrase, alkaline phosphatase, superoxide dismutase, carboxypeptidase A and B, alcohol dehydrogenase, lactic dehydrogenase etc. which are involved in the metabolism of carbohydrates, nucleic acid and fatty acid. Zinc is important for the function of DNA polymerase, thymidine kinase, DNA dependent RNA polymerases involved in the nucleic acid synthesis. Deficiency of Zn in growing animals reduces cellular division, growth and retards puberty. Zinc along with vitamin A is important for the normal functioning of ovary and vision. Zinc regulates phagocytosis by macrophages and neutrophils. It is important for the activity of immune modulators like thymulin which promotes T lymphocyte maturation. It plays a role in embryo implantation, membrane stability of RBC and wound healing. Supplementation of Zn in pasture grazed sheep increases lamb production as compared to non-supplemented sheep. In goat, Zn supplementation increase prolificacy by 14%. Zinc deficient ration in ram's causes atrophy of seminiferous tubules and complete inhibition of spermatogenesis. In females, Zn is important for uterine involution and tissue repair after parturition. Zinc deficiency in sheep causes stiffness of joints, soft edematous swelling of the fetlock, development of horny overgrowths on mucosa of lips, parakeratosis, rough hair coat, emaciation and alopecia.

- **Manganese**: It is important for bone formation, reproduction, growth and enzyme functioning. It plays an important role in the functioning of corpus luteum. Depressed and delayed estrus, poor conception rate and abortion have been associated with Mn deprivation in goats and ewes. In ram lambs, Mn deficiency restricts testicular growth. Manganese is required for lipid and carbohydrate metabolism as it is involved in the activity of pyruvate carboxylase. It is needed for synthesis of mucopolysaccharides in cartilage through the activation of the glycosyltransferase enzyme. Manganese is commonly supplemented in the ration in the form of $MnSO_4$, MnO and $MnCO_3$.

- **Cobalt:** Cobalt is needed for vitamin B12 synthesis which is essential for energy and protein metabolism in ruminants. It is also associated with RBC production. Sheep and goats are more vulnerable to cobalt deficiency than cattle. Cobalt deficiency in sheep leads to anaemia, ill thrift, reduced appetite, poor reproduction, weepy eye with damp matted wool below eyes and wool break. Diet should contain 0.1 mg/kg DMI to prevent deficiency disorders. Availability of pasture cobalt is dependent on soil pH as soil pH rises cobalt availability decreases.

- **Selenium**: It protects the tissue from oxidation and breakdown of cell membrane. It is essential for production of thyroid hormone by activating deiodinase enzyme. It is also essential for the production of prostaglandin. In pregnant ewes' efficiency of Se causes white muscle disease in lambs which is known as stiff lamb disease and in male animals deficiency can lead to poor fertility. Excess selenium can be toxic to sheep and lead to colic, diarrhoea and collapse.

- **Copper**: Copper is an essential component of a range of enzymes involved in cell energy metabolism in brain and signalling in the nervous system. It is involved in cellular respiration, bone formation and connective tissue development. Copper deficiency during mid-pregnancy in ewes leads to sway back in newborn lambs characterized by impaired development of spinal cord and cerebellum. In growing lambs copper deficiency leads to poor growth, scouring and poor fleece quality. When goats are exposed to prolonged Cu deficiency, they present nymphomaniac reproductive behaviour. Goats are more sensitive to Cu deficiency than sheep. Excess Mo and S lead to Cu deficiency which leads to reproductive disorder in

sheep and goats. Recommended level of Cu and Mo ratio in the ration is 3:1 to 6:1. Excess Cu can be toxic to sheep. Recommended level of copper in the diet is 10 ppm however, the maximum permissible level to prevent Cu toxicity is 17 ppm.

- **Iron**: About 60% of Fe is present in the body is in the form of haemoglobin which is required for oxygen transport. It is a component of enzyme i.e. cytochrome oxidase which is involved in oxidative phosphorylation. It is involved in connective tissue development through activation of hydroxylases enzyme. Major deficiency symptom of Fe is anaemia. Milk contains a very low concentration of Fe therefore, kids/ lambs raised on milk alone for a long time can develop anaemia.
- **Iodine**: It is required for the formation of thyroxin hormone which plays an important role in energy metabolism. It is important for normal fetal growth and development. Iodine plays a role in appetite control and adaptation to temperature changes. Along with Se, I2 plays an important role in brown fat metabolism in newborn lamb thus promoting lamb survival in cold climatic conditions. The minimum recommended level of iodine to prevent deficiency disorder in growing animals are 0.2 mg/kg DM whereas, in pregnant and lactating animals it is 0.5 mg/g DM. Care must be taken when animals graze on certain forage crops containing goitrogens which limits thyroid hormone production and results in increased iodine requirement. Iodine deficiency causes goitre, late-term abortion, stillborn, weak lamb and poor survival rate of lamb. However, oversupply of iodine in late pregnancy leads to increased neonatal lamb death due to reduced antibody absorption.
- Khalil et al., 2019 reported that the age of maturity of female Kacang goats reared under a tethering system ranged between 5 and 9 months and the first kidding occurred between 12 and 23 months and mentioned that supplementation with minerals is an effective method to enhance nutritional status and health to increase pregnancy rate of tethered female.
- Sing et al., 2016 revealed that final body weight as well as average daily gain (ADG) in three months significantly ($P<0.05$) differed from control and treatment group. Among treatment groups, better body weight gain was observed in higher mineral supplemented group but was not significant. But, interestingly, the overall body condition score (BCS) differed significantly ($P<0.05$) between control and treatment as well as within treatment group. Age at maturity of control and treatment groups were 222.50 ± 5.74, 207.50 ±8.92, 187.50 ± 5.12 and 192.50 ± 6.29 days, respectively and the difference was significantly varied. Mean oestrogen and progesterone level was marginally high in mineral supplemented group than control group.
- Aditia et al., 2019 mentioned that giving 200 mg Zn/head tends to increase ($P<0.05$) the Zn concentration in the blood of doelings among the levels of Se. Percent digestibility of Zn decreased with Zn supplementation at 200 mg. Percent apparent digestibility of Zn tends to be higher in animals without mineral supplementation. Zn supplementation increased blood Zn concentration, but did not affect digestibility of Zn.
- Sallam et al., 2017 suggested that supplementation of pregnant goats with organic minerals improved their immune status and their kids' performance.
- Tiwari et al., 2014 reported that higher body weight gain was achieved due to supplementing effect of mineral mixture and suggested superior daily gains in male goat with supplementation of 15 g mineral mixture/goat/day with basal diet.

Mineral	**Function**	**Signs of Deficiency**
Calcium & Phosphorus	Bone development, lactation	• Weak bones, poor growth
Magnesium	Nervous function	• Grass tetany, restlessness
Zinc	Skin, hoof health	• Poor coat, foot problems

Mineral	Function	Signs of Deficiency
Copper	Enzyme function, coat colour	• Anaemia, faded coat (but toxic in excess)
Selenium	Reproductive health, muscle function	• White muscle disease
Iodine	Thyroid function	• Goiter, weak kids/lambs

The effectiveness of mineral mixtures depends on several factors:

- **Animal Requirements:** The specific mineral needs of sheep and goats vary depending on their age, physiological state (e.g., growth, pregnancy, lactation), and breed.
- **Diet Composition:** The base diet, including the type of forage and any other feedstuffs, influences the animal's existing mineral intake.
- **Mineral Bioavailability:** The form of the minerals in the mixture (e.g., organic vs. inorganic) affects how well they are absorbed and utilized by the animal.
- **Regional Variations:** Soil mineral content varies geographically, leading to deficiencies or excesses in certain areas. Formulations should consider this.

It's important to note that over-supplementation can also be detrimental. For example, excess copper can be toxic to sheep. Therefore, it is crucial to use mineral mixtures that are specifically formulated for small ruminants and to follow recommended feeding guidelines.

To maximize the benefits of mineral supplementation:

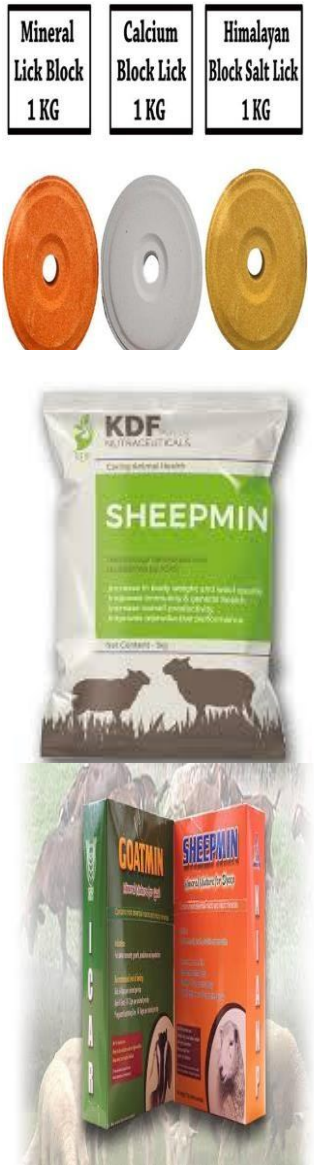
- **Consult with Experts:** Consult with a veterinarian or animal nutritionist to determine the specific mineral needs of your animals and the most appropriate mineral mixture formulation for your region and production system.
- **Use High-Quality Products:** Choose mineral mixtures from reputable manufacturers that use high-quality ingredients and ensure proper mineral balance.
- **Provide Free Choice:** Offer mineral mixtures on a free-choice basis, allowing animals to consume what they need. Ensure a clean and dry feeder is always available.
- **Monitor Animal Health:** Observe your animals for any signs of mineral deficiency or toxicity, and adjust supplementation as needed.
- **Consider Soil and Forage Testing:** In areas with known mineral imbalances, consider testing soil and forage to determine the specific deficiencies that need to be addressed.
- **Balanced Nutrition:** Remember that mineral supplementation is just one component of a balanced nutrition program. Ensure that animals also receive adequate energy, protein, and other essential nutrients.

How to Offer it:

- **Form of Minerals:** Chelated trace minerals are generally preferred for better absorption. Ensures uniform intake but may increase feed cost. Loose mineral form: Kept in weather-proof feeders.
- **Quality and Purity:** Ensure that the mineral mixture is of high quality and free from contaminants.
- **Individual Needs:** The specific mineral requirements may vary depending on the age, breed, and production stage of the animals. **Sheep and goat mineral mixtures level of feeding**

  Young animals @ 4-6 g/day
  Growing and Adults @ 8-10 g/day
  Pregnant and lactating @ 12-14 g/day
- **Environmental Factors:** Soil and forage mineral content can also influence the need for supplementation.
- **Free Choice vs. Supplemented Feeding:** Free-choice mineral feeders allow animals to consume minerals as needed, while supplemented feeding involves adding minerals to the feed mix.

- **Mineral blocks or licks**: @ 1 block for 5 animals. Convenient but may lead to uneven consumption.



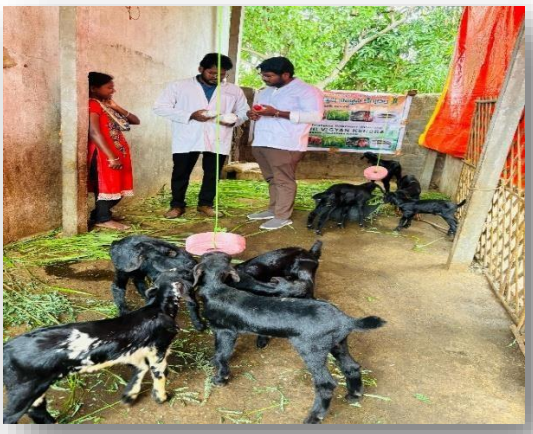
Commercially available mineral licks and mineral mixtures for small ruminants

Best Practices

- **Consult a Vet or Animal Nutritionist**: Always use tested, balanced mixtures suited for your animals and region.
- **Avoid Excess Copper in Sheep Diets**: Goats can tolerate more copper, but sheep are very sensitive.
- **Ensure Free Access to Clean Water**: Minerals affect and are affected by hydration levels.
- **Regular Health Checks**: Monitor for signs of mineral deficiency or toxicity.
- **Observe Feed and Soil Reports**: Mineral needs vary based on grazing conditions.

Conclusion

Mineral mixtures are a valuable tool for improving the health, productivity and profitability of sheep and goat farming. A well-formulated mineral mixture is an essential part of a balanced diet for sheep and goats. By addressing specific mineral deficiencies, these supplements can enhance growth, reproductive performance, immunity and overall well-being of small ruminants.



Distribution of Small ruminant mineral mixtures and mineral blocks by KVK Mamnoor scientists

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