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Impact of Nutrient Rich Diet on Milk Production of Cattle

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Abstract

Vitamins and minerals are organic compounds needed in minute amounts which are essential for life. Vitamins and Minerals rich well-balanced diets maximize milk production and improve cattle health. Dairy cattle need at least 17 minerals and three vitamins in their diet for optimal milk production, reproductive success, and herd health. Even minor imbalances or defects may lead to problems with reproduction, hygiene, and milk production. Natural feeds (forages and grains) and mineral supplements are the two main sources of minerals used to complement the minerals found in the forages and grains. Whether a mineral's requirement is high (measured in percent of dry matter) or low (measured in ppm), the correct amount must be fed to ensure optimal production and herd well-being. Deficiency or excess of any type of nutrient can limit the performance significantly. For dairy cattle, vitamins and minerals in the proper quantities are critical for their fitness, growth, and optimal milk production.

Introduction:

Minerals are typically classified as metal elements that are inorganic compounds required for different bodily functions from structure, nerve impulses to osmotic balance and enzyme function. Minerals are divided into two categories macrominerals (including Ca, P, Mg, K, Cl, Na, and S) which are required in relatively large amounts, expressed as a percentage of the diet or grams per day and microminerals (including Cu, I, Se, Mo, Co, Fe, Zn, F and Mn) also known as trace minerals are required in mg or µg quantities.

Table1: Common feed sources of minerals

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Calcium	Phosphorus	Magnesium	Sulfur
Monocalcium phosphate	Monocalcium phosphate	Magnesium oxide	Calcium sulfate
Dicalcium phosphate	Ammonium phosphate	Magnesium sulfate	Sodium sulfate
Calcium chloride	Dicalcium phosphate	Magnesium carbonate	Potassium sulfate
limestone	Dicalcium phosphate	Magnesium chloride	Magnesium sulfate
Forages	Low fluorine rock phosphate	Dolomitic limestone	Elemental sulfur
Calcium carbonate	Defluorinated phosphate	Forages, grains	

Mineral Requirements:

1. Macrominerals

***Calcium and Phosphorus*:** Calcium (Ca) and Phosphorus (P) are present in teeth and bones, but calcium can also be found in milk and eggs. Ca is required for blood clotting, muscle contraction, and the proper processing of various biochemical reactions in the body. Phosphorus is needed for all biochemical reactions that enable animals to use the energy in their food. Both are required for the complete lactation cycle. For high-producing cows, the dietary calcium level of 0.80% and phosphorus level of 0.50% of dietary dry matter is needed. A lack of P in the diet will lead to poor reproductive success in females and a reduction in vitamin A availability. Lactating cows' calcium requirements are variable, with a minimum of 0.61 % of the diet required (DM basis). Green forages and limestone are good sources of calcium. Growing cattle have 6–8 mg P/100 mL in blood plasma, while adult cattle have 4–6 mg P/100 mL. It is required for the synthesis of microbial crude protein. Calves require 0.3–0.4 % P in their diet (on a DM basis), while cows require 0.32–0.42 %. Phosphorus deficiency is very general. Symptoms include poor appetite, poor growth, reduced fertility, and typically poor overall performance.

***Sodium and Chlorine*:** Sodium and Chlorine are found together as sodium chloride (NaCl or common salt) and serve to maintain proper acidity levels in body fluid and pressure in body cells. HCl in the stomach contains chlorine. It's widely used as a rumen buffer and as a salt.

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Feeding high amounts of Na during the pre-partum period can result in hypo-calcemia while feeding it during the post-partum period stimulates water intake, rate of passage through the gastrointestinal tract and therefore feed intake. The requirements of Na are highly variable and are about 0.24% of the diet. Pica is caused by a lack of salt. If there isn't enough fresh drinking water, salt toxicity will develop; resulting in udder edoema and subsequent failure. Chloride is the most abundant anion in extracellular fluid, accounting for up to 60% of all anions. It has a close connection to K and Na. It's essential for the exchange of oxygen and carbon dioxide. It's also the most abundant anion in gastric secretions, which is needed to start protein digestion in the abomasum. 0.34 % Cl is needed in the diet. Metabolic alkalosis, faecal mucus, and polyuria are all symptoms of a Cl deficiency.

Magnesium- This is necessary for the utilization of energy in the body, bone growth and many enzymatic reactions. Cattle feeding on green, immature pasture can have low Mg levels in their blood, resulting in grass tetany, a disease marked by convulsions, muscle twitching, staggering gait, and dropping. Mg is needed in 0.2 % of DM in the diet. During early lactation, when dietary fat is fed, or when grass tetany occurs, higher magnesium levels can be needed. Supplements such as magnesium oxide (56% magnesium) or dynamate (12% magnesium) should be fed.

Potassium- This serves to maintain proper acidity levels in body fluids and pressure in body cells, acid-base regulation, water balance, nerve transmission, muscle contractions, oxygen and carbon dioxide transport and a co-factor in many enzymatic reactions. Legume forages are good potassium sources. Potassium needs are raised to 1.3-1.5 % of ratio DM when heat stress is a concern. Potassium is primarily absorbed in the duodenum by diffusion and it is primarily excreted via the kidney in the urine. Lactating dairy cows should be fed a diet containing 1.5% K or more, while calves need 0.4%–0.55%.

Sulfur- This is a part of body protein, vitamins, and hormones. It plays a role in protein, lipid, and carbohydrate metabolism, as well as blood clotting and body fluid acidity regulation. It is found in amino acids such as methionine, cysteine, and taurine, thiamin, biotin and chondroitin sulfate. Sulfur sources include legumes and protein feeds. Sulfur in excess raises the risk of molybdenum toxicity and impedes copper use. S is needed in 0.2 % of the diet (DM basis). Neurological changes such as blindness, coma, and recumbency may occur as a result of toxicity.

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2. Micro minerals

Copper- This is a part of the cytochrome oxidase system necessary for the electron transport chain. It's part of the lysyl oxidase enzyme, which catalyzes the forming of desmosine cross-links in collagen and elastin, which are essential for bone power. It also plays a role in ceruloplasmin, which is needed for Fe transport during haemoglobin synthesis, as well as superoxide dismutase, an antioxidant. Copper deficiency can result in anemia, de-pigmentation in hair, infertility, scouring, loss of coat pigment especially around the eyes resulting in "spectacle eyes" and cardiac failure. Copper requirements are low for lactating cows i.e, 0.15 mg/kg of milk. Cu has a maximum tolerable concentration of 40 mg/kg dry matter.

Iodine- This is necessary for the production of the hormones tri-iodothyronine and thyroxin. Deficiencies symptoms are an enlarged thyroid gland known as goiter, hairless calves, reduced fertility and decreased immunity. Iodine has a maintenance requirement of 0.6 mg/100 kg of body weight. Due to thyroxin activity, this rises to 1.5 mg/100 kg of body weight during lactation. Goitrogens are a form of feed that can minimize I absorption. Iodized salt, NaI, KI, or CaI can be used as a source of supplemental I. At 68 mg/day, toxicity manifests as nasal and ocular discharge, excessive salivation, and scaly hair coats.

***Selenium*:** Along with vitamin E, this is an essential part of the enzyme glutathione peroxidase. The conversion of cell-damaging hydrogen peroxide to water is carried out by this enzyme. Selenium deficiency may result in "white muscle disease (WMD)", with leg weakness, stiffness, and muscles have chalky striations, lower fertility and an increased incidence of retained placentas. When cattle ingest feed containing poisonous or excessive levels of Se (10 ppm) for an extended period of time, "alkali disease" or "blind staggers" develop. To resolve Vitamin E-Selenium deficiency, Grow E- Sel should be added to the feed. The US FDA regulates selenium supplementation in the diet at 0.3 mg/kg. Retained placenta, cystic ovaries, metritis and mastitis are all reduced by supplementation of Se. Se travels through the placenta and reduces the risk of WMD when fed to a pregnant cow.

***Molybdenum*:** This forms an essential part of some enzymes (xanthine oxidase, sulfide oxidase, and aldehyde oxidase) and has a stimulating effect on fiber-digesting microorganisms in the rumen. In cattle, there is no provision for Mo. However, the highest dose that can be tolerated is 10 mg/kg dry matter.

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***Manganese*:** This is essential for the utilization of carbohydrates. This is required for the production of superoxide dismutase. In cattle, manganese deficiency causes slow bone growth and reproductive failure. Silent heat and poor pregnancy rates are the results of toxicity. Deficiency can cause skeletal defects. The required Mn is 40 mg/kg dry matter in the diet.

***Iron*:** This is an essential part of hemoglobin and is involved in enzymes in the electron transport chain, such as cytochrome oxidase and cytochrome P-450 enzymes. Iron deficiency can lead to anaemia and stunted development. A pre-ruminant calf needs about 150 mg/kg of DM while a mature cow only needs 24 mg/kg of DM. If Fe cannot be transferred out of the body and toxicity occurs (as low as 250–500 mg/kg of dry matter intake), it can build up in tissues, producing oxygen radicals and eventually causing cellular damage.

***Zinc*:** This is part of several metalloenzymes such as RNA polymerase and carbonic anhydrase and is involved in protein synthesis, carbohydrate metabolism, and many other biochemical reactions. This affects growth rate, skin conditions, reproduction, skeletal development, and the utilization of protein, carbohydrates, and fats in the body. A severe zinc deficiency causes skin parakeratosis (scaly skin), reduced growth, general debility, weak hooves, impaired testicular growth and increased susceptibility to infection. The small intestine is where zinc is absorbed the most. In a developing heifer, the requirement is 200–300 mg, while in a cow; the requirement is 22.8 mg/kg of diet (on a DM basis).

***Fluorine*:** This is essential for proper bone development but can cause toxicity if fed at a too high rate. Too much Fluorine causes abnormal bone growth, mottling and degeneration of teeth and delayed growth and reproduction.

Table2: Mineral requirements for lactating dairy cattle

Mineral	Unit	Ration level		Estimated amount/day
		Recommended	Maximum	
Calcium	%	0.43 - 0.77	2	116 g
Phosphorus	%	0.28 - 0.49	1	75 g
Magnesium	%	0.20 - 0.25	0.5	41 g
Potassium	%	0.90 - 1.00	3	184 g
Sodium	%	0.18	-	37 g
Chloride	%	0.25	-	51 g

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Iron	ppm	50	1000	1020 mg
Manganese	ppm	40	1000	816 mg
Selenium	ppm	0.3	2	6 mg
Zinc	ppm	40 - 60	500	816 mg

Source- Dairy NRC (1989)

Vitamins:

Vitamins are needed for metabolism. Vitamins that dissolve in water are referred to as water-soluble vitamins. They are usually synthesized in sufficient amounts within the rumen. Any water-soluble vitamins, on the other hand, can be useful when supplemented. Fat-soluble vitamins include vitamins A, D, E, and K. Vitamin K is needed for blood clotting and is synthesized in sufficient amounts by rumen microbes. Various amounts of vitamin A, D, and E supplementation are needed based on the diet consumed.

***Vitamin A*:** This is needed for bone growth, vision, and the preservation of healthy epithelial tissues (i.e. lining of digestive and reproductive tracts). This is found in the form of retinol in the animal body. Increased susceptibility to disease, night blindness, and reproductive failure may all result from a deficiency. Green forages containing carotenoids can include vitamin A. In the body, carotenoids are converted to vitamin A. Cattle should be given water-soluble vitamin A to meet their vitamin A requirements. Grovit -A is an excellent supplement for overcoming Vitamin -A deficiency. The requirement for feeding dairy cattle is 110.25 IU of vitamin A/kg of body weight.

***Vitamin D*:** This is found in sun-cured forages. Animals kept outside or fed sun-cured hay are unable to develop a deficiency, although those kept indoors and fed silage are more likely to do so. Adding to it, Vitamin D (sunshine vitamin) is an important nutrient that is required for mineral metabolism, especially calcium metabolism. The requirement is approximately 30.87 IU per kg of body weight.

***Vitamin E*:** This is important for the reproduction of dairy cattle. Embryonic death, testicular atrophy, and ovarian dysfunction have all been attributed to vitamin E deficiency. It is essential to maintain cellular integrity and reduces the effects of any disease that can impact cell health such as mastitis and metritis. Vitamin E supplementation will enhance the activity of neutrophils and enhances immunoglobulin production. It serves as an antioxidant with the mineral selenium and protects cells from damage by peroxidases. Vitamin E is commonly

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supplemented in the form of all-rac-tocopheryl acetate (1 mg = 1 IU) and is present in high concentrations in green forages. Vitamin E supplementation is recommended for dry cows at 1,000 IU per day and lactating cows at 500 IU per day.

B-vitamins or water-soluble vitamins are synthesized in the rumen and are not needed in the ration. B-vitamin supplements can be useful in stressful situations where feed consumption is poor. Niacin is a B vitamin that helps to regulate body fat mobilization, especially in over-conditioned, early lactation cows. In these cows, when ketosis is a problem, niacin added at 6 to 12 grams per head daily increases milk yield by about 0.5 kg. Biochemically, niacin may improve blood supply in certain animals and lower skin temperature, so it could be recommended to feed to heat-stressed cows. When fed at 48 g/d, nicotinic acid niacin has been shown to enhance colostrum production (increased immunoglobulin G). Another water-soluble vitamin that has been used in the dairy industry is biotin. It has been shown that supplementing cows with 22 mg improve hoof health and, as a result, milk yield.

Conclusion:

The high-producing cattle require a diet that supplies the nutrient needs for high milk production. Carbohydrates, amino acids, fatty acids, minerals, vitamins, and water are all nutrients required by the lactating dairy animals to meet the demand by the mammary gland to produce milk and milk components. Feeding Essential vitamins and minerals must be fed to dairy cattle in order for them to be healthy, which contributes to a prosperous dairy farming industry. However, in order to develop and maintain the proper health of the animal, optimum nutrition is necessary. Meeting the mineral and vitamin needs of dairy cattle is crucial to achieve high levels of milk production and maintain cow health and reproductive performance. Changes in the forage and diet of cattle surely increase milk production and quality.