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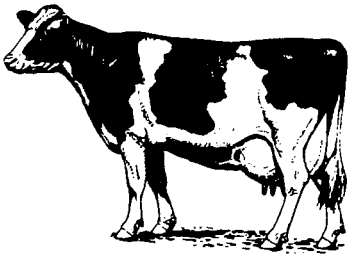

Dairy Update

CALCIUM AND PHOSPHORUS: REGULATION, REQUIREMENTS AND ROLE IN MILK FEVER

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Regulation of Calcium and Phosphorus

Calcium and phosphorus are the most abundant minerals in the dairy animal's body. About 98 percent of the calcium and 86 percent of the phosphorus is found in the skeleton and teeth. The blood of a mature cow contains only about 2 grams of calcium and 1.1 grams of phosphorus--the same amount found in three pounds of milk. Thus, these minerals must be closely regulated by the animal and continuously replaced in the diet.

The calcium level in the blood is regulated by parathyroid hormone, calcitonin and a metabolite of vitamin D (1,25-dihydroxyvitamin D). These hormones regulate calcium in the blood by adjusting absorption from the small intestine and regulation of calcium into and out of bone stores. When blood calcium drops from dietary deficiencies or increased lactation demands, parathyroid hormone exerts its effect by mobilizing calcium stored in bones and by increasing the absorption rate of calcium from the small intestine via 1,25 dihydroxyvitamin D. If blood calcium levels becomes to high, calcitonin becomes activated, directing calcium into bone stores and lowering the absorption rate from the small intestine. The result of a calcium deficient diet is depletion of skeletal reserves while excess dietary calcium, once reserves are replenished, is lost in the feces.

Blood phosphorus is not as tightly regulated as calcium. Like calcium, phosphorus absorption occurs in the small intestine under the influence of vitamin D but the percentage of phosphorus absorbed is not as closely related to need as is the percentage of calcium absorbed. In ruminants, up to eighty percent of the phosphorus reaching the digestive tract is directly from saliva with the balance being supplied by the diet. Secretion of phosphorus in saliva appears to be under the control of parathyroid hormone. The salivary phosphate mixes with dietary phosphorus before a portion of the total is absorbed in the small intestine. By regulating the amount of phosphorus

in saliva an animal can regulate the amount of phosphorus reaching the small intestine and the amount excreted in the feces. Thus, an animal with a low blood phosphorus level as a result of consuming a low phosphorus diet increases the absorption of phosphorus from the intestine and reduces the salivary secretion of phosphorus into the digestive tract. Mobilization of phosphorus to and from bone occurs but to a lessor degree than with calcium.

Deficiency, Excess and Ratio

A dietary deficiency of calcium is often not quickly noticed since the animal can closely regulate blood calcium levels by mobilizing skeletal reserves. In young animals, calcium deficiency retards general growth and prevents normal bone development. Short term feeding of a calcium deficient diet to lactating cows causes a depletion of calcium from bone as well as a phosphorus depletion since the two are complexed in bone and are removed in concert. Long term deficiencies result in fragile, easily fractured bones and reduced milk yield.

Feeding excess calcium can be antagonistic to other elements especially phosphorus, magnesium, iron, iodine and manganese. Feeding calcium at greater than one percent of dry matter may reduce dry matter intake. Determining if a ration contains "excessive" calcium is vague since ruminants perform well under a wide range of calcium levels and ratios of calcium to phosphorus. Several studies have shown dietary calcium to phosphorus ratios between 1:1 and 7:1 resulted in good performance provided the animals recommended phosphorus level is met (Table 1). A large excess of calcium over phosphorus can reduce protein and carbohydrate digestibility.

Table 1. Influence of dietary calcium and phosphorus ratio ration dry matter intake, milk production and feed efficiency.

Calcium (% of DM)	1.0	1.7	1.0	1.7
Phosphorus (% of DM)	0.30	0.30	0.54	0.54
Ca/P ratio	3.2:1	6.0:1	1.8:1	3.1:1
Dry matter intake, lb	47.5	48.8	49.3	49.3
Milk production, lb	60.1	63.4	66.9	65.3
Feed efficiency	0.98	1.01	1.08	1.07

Adapted from Kincaid (1981).

The diets in Table 1 are high (1% or above) in calcium and low (.3%) or normal (.54%) in phosphorus content. The results indicate when calcium feeding is adequate, phosphorus content of the diet and not the calcium to phosphorus ratio determines animal performance.

A phosphorus deficiency can occur rather quickly since animals blood phosphorus levels are not regulated as closely as calcium. Deficiencies in phosphorus lowers the mineral content of bones, retards growth rate, reduces feed efficiency, decreases milk production, impairs reproduction and lowers feed intake. Because animals cannot select phosphorus based on need, providing

phosphorus only as a free choice mineral is not adequate to meet the requirements of animals.

Research has shown that feeding twice the recommended levels of phosphorus has not caused problems but excessive phosphorus should be avoided since it is expensive and a pollutant.

Recommendations

The calcium and phosphorus levels needed in an animal's diet varies depending on age, body weight, milk production, milk composition and stage of gestation (Table 2).

Table 2. Calcium, phosphorus and vitamin D requirements for various animals.

Animal	Calcium % DM	Phosphorus % DM	Vitamin D IU/lb DM
Heifer 3-6 months	.52	.31	140
Heifer 6-12 months	.41	.30	140
Heifer >12 months	.29	.23	140
Dry cows	.39	.24	540
Early lact. (0-3wks)	.77	.48	450
Supplemental fat	.95	.41	450
1320 lb cow			
lb of 4% BF milk			
20	.43	.28	450
45	.51	.33	450
65	.58	.37	450
90	.64	.41	450
110	.66	.41	450

Adapted from National Research Council (1989).

The basic NRC recommendations are adequate under most conditions but the following factors may necessitate adjustments:

- Feeding large amounts of dietary fat. Table 2 includes the NRC recommendation for rations with added fat.
- Diets low in phosphorus (less than 50% of recommendation) have been implicated in reduced availability of calcium.
- Deficiencies of Vitamin D can result in less calcium and phosphorus being absorbed from the intestines.

Milk Fever

Milk fever is one of the most common diseases associated with parturition and early lactation. It occurs because of the animals inability to meet the increased demand for calcium and phosphorus at the onset of lactation. During the dry period, fetal development is the major factor in depletion of blood calcium and phosphorus. At onset of lactation, the draw on the blood pool of calcium and phosphorus increases from three to tenfold. The increased demand is further complicated by the low feed intake which occurs at calving, causing less absorption of these minerals. If the animal's hormonal controls are unable to overcome both the increased demand and reduced intestinal absorption, blood levels of calcium and phosphorus drop. If the blood calcium levels fall low enough the animal develops milk fever resulting in paralysis of skeletal and digestive system muscles. When a cow goes down, muscle and nerve damage, teat lacerations and broken or dislocated bones may occur. Animals which develop milk fever also exhibit an increased incidence of displaced abomasum, retained placenta, ketosis and mastitis.

The cause of milk fever is not due to a shortage of parathyroid hormone but rather the inability of the animal to mobilize calcium stores in response to the hormone. Cows receiving excessive dietary calcium during the dry period rely solely on calcium absorbed from the intestine to meet their requirements. A dry cow maintained on an adequate but not excessive calcium diet has an increased absorption efficiency of calcium from the intestine and also is able to mobilize skeletal reserves of calcium to meet the extra calcium demands at the onset of lactation.

Dry cow rations should not contain more than 100 grams of calcium with intakes in the 50 to 80 gram range being preferable. Other dietary factors to consider are:

- phosphorus intakes over 40 grams per day in high calcium diets will increase the incidence of milk fever.
- calcium-phosphorus ratio in the diet should be at least 1.4:1 but avoidance of excessive intakes is more important than a specific ratio.
- low dietary magnesium levels (less than .16%) may increase milk fever.
- high concentrations of potassium may predispose cows to milk fever.
- dry cow diets should contain adequate levels of vitamin D.
- free-choice feeding of minerals to dry cows should not be practiced.

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