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Role Of Potassium In Determining Susceptibility To Milk Fever

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The onset of lactation incurs a sudden and large demand for calcium from the blood of the dairy cow. In order to prevent blood calcium from decreasing, the cow must replace calcium lost to milk by withdrawing calcium from bone or by increasing the efficient absorbtion of dietary calcium. Bone calcium mobilization is regulated by parathyroid hormone (PTH) produced by the parathyroid glands located in the neck. Whenever there is a drop in blood calcium, blood PTH levels increase dramatically. A second hormone, 1,25-dihydroxyvitamin D, is required to stimulate the intestine to efficiently absorb dietary calcium. This hormone is made within the kidney from vitamin D in response to an increase in blood PTH. Milk Fever occurs when cattle do not remove enough calcium from their bones and the diet to replace calcium lost to milk. This occurs because a key hormone involved in calcium metabolism, parathyroid hormone, acts poorly on bone or kidney tissues when the blood pH is high[1]. Blood pH of cattle is often alkaline because forage potassium is often excessively high. To avoid milk fever the blood pH needs to be decreased. The best way to do this is to reduce the potassium content (and in some areas of the country, the Na content) of the diet fed to the prepartum cow. Removing potassium from the ration can present a problem. All plants, must have access to a certain amount of potassium to obtain maximal growth. However alfalfa, other legumes, and at least some grasses accumulate potassium within their tissues to concentrations that are well above that required for optimal growth of the plant if soil potassium is high. Optimal growth of alfalfa occurs when the plant potassium concentration is 1.7-2.0%. Alfalfa often contains much higher levels. Lanyon[2] reported that the potassium concentration of alfalfa samples submitted by Pennsylvania producers averaged 3.1% potassium, ranging from 1.42 to 4.05%. Many producers fertilize alfalfa heavily with potassium to increase the plant's resistance to winter kill. However it is unlikely that any benefit is seen by increasing plant potassium beyond 2.5%. It appears that current agronomic practices encourage overfertilization with potassium, resulting in luxury consumption of potassium by plants which can be detrimental to the health of the periparturient dairy cow. What practices can be instituted by the producer so that a low potassium forage crop can be obtained for the transition cow ration?

Low potassium forages

Grasses-Corn is actually a warm season grass. Corn silage tends to be 1.1-1.5% potassium. It is difficult to find any other forage this low in potassium. Some other warm season grasses, such as switchgrass, big bluestem, and indiangrass tend to be low in potassium also but they are low in protein and digestibility.

Cool season grasses such as bluegrass, orchardgrass, and brome tested lower in potassium than alfalfa did 20 years ago. At that time these hayfields were unlikely to receive fertilizer. The tremendous increase in the number of cows on each farm has not been accompanied by an increase in the amount of land available for spreading manure. As a result hayfields that were not fertilized in the past are now being used extensively as a place to get rid of animal wastes. Cool season grasses have a fibrous root system which makes them very efficient utilizers of soil potassium. They will actually out compete alfalfa for potassium which is why alfalfa stands eventually becomes grassy. Research at the Miner Institute[3] indicates that timothy accumulates potassium to a lesser extent than other grasses and the second cutting of grass hays generally contain less potassium than the first cuttings.

Legumes -In the past alfalfa and other legumes were left out of dry cow rations because they were high in calcium. However we now know that dietary calcium has little effect on the alkalinity of the cow's blood under practical conditions so it does not induce milk fever. By restricting potassium application to the soil it is possible to grow alfalfa that is as low in potassium as many of the grass hays. However, this eventually allows grasses to take over the stand and increases winterkill. One option may be to withold potassium fertilization from a field that is in its last year of production and harvest that field specifically for the dry cows. However it can take several years to deplete soil potassium reserves if plant potassium values have been high. Also, alfalfa potassium content is highest in alfalfa harvested in the early vegetative stage so letting the stand mature will result in lower potassium concentrations. Full bloom alfalfa may therefore be more suitable for the dry cow. Potassium is released from wet soil more readily than from dry soil. Most years the first cutting of alfalfa will have a higher potassium content than later cuttings.

The key to milk fever prevention is to find a low potassium hay source and combine it with corn silage to form the basis for your dry cow ration. Try to formulate a total ration with less than 2% potassium. Limit access to pasture and watch to see if cows are eating bedding. Oat straw bedding is particularly high in potassium.

Anionic salts

Adding anions to the diet of the cow can counteract the effects that dietary potassium and sodium have on the blood pH. Commonly used anion sources are calcium chloride, ammonium chloride, magnesium sulfate, ammonium sulfate, and calcium sulfate. All anionic salts are unpalatable as they give a strong salty taste to the diet. Sulfate salts maybe somewhat more palatable than chloride salts-but since they are much less effective acidifiers of the blood their use is not highly reccommended. If used inappropriately anionic salts will cause inappetance and actually exacerbate fresh cow problems. Therefore they should be used sparingly. Goff and Horst[4] recently used hydrochloric acid as a source of anions. They observed no detrimental effects on feed intake and actually observed a slight enhancement of feed intake in the animals consuming the hydochloric acid treated diet. Hydrochloric acid imparts an acid taste rather than the salty tastes which are characteristic of the anionic salts.

The pH of the urine of the close-up dry cow can tell you if the blood of the cow remains too alkaline or if you have added too many anionic salts. In herds experiencing a milk fever problem the urine of close-up dry cows will be very alkaline with a pH above 8.0. For successful control of milk fever the average pH of the urine of the cows (Holstein) should be between 6.0 and 6.5. In Jersey cows the average urine pH of the close-up cows has to be reduced to between 5.8 and 6.2 for effective control of milk fever. If the average urine pH is between 5.0 and 5.5 you have probably added too many anions to the diet and the cows will suffer a decline in dry matter intake. Various formulas exist to tell you how much of an anionic salt to add to the diet. Most nutritionists using the equation $(Na^+ + K^+) - (Cl^- + S^{--})$ have a target DCAD for milk fever prevention of about -50 mEq/kg. Using the more physiologically relevant equation, $(0.15\ Ca^{++} + 0.15\ Mg^{++} + Na^+ + K^+) - (Cl^- + 0.25\ S^{--} + 0.5\ P^{---})$, the target DCAD should be around +200 and+300 mEq/kg. These are simply guidelines and are based on the setting of certain parameters at constant values as outlined below. Urine pH of the cows will be the better gauge of the appropriate diet DCAD than any formula. Some of the variables in the above formulas are somewhat fixed. Dietary magnesium should be set at 0.4% (higher than NRC reccommendations). We like to use magnesium sulfate in our close-up rations to supply magnesium in a readily soluble form, not because it is an effective source of anions to prevent milk fever. Magnesium chloride, where available, would be another good method of raising diet magnesium to 0.4% and would give a stronger acidifying effect. The diet should supply between 35 and 50 g phosphorus daily so diet phosphorus will be set at about 0.4 %. More than 80 g Phosphorus / day will inhibit renal synthesis of 1,25-dihydroxyvitamin D which can induce milk fever. Dietary S should not exceed 0.4%. Some studies have reported a polioencephalomalacia-like syndrome (non-responsive to thiamine) when dietary sulfate is raised above 0.4%. In addition our results suggest that adding more sulfate is a poor choice because it is a fairly ineffective acidifying agent. Dietary Cl can nearly always be raised to 0.5% with little effect on dry matter intake. Most diets will require closer to 0.6% Cl for effective prevention of hypocalcemia. Getting ration Cl above 0.8-1.0% will often risk inappetance in the animals. Dietary calcium remains somewhat difficult to set. In a controlled trial there has been no advantage in keeping dietary calcium low (less than 40 g /day)[5]. Anecdotal evidence and at least two published trials suggest that high dietary calcium concentrations (<0.5 % Ca) are desirable when coupled with anionic salts and helps prevent hypocalcemia[6-8]. Good results have been achieved by feeding as high as 180 g calcium/day. However when limestone is used to achieve these high dietary calcium levels the alkalinizing effect of the added calcium carbonate can be a factor. More importantly the limestone is taking up room in the ration that might better be used for energy sources. We currently bring calcium to 1.2% which is fairly easily achieved, especially if calcium chloride is used as one of the anionic salts. More work needs to be done on availability of the different calcium sources and the role of dietary calcium during the periparturient period. Anionic salts generally add between $5 and $9 to feed costs for a close-up dry cow. We are currently investigating the use of hydrochloric acid preparations as a source of anions for the dry cow. These have proved more palatable, in our hands, than traditional anionic salts as they impart an acidic taste rather than a salty taste to the ration and should be less expensive as well.

Anionic diets prepartum may enhance milk production and health in the subsequent lactation, simply because hypocalcemia is decreased and the animal does not have the secondary problems associated with milk fever[9-11]. It is difficult to assess the economic impact of subclinical hypocalcemia. It seems likely that if milk fever is associated with loss of muscle tone (i.e., abomasum, teat sphincters) and ruminal stasis, subclinical hypocalcemia will be associated with these same problems to a lesser degree. The impact of subclinical hypocalcemia on herd health may be nearly as great as milk fever because it is much more common than milk fever.

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