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# Current Knowledge Concerning Silica Urinary Calculi

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BEEF REPORT

# CURRENT KNOWLEDGE CONCERNING SILICA URINARY CALCULI

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## Summary

Laboratory research has shown phosphate to inhibit the formation of insoluble silica-protein complexes that are believed to be important in the formation of silica urinary calculi. In work with laboratory animals, increases in dietary phosphorus and urine acidifying salts reduced the incidence of silica urinary calculi. These findings translate into feeding and management practices that may be beneficial in reducing the incidence of silica urinary calculi in cattle and sheep.


(Key Words: Urinary Calculi, Silica, Phosphorus, Calcium, Ammonium Chloride, Sodium Bicarbonate.)

## Introduction

Two main types of urinary calculi occur in cattle and sheep. Phosphatic calculi composed of calcium, magnesium and ammonium phosphates mainly occur in feedlot animals consuming high-concentrate diets. On the other hand, silica urinary calculi most generally occur in range animals with silica as the main component.

One of the more important nutritional developments of the 1960's era was the finding that phosphatic urinary calculi in feedlot cattle and sheep were caused by excess dietary phosphorus coupled with a low calcium to phosphorus ratio and conditions promoting an alkaline urine. Since that time, cattle and sheep feeders have been admonished to use phosphorus supplements sparingly if at all with high-concentrate diets and to increase dietary calcium to achieve a ratio of 1.5 to 2 parts calcium to 1 part phosphorus. This widely disseminated recommendation has been instrumental in reducing this once costly nutritional disease to only an occasional occurrence in the nation's feedlots.

During this time, the parallel problem of silica urinary calculi in range cattle and sheep remained unresolved and loss of cattle and sheep from silica urinary calculi is a recurring problem for many ranchers of South Dakota and their counterparts in other western range states and Canada. In many areas, the presence of silica kidney deposits in grazing animals is considered the norm rather than the exception and many ranchers accept losses of livestock from urinary blockage as an unavoidable business cost.

While most losses occur in males raised under range conditions, the silica type of urinary calculi sometimes occurs in animals confined to drylot. Most notable of these are sheep or calves fed diets consisting mainly of oats and grass hay. Silica content of range grass may exceed 7% on a dry basis at maturity. Oat grain contains approximately 3% silica while straw of oats, wheat or barley has a higher silica content. Otherwise, there are very few common feeds providing silica levels adequate to promote silica urinary calculi.

Concentrated research efforts by the author and co-workers and a survey of pertinent literature have resulted in perceptions of feeding and management practices that may reduce the incidence of silica urinary calculi. Although the observations on which these perceptions are based are mainly from studies with laboratory animals and laboratory chemical reactions, they represent basic principles that are believed to be applicable to cattle and sheep, and they translate into sound feeding and management practices for producers whether or not losses from silica urinary calculi have been considered a problem.

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Factors in Silica Urinary Calculi Formation

**Urinary silica concentrations.** Because of the high silica content of range grasses, oats and straw, the rumen digestive fluid of animals consuming these feeds is saturated with silica. Amounts of silica absorbed and subsequently excreted in the urine under these conditions are often adequate for calculi formation and become even higher if water intake is reduced because of freezing, poor water quality or winter storms or if the water is not readily accessible.

**Silica polymerization.** Polymerization refers to the combining of molecules to form increasingly larger molecules. At excessively high silica concentrations under experimental conditions, silica polymerization proceeds to the point that it forms a gel not unlike that of gelatin. The rate of silica polymerization in solution varies with the square of its concentration. This means that as the concentration doubled the rate of polymerization increased fourfold.

Silica polymerization is also influenced by the concentration of salts known as electrolytes. Thus, the concentrations of almost all urinary constituents are important to the formation of silica urinary calculi.

Silica polymerization occurs over the full range of pH values occurring in urine (pH is a measure of the degree of acidity or alkalinity). The type of particle formed may differ depending on the pH of the solution. At an alkaline pH, conditions favor the growth of individual polysilica particles. At acid pH values, conditions favor growth by combining individual particles into aggregates. However, silica urinary calculi do not normally consist of pure silica. In addition to silica, they contain important amounts of organic matrix materials high in protein content.

**Formation of insoluble protein-polysilica complexes.** Intermediate size molecules of polymerized silica are capable of reacting with proteins, effectively linking protein molecules together into larger insoluble complexes that precipitate from the solution in which they were formed. This reaction has been shown to occur with a wide variety of proteins, including those normally present in urine. This is believed to be the mechanism whereby combinations of silica and protein are deposited as urinary calculi.

Factors in the Prevention of Silica Urinary Calculi

**Increases in urine volume.** Increases in water intake, generally in response to the feeding of high levels of salt, have been used by some researchers to increase urine volume. This results in a dilution of the urinary silica concentration and a reduction in the rate of silica polymerization. At this time, this is the only method of silica urinary calculi prevention that has been proven to be somewhat effective in experiments with cattle, although impractical for widespread use under range conditions.

**Supplemental dietary phosphate and urine acidification.** Recently, a model system utilizing laboratory rats has been used by the author and co-workers to identify dietary factors that prevent or intensify silica urinary calculi formation. From these studies, supplemental dietary phosphate and urinary acidifying salts have emerged as principal measures of prevention. On the other hand, supplemental calcium and urinary alkalizing salts increased silica calculi incidence. In addition, it was observed that phosphates and urinary acidifying salts combined had a total effect greater than the use of their independent effects (a synergism). In subsequent laboratory studies, phosphate in solutions of partially polymerized silica and urinary proteins was found to interfere with formation of the insoluble protein-polymeric silica complex described above. This effect of phosphate was most pronounced in slightly acidic solutions. Phosphate is believed to act by blocking reactive sites on the protein, preventing cross-linking with silica.

While these principles have not yet been applied to cattle and sheep, range forages are often suboptimum in phosphorus content, but they generally supply adequate quantities of calcium. Thus, the implication of phosphates in the prevention of silica urinary calculi should not be ignored in attempts to minimize silica urinary calculi in cattle and sheep.

Recommendations

Recommendations that can be made at this time are rather limited in scope due to lack of testing of some of the preventative measures with cattle and sheep. However, some generalizations can be made that are in accordance with good management practices whether or not a producer has experienced losses from silica urinary calculi.

The need for maintaining an easily accessible source of high quality drinking water at all times cannot be overemphasized and this should be the first step in a calculi prevention program. Secondly, assure that the nutritional phosphorus needs of the animals have been met. This may be achieved through use of a mineral mixture designed for range feeding of cattle and sheep. The mineral mix for use under these conditions should have a phosphorus content equal or exceeding the calcium content. Ratios of .7 or 1 part calcium to 1 part of phosphorus appear appropriate. **CAUTION: Pending further research, the use of higher concentrations of phosphorus should be approached with caution because of the close proximity between levels that may inhibit silica urinary calculi and those known to cause phosphatic urinary calculi in animals excreting alkaline urine (See Great Plains Beef Cattle Handbook Fact Sheet 3451 entitled Urinary Calculi in Cattle and Sheep).**

Meeting the phosphorus requirement should be a primary goal. However, contributing acidity to the urine may also be achieved by use of phosphorus sources having acid-forming potentials. Monosodium phosphate ($NaH_2PO_4.H_2O$) and monocalcium phosphate ($Ca(H_2PO_4)_2.2H_2O$) are examples of sources having this potential. The mineral mix will often be provided free choice. However, creep feeding of calves or lambs provides an additional opportunity to assure adequate phosphorus intake. In addition, the feed provided in a creep feeder can be used as a carrier for ammonium chloride, used for urine acidification, at a level providing a daily intake not exceeding 1.5 oz per head for calves or .25 oz for lambs. Salt (sodium chloride) may be added to limit feed intake and increase water consumption (See Great Plains Beef Cattle Handbook Fact Sheet 1950 entitled Limiting Feed Intake with Salt).

Grains probably provide adequate levels of phosphorus but require calcium supplementation to meet the requirements of calves and lambs. However, when oats constitute a higher percentage of the diet, it may be important to avoid an excess of calcium and use of other urinary alkalizing salts such as sodium bicarbonate.

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