2009

Sulfur in Distillers Grains

Sarah Vanness
University of Nebraska - Lincoln

Terry J. Klopfenstein
University of Nebraska - Lincoln, tklopfenstein1@unl.edu

Galen E. Erickson
University of Nebraska - Lincoln, gerickson4@unl.edu

Kip Karges
University of Nebraska - Lincoln

Sulfur in Distillers Grains

Sarah J. Vanness
Terry J. Klopfenstein
Galen E. Erickson
Kip K. Karges[1]

Summary

Data were compiled from 4,143 cattle on byproduct feeding experiments. Incidence of polioencephalomalacia was small (0.14%) in diets containing 0.46% or less sulfur (S). Incidences of polioencephalomalacia increased when cattle were fed diets above 0.46% S and especially above 0.56%. Phosphoric acid successfully replaced sulfuric acid in ethanol fermentation, but the amount and cost of phosphoric acid likely limit the economic feasibility of its use.

Introduction

Sulfuric acid is used to control pH in fermentation and for cleaning in ethanol production from corn. Sulfuric acid adds sulfur to the byproduct, distillers grains plus solubles. Buckner et al. (*2008 Nebraska Beef Report*, pp. 113-114) found wet distillers grains plus solubles (WDGS) averaged 0.79% S (DM basis) in 1,200 samples from six Nebraska ethanol plants. When WDGS is fed at high levels in finishing diets, the dietary S levels may exceed nutritional guidelines. The National Research Council (1996) suggests the upper limit for S in diets should be 0.40%. However, very few data support that limit. High levels of S in the diet may cause polioencephalomalacia (polio), commonly called "brainers" by the feedlot industry. High S content also may reduce dry matter intake (DMI) and average daily gain (ADG). The objectives of the current research were to: 1) estimate the level of risk for polio at increasing dietary S levels, and 2) determine if phosphoric acid could replace sulfuric acid in the ethanol plant.

Procedure

Data were compiled from experiments on byproduct feeding conducted at the University of Nebraska–Lincoln Research Feedlot (Mead, Neb.) over the past several years. The experiments included calf-fed and yearling cattle. In most experiments, control diets contained no byproducts.

Computerized health records were maintained on all cattle. These records were compared to the S levels in the diets fed to the cattle. Composite samples of all diets were analyzed for S level by Ward Laboratories Inc. (Kearney, Neb.), using a wet digest and colorimetry. The water was tested and contained essentially no S (11 ppm S). All diets provided 75 to 150 mg/head daily of thiamine. Cattle were determined to be polio cases if they were identified by the health crew as showing signs of polio. These cattle were treated with an intravenous injection of thiamine. Some cattle recovered and some died. All cattle that did not recover were necropsied and confirmed as having polio with lesions in the brain.

In order to determine the feasibility of using phosphoric acid as a replacement for sulfuric acid, test runs were conducted by researchers at the Poet Research Center (Sioux Falls, S.D.). Hydrochloric acid is a possible alternative acid choice; however, this acid deteriorates the metal equipment at the ethanol plant. Phosphoric acid is safe for the ethanol plant to use, and the byproduct is safe for animal consumption. A total of 28 batches were fermented using sulfuric acid and eight were fermented using phosphoric acid. Samples were taken of the corn, whole stillage (after distillation), thin stillage and wet distillers grains. The whole stillage was separated into thin stillage and wet distillers grains by continuous flow centrifugation.

Dry matter analysis of corn was conducted by drying at 60°C for 48 hours. The wet samples were freeze dried and DM determined by loss on freeze-drying followed by 60°C oven drying to ensure all the moisture and ethanol were removed. The dry samples were analyzed for nitrogen, sulfur, phosphorus, fat and neutral detergent fiber (NDF). Percentage fat was determined using a method of solvent extraction developed at the University of Nebraska (Bremer et al., *2009 Nebraska Beef Report* pp. 64-65).

Results

Of 4,143 cattle finished in byproduct experiments, 23 were removed from the pens and classified as cases of polio. Eleven of the cattle were from one treatment in one experiment, consuming a diet that contained 0.47% S and no roughage. Based on this observation and others, we believe roughage level is important in minimizing polio incidences. These 11 animals were excluded from the remaining summary because the diet of these cattle did not include the typical 6-7.5% roughage most feedlot diets contain.

Of the cattle consuming diets with less than 20% byproduct (DM basis), 0.1% (1/1000) were diagnosed with polio. This number included cattle on the control diets without byproducts, and we believe it represents the baseline level of expected polio prevalence. Of cattle consuming diets containing 0.46% S or less, 0.14% (3/2147) were diagnosed with polio. When sulfur levels were between 0.47% and 0.56% S, the polio incidence increased to 0.35% (3/566). When dietary S rose above 0.56%, the polio incidence was 6.06% (6/99).

These data suggest that diets at or below 0.46% S have a low risk of producing polio if roughage levels are maintained, allowing the feeding of

(Continued on next page)

Table 1. Nutrient analysis of samples throughout ethanol production.

	Sulfuric acid	Phosphoric acid	*P*-value
Dry matter (%)			
Corn	89.27	89.42	0.81
Whole stillage	13.72	14.70	0.26
Thin stillage	8.23	8.77	0.36
Wet cake	30.08	30.55	0.42
Crude protein (%)			
Corn	9.64	9.68	0.93
Whole stillage	31.21	30.00	0.08
Thin stillage	22.30	20.21	< 0.01
Wet cake	34.15	34.92	0.12
Fat (%)			
Corn	3.73	3.84	0.92
Whole stillage	14.76	16.18	0.69
Thin stillage	35.46	35.66	0.84
Wet cake	4.79	4.89	0.91
NDF (%)			
Corn	12.01	9.92	0.01
Whole stillage	25.84	22.98	0.48
Thin stillage	1.45	0.83	0.44
Wet cake	39.83	38.62	0.13
Phosphorus (%)			
Corn	0.27	0.29	0.62
Whole stillage	0.96	1.92	< 0.01
Thin stillage	1.55	3.36	< 0.01
Wet cake	0.49	1.08	< 0.01
Sulfur (%)			
Corn	0.15	0.16	0.84
Whole stillage	0.81	0.43	< 0.01
Thin stillage	1.66	0.35	< 0.01
Wet cake	0.71	0.47	< 0.01

WDGS up to about 50% of diet DM. Above 0.46% S in the diet, the risk for polio increases. Typically one load of WDGS lasts 7-10 days in the research feedlot, so a load with high S content would be fed for this extended period of time. Many feedlots feed multiple loads per day, so one load with a high concentration of S would be diluted by other loads. We were not able to identify any loads with high levels of S that related to cases of polio.

The substitution of phosphoric acid for sulfuric acid did not affect fermentation or ethanol yields. Since phosphoric acid does not disassociate as readily as sulfuric acid, approximately 2.5 times more phosphoric acid is required to provide the same pH control. Since phosphoric acid is more expensive and does not disassociate as readily as sulfuric acid, the increased cost of using phosphoric acid would need to be returned through increased cost of WDGS. The added P would have fertilizer value, but it is assumed that at current prices, cattle feeders would be unwilling to pay the higher price for low-S WDGS in order to reduce the risk of polio.

Only minor differences were noted in the protein, fat and neutral detergent fiber (NDF) contents of the corn and byproducts due to acid used in the fermentation (Table 1). Protein content increased 3.1 times in WDGS compared to the corn, as expected.

Sulfur content of the whole stillage was 0.81% when sulfuric acid was used; however, the sulfur value dropped to 0.43% when phosphoric acid was used. The difference (0.38%) represents the sulfur from added sulfuric acid. Sulfur content in whole stillage (0.43%) was 2.7 times the sulfur content of corn (0.16%).

Phosphorus content of the whole stillage was 1.92% when phosphoric acid was used and 0.96% when sulfuric acid was used. The difference (0.96%) represents the P from the added phosphoric acid.

Both S and P contents were greater in thin stillage than in wet cake. In commercial plants, the thin stillage is condensed to about 35% DM and named distillers solubles or "syrup." This condensation does not change the nutrient analysis on a DM basis. The amount of solubles added to the wet cake influences the S and P content of WDGS.

The added P from the use of phosphoric acid increases byproduct P levels. Because these levels are above the requirement of feedlot cattle, all of the extra P is contained in the manure. The P in the manure has value as fertilizer roughly equivalent to the cost of the phosphoric acid. Recovery of the cost and distribution costs of the manure must be considered. At current prices of phosphoric acid and because of the amount of phosphoric acid needed, it doesn't seem economically feasible to replace some or all of the sulfuric acid with phosphoric acid, even though the chemistry is feasible.

[1]Sarah J. Vanness, research technician; Terry J. Klopfenstein, professor; Galen E. Erickson, associate professor, Animal Science, Lincoln. Neb. Kip K. Karges, Poet Research Center, Sioux Falls, S.D.