Evaluation and Observations of Total Sulfur Intake with Corn Co-Product Diets for Feedlot Cattle

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Summary and Implications

Four complete feedlot rations between 41 & 48 Mcal/cwt Net Energy Gain (NEg) containing corn co-products were analyzed to determine total percent sulfur on a dry matter basis (DMB). Ration sulfur level averaged 0.37% and ranged from 0.28-0.50%. Water sulfur content averaged 134 ppm and ranged from 98-205 ppm. The College of Veterinary Medicine spreadsheet to determine total sulfur intake calculated that the 650 pound steer consuming 20 pounds of a 44 Mcal/cwt NEg ration with 0.37% sulfur and water with 134 ppm sulfur was consuming 0.46% total sulfur intake. Twenty percent of the total sulfur comes from the water. Nine complete feedlot rations containing corn co-products were analyzed between 50 & 58 Mcal/cwt NEg to determine total percent sulfur on a DMB. Ration sulfur averaged 0.33% and ranged from 0.21-0.46%. Water sulfur content averaged 32 ppm and ranged from 5-83 ppm. The College of Veterinary Medicine spreadsheet to determine total sulfur intake calculated that the 800 pound steer consuming 24 pounds of a 55 Mcal/cwt NEg ration with 0.33% sulfur and 32 ppm sulfur water was consuming 0.35% total sulfur intake.

Introduction

Iowa is the center of a large and rapidly growing corn processing industry. Both wet and dry mill processes are producing ethanol, corn oil and corn sweeteners. These plants produce large quantities of co-products that can be successfully utilized by Iowa beef producers as a relatively inexpensive feed alternative.

Polioencephalomalacia (PEM) in cattle was thought at one time to be caused exclusively by a thiamine deficiency. Some of the confusion surrounding the cause of PEM is because there is no method to accurately evaluate thiamine status in animals. It is now known that the laminar cortical necrosis observed in the brain can be caused by sulfur toxicity in addition to lead toxicity, salt toxicity, hypoxia, thiamine deficiency and vascular damage. Rumen microbes produce too much hydrogen sulfide when sulfur is ingested in excess. Sulfide interferes with energy production in the same way that cyanide does. Sulfur intake can occur in the feed or water so the total dietary sulfur intake is needed to evaluate the risk of developing PEM.

Corn milling co-products may contain high concentrations of sulfur. According to NRC 2005, the maximum tolerable dietary sulfur concentration is 0.30% (3000 mg/kg or ppm) in a low-forage (<40%) ration on a DMB. NRC 2005 states the maximum tolerable dietary sulfur concentration is 0.50% (5000 mg/kg or ppm) in a high-forage (>40%) ration on a DMB. Not all cattle consuming these sulfur levels or more will develop clinical PEM.

Materials and Methods

Feedlot managers, veterinarians, feed company representatives and extension staff collected a corn co-product sample, a total mixed ration (TMR) sample and a water sample from the cooperating feedlots for laboratory analysis of sulfur content. Selected cooperators were feeding higher levels of corn co-products and/or have had PEM diagnosis. Dairyland Laboratories, Inc., Arcadia, Wisconsin used wet laboratory chemical analysis of the corn co-product and the TMR to determine dry matter, crude protein, neutral detergent fiber, fat, ash, calcium, phosphorous, potassium, magnesium, sulfur and diet cation-anion balance (DCAB). The water sample was analyzed for sodium (+Na), potassium (+K), sulfur (-S) & chloride (-Cl) at Ajinomoto USA, Inc, Eddyville, Iowa.

Results and Discussion

Thirteen feedlots sampled the corn co-products, TMR and feedlot water for wet laboratory chemical analysis. The corn co-product samples consisted of two wet distiller grains (WDG), six modified distiller grains with solubles (MDGS), two dry distiller grains with solubles (DDGS) and three condensed distiller solubles (CDS). The co-product wet laboratory chemical analysis and standard deviation are reported in Tables1 & 2.

Four feedlots were feeding a TMR of less than 50 Mcal/cwt DM and nine feedlots were feeding a TMR greater than 50 Mcal/cwt DM. The TMR wet laboratory chemical analysis is presented in Table 3.

Water samples were collected from the feedlots and analyzed for Na, K, S & Cl. Results are in Table 3 and average 70 ppm water sulfur with individual feedlot water sulfur range of 5-205 ppm.

The diet cation-anion balance (DCAB) is a measure of strong ions in the diet which have metabolic or

systemic significance in feedlot animals. The DCAB equation is +Na+K-S-Cl. The DCAB results in Table 1-3 are expressed in milli-equivalence/lb DM. A negative DCAB (negative milli-equivalence is due to more Cl and/or S than Na and/or K) will cause a metabolic acidosis and is undesirable for optimal feedlot production efficiency. The total mixed rations DCAB values ranged from -34 to +92 mEq/lb DM. Of the four elements used in the DCAB equation (+K, +Na, -S, -Cl), potassium was the most variable. Two out of four TMRs with S higher than 0.40% had positive DCAB, while 1 out of 4 TMRs with S below 0.30% had a negative DCAB. The implications of a negative DCAB with a high S level in feedlot rations are not fully understood and warrant further research.

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Table 1. Summary of wet distillers grains (WDG) and modified distillers grains with solubles (MDGS) wet laboratory chemical analysis on a dry matter basis.

Item	WDG Average	WDG Standard Deviation	MDGS Average	MSGS Standard Deviation
Dry Matter	35.8%	3.6%	45.1%	2.4%
Crude Protein	33.9%	2.5%	29.7%	6.7%
aN D F (w/ Na2SO3)	33.5%	3.4%	24.6%	6.8%
Fat (PE)	7.6%	3.6%	11.2%	0.9%
Ash	2.3%	0.2%	4.3%	2.3%
Calcium	0.05%	0.01%	0.06%	0.01%
Phosphorus	0.49%	0.13%	0.84%	0.40%
Magnesium	0.18%	0.00%	0.36%	0.16%
Potassium	0.53%	0.04%	1.17%	0.64%
Sulfur	0.57%	0.18%	0.50%	0.11%
Sodium	0.09%	0.01%	0.23%	0.13%
Chloride	0.10%	0.00%	0.15%	0.07%
Manganese (ppm)	11.5	4.9	17.5	2.1
Zinc (ppm)	69.5	4.9	75.5	2.1
Copper (ppm)	7.5	2.1	6.5	0.7
Iron (ppm)	83.0	18.4	118.5	12.0
CALCS:				
T. D. N. – OARDC	83.5%	3.5%	88.4%	0.8%
N. F. C.	22.7%	9.2%	30.1%	10.3%
N. E. L. -OARDC (Mcal/cwt)	87.54	3.95	92.96	0.91
N. E.G. -OARDC (Mcal/cwt)	62.99	4.09	68.54	0.92
N. E.M. -OARDC (Mcal/cwt)	92.97	4.79	99.51	1.09
DCAB (mEq/lb)	-95.4	49.9	+19.0	58.3

Table 2. Summary of dried distillers grains with solubles (DDGS) and condensed distillers solubles (CDS) wet laboratory chemical analysis on a dry matter basis.

Item	DDGS Average	DDGS Standard Deviation	CDS Average	CDS Standard Deviation
Dry Matter	88.3%	1.2%	30.0%	1.3%
Crude Protein	28.6%	2.1%	21.8%	0.9%
aN D F (w/ Na2SO3)	21.0%	1.5%	2.8%	1.1%
Fat (PE)	11.8%	0.0%	17.2%	4.9%
Ash	4.4%	0.6%	11.0%	1.2%
Calcium	0.07%	0.03%	0.21%	0.16%
Phosphorus	0.86%	0.08%	1.46%	0.42%
Magnesium	0.38%	0.04%	0.65%	0.10%
Potassium	1.15%	0.11%	2.43%	0.36%
Sulfur	0.76%	0.18%	1.35%	0.39%
Sodium	0.14%	0.08%	0.66%	0.20%
Chloride	0.16%	0.00%	0.51%	0.02%
Manganese (ppm)	16.0	0.0	32.0	5.7
Zinc (ppm)	110.5	43.1	265.5	301.9
Copper (ppm)	8.0	0.0	13.5	0.7
Iron (ppm)	99.0	1.4	278.5	87.0
CALCS:				
T. D. N. – OARDC	90.0%	1.0%	100.6%	0.05%
N. F. C.	34.3%	4.2%	47.2%	5.7%
N. E. L. -OARDC (Mcal/cwt)	94.79	1.13	106.58	
N. E.G. -OARDC (Mcal/cwt)	70.37	1.12	81.76	
N. E.M. -OARDC (Mcal/cwt)	101.69	1.34	115.47	
DCAB (mEq/lb)	-76.8	24.8	-36.5	111.3

Table 3. Summary of TMR wet laboratory chemical analysis on a dry matter basis.

	NEg < 50 Mcal/cwt		NEg > 50 Mcal/cwt	
Item	Average	Standard Deviation	Average	Standard Deviation
Dry Matter	62.6%	6.5%	65.8%	7.1%
Crude Protein	14.7%	4.1%	15.6%	2.0%
NDF (w/ Na2SO3)	37.5%	10.3%	21.3%	4.1%
Fat (PE)	6.8%	2.0%	6.4%	1.3%
Ash	9.3%	2.1%	5.7%	1.7%
Calcium	0.80%	0.25%	0.82%	0.40%
Phosphorus	0.46%	0.06%	0.52%	0.12%
Magnesium	0.28%	0.03%	0.28%	0.13%
Potassium	1.07%	0.33%	1.00%	0.34%
Sulfur	0.37%	0.09%	0.33%	0.09%
Sodium	0.18%	0.06%	0.22%	0.11%
Chloride	0.31%	0.15%	0.31%	0.11%
Manganese (ppm)	69.8	22.8	47.2	15.6
Zinc (ppm)	133.0	41.3	118.4	80.4
Copper (ppm)	15.3	9.2	17.0	5.5
Iron (ppm)	591.5	211.2	228.9	112.1
CALCS:				
T. D. N. – OARDC	67.85%	2.8%	76.28%	1.9%
N. F. C.	32.42%	13.6%	51.84%	4.2%
N. E. L. -OARDC (Mcal/cwt)	70.11	3.1	79.50	2.1
N. E.G. -OARDC (Mcal/cwt)	43.91	3.6	54.47	2.3
N. E.M. -OARDC (Mcal/cwt)	71.09	4.0	83.07	2.6
DCAB, average mEq/lb	+27	42.8	+14	30.8
DCAB, minimum mEq/lb	-34		-16	
DCAB, maximum mEq/lb	+92		+57	
Water Sulfur (ppm)	133.67	61.78	32.16	32.57
Water Sodium (ppm)	79.67	31.02	62.92	42.54
Water Potassium (ppm)	5.60	1.67	7.92	5.28
Water Chloride (ppm)			4.53	1.80