Effect of finishing cattle on low fat distillers grains on animal performance and carcass and meat characteristics

April 2013

By:
Alfredo DiCostanzo
Department of Animal Science
University of Minnesota, St. Paul, MN

Grant Crawford
Formerly of Department of Animal Science
University of Minnesota, St. Paul, MN
Currently at Form-A-Feed, Stewart, MN

Partners:
Minnesota Corn Research & Promotion Council

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

SUMMARY 4

INTRODUCTION 4

MATERIALS AND METHODS 5

RESULTS AND DISCUSSION 7

IMPLICATIONS 8

ACKNOWLEDGEMENTS ....

LITERATURE CITED 9

TABLES 6

TABLE 1. INGREDIENT AND NUTRIENT COMPOSITION FOR FINISHING DIETS (DM BASIS) 10

TABLE 2. EFFECTS OF DIETARY ROUGHAGE AND SULFUR CONCENTRATIONS ON FEEDLOT PERFORMANCE OF BEEF STEERS 11

TABLE 3. EFFECTS OF DIETARY ROUGHAGE AND SULFUR CONCENTRATIONS ON CARCASS CHARACTERISTICS OF BEEF FEEDLOT STEERS 12

Executive Summary

High fat and high sulfur (S) concentrations in traditional distillers grains plus solubles limit inclusion rates in feedlot cattle diets. High dietary S concentrations are known to affect intake potentially impacting health and performance of cattle. Hydrogen sulfide is the culprit; it results from reducing dietary sulfate in the rumen. Sulfate reduction to hydrogen sulfide is dependent on rumen pH. At lower rumen pH, sulfate is readily transformed to hydrogen sulfide. Several strategies have been used to prevent impact of high S in distillers grains on cattle health and performance. Oxidizing agents have been used to turn hydrogen sulfide, generated from reducing sulfate in the rumen, back to sulfate to at least temporarily reduce negative effects of hydrogen sulfite. We, at the University of Minnesota, researched use of manganese oxide (MnO) as an intervention with positive results during the receiving phase. Use of roughage to encourage greater ruminal pH thereby reducing transformation of sulfate to hydrogen sulfide presents another opportunity to abate negative impact of hydrogen sulfide on cattle health and performance.

Due to limited research available evaluating the effectiveness of adding roughage to maintain a greater rumen pH and reduce transformation of sulfate to hydrogen sulfide, there is an urgent need to determine animal performance and carcass responses to inclusion of greater concentrations of dietary roughage. It is already well established that greater roughage concentrations in feedlot diets may reduce performance. However, slightly poorer performance may be warranted if it affords protection from excessive hydrogen sulfide production.

The research objective of this experiment was to evaluate utilization of greater roughage concentrations to manage high S concentrations in distillers grains and solubles-based diets. Feeding higher roughage concentrations in diets containing high S had no impact on performance or carcass characteristics other than the increase in intake expected at greater roughage feeding. These data demonstrated that although feeding high S concentrations reduced intake no other negative effects on performance or carcass characteristics were observed. Therefore, feeding 0.56% S in diets of feedlot cattle is possible and increasing roughage concentration is not necessary to manage high S concentrations. At average S concentrations for grain, hay and supplements, the source of distillers grains and solubles may contain up to 1.1% S when distillers grains and solubles is included at 40% of the diet DM. Concurrently, current survey data from another project funded by Minnesota Corn Growers Association indicated that the ethanol industry has made tremendous progress in managing grain fermentation so that concentrations of S in resulting coproducts are lower.

Summary

The objective of this study was to determine the effect of differing dietary concentrations of roughage (R) and sulfur (S) in beef cattle feedlot finishing diets. Eighty-four Angus, Limousin, and Charolais steers (initial BW 1,016 ± 79 lb) were arranged in a randomized complete block design. Steers were fed in a Calan gate individual feeding system and treatments were arranged in a 2 x 3 factorial arrangement, with two dietary concentrations of S (0.28%, **LS** or 0.56%, **HS**) and three dietary concentrations of R (5%, **LR**; 10%, **MR**; 15%, **HR**). All diets contained 40% modified distillers grains with solubles and grass hay was the roughage source. Steers were harvested after 134 d (blocks 1 and 2) and 92 d (block 3). Final carcass-adjusted BW was not affected by R, S, or their interaction ($P \geq 0.40$), and averaged 1,407 lb across treatments. Dry matter intake increased linearly ($P = 0.01$) with increasing R, and averaged 21.8, 23.2, and 23.6 lb/d for LR, MR, and HR, respectively. Increased dietary S concentration decreased ($P = 0.02$) DMI, averaging 23.4 and 22.3 lb/d for LS and HS, respectively. Average daily gain was not affected ($P \geq 0.24$) by R, S, or their interaction, and averaged 3.18 lb across treatments. Feed:gain was not affected by dietary S concentration or a S x R interaction ($P \geq 0.31$) and increased linearly ($P = 0.01$) with increasing R, averaging 6.59, 6.94, and 7.56 for LR, MR, and HR, respectively. Hot carcass weight (911 lb across treatments), ribeye area (15.5 in^2), 12^{th} rib fat thickness (0.46 in), marbling score (459), or frequency of individual USDA quality grades was not affected by S, R, or their interaction ($P \geq 0.12$). A tendency ($P = 0.07$) for a decrease in USDA yield grade 1 and 2 carcasses was observed with increasing R and averaged 60.8, 50.1, and 43.0% for LR, MR, and HR, respectively. No other effects on individual USDA yield grades were observed ($P \geq 0.15$). Results demonstrated that increasing dietary roughage concentration increased DMI while high dietary S concentrations decreased DMI. However, no interactions occurred to suggest that performance may be enhanced by feeding increased roughage in high-S feedlot diets.

Introduction

Increases in traditional feed costs have feedlot producers looking for more economic feeding options while still delivering rations with high energy and adequate protein. Many co-products contain substantially more protein and fiber, and in the case of distiller grains (DG), more fat, than corn grain (DiLorenzo and Galyean, 2010). Use of DG in the United States feedlot industry has increased since United States became the largest ethanol producer in world in 2005 (RFA, 2011).

Dietary inclusion of DG in feedlot diets averaged 16.5% of dietary DM in a recent survey (Vasconcelos and Galyean, 2007), though a 2009 Upper Midwest feedlot survey indicated a higher inclusion of 23-25% (G.I. Crawford, unpublished data). Average daily gain and feed efficiency reached optimum response when DG is 20 to 30% of dietary DM (Klopfensein et al., 2008).

One of the main concerns when feeding DG is the risk of inducing polioencephalomalacia (PEM) in feedlot cattle. The NRC (2005) lists the maximum tolerable concentration of dietary S for feedlot cattle at 0.3% of DM. However, many feedlot rations contain S well beyond this concentration. The conversion of dietary S and water sulfate to hydrogen sulfide appears to be inversely related to ruminal pH (Kung et al., 1998). Increasing dietary roughage concentration increases ruminal pH (Crawford et al., 2008). The objective of this experiment, therefore, was to determine the interaction between dietary S and roughage concentrations on feedlot performance and carcass characteristics. Our hypothesis was that increased concentrations of dietary S may be fed with increased dietary roughage concentrations while avoiding performance decreases associated with feeding high concentrations of dietary S in lower-roughage diets.

Materials and Methods

All procedures were approved and reviewed by the University of Minnesota Institutional Animal Care and Use Committee (IACUC)

The experiment was conducted at the U of M Rosemount Research and Outreach Center at UMore Park (Rosemount, MN) from February to September 2011. Eighty-four Angus, Limousin, and Charolais steers (initial BW 1,016 ± 79 lbs) were blocked by breed type and arranged in a randomized complete block design. Steers were fed in a Calan gate individual feeding system. Treatments were arranged as a 2 x 3 factorial, with two dietary concentrations of S (0.28%, **LS** or 0.56%, **HS**) and three dietary concentrations of roughage (5%, **LR**; 10%, **MR**; 15%, **HR**) resulting in six treatments and 14 replications per treatment. Grass hay served as the roughage source. Modified DG with solubles (48% DM) were delivered weekly from Western Wisconsin Energy (Boyceville, WI; now Big River Energy, LLC) to the research station and were stored on a concrete pad and covered with plastic to protect from weather elements.

Diets were formulated to meet or exceed nutrient requirements for finishing steers over 1,016 lb (NRC, 1996; Table 1). Gypsum (calcium sulfate dihydrate) was included in the diets to manipulate the S concentration in HS treatments. Limestone was added to LS treatments to balance dietary Ca concentrations provided by the addition of gypsum within roughage concentrations. Prior to treatment initiation, cattle were vaccinated against viral (IBR, BVD, BRSV, PI_3), dewormed, implanted and ear tagged identifying bunk, treatment, and pen number. Within block, steers were assigned to treatment based on initial BW and allocated into 1 of 9 pens with 10 to 12 head per pen. All steers were maintained on a diet containing 25% grass hay, 40% DG, 30% dry-rolled corn, and 5% liquid supplement diet for a four week period while training to the Calan gate feeding system. Adaptation diets were provided until d 1 when all 84 steers were introduce to their finishing diets.

Steers were weighed every 28 d throughout the experiment at approximately 0800 h. Feed was mixed weekly with a vertical mixer and samples collected for later laboratory analysis. Every morning at 0600 h feed refusals were weighed and a sub-sample collected from each bunk. Feed delivery depended on the amount of feed refusal from previous two days. If feed was consumed fully for two days in a row, a 0.5 lb DM increment was effected. Steers had access to fresh clean water throughout the day, and corn stalk bedding was provided weekly.

Steers were harvested after 134 d (block 1 and 2) or 92 d (block 3). Block 1 and 2 steers were harvested at Tyson Fresh Meats in Dakota City, NE and block 3 steers were harvested at Tyson Fresh Meats in Joslin, IL. Quality grade, yield grade, and marbling score were evaluated by USDA personnel; all other measures were evaluated by University of Minnesota personnel (Joslin, IL) or a custom carcass data collection service (Dakota City, NE).

Feed samples, feed refusals, and feed ingredient samples were frozen after collection. At the end of the experiment, samples were analyzed for DM using a 60° C dryer for 3 d. After 72 h in the dryer, samples were weighed and placed back into the dryer for an extra day. A second weight was taken to ascertain 100% DM was reached. Dried samples were ground using a Wiley mill with a 1 mm screen and kept frozen for later quality analysis. All other nutrient analyses were conducted at a commercial lab (Dairyland Labs, St. Cloud, MN).

Live steer performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS 9.2, SAS Institute, Inc., Cary, NC). Fixed model effect was treatment and random effect was pen. Carcass quality and yield grade categorical data were analyzed using GENMOD procedure of SAS with fixed model effects of treatment and pen. Statistical significance was declared with P-values ≤ 0.05, and trends were discussed with 0.05 < P-values ≤ 0.10. The PDIFF option was used to separate least squares means when a significant F-test statistic was present.

Results and Discussion

None of the steers showed or presented any symptoms of PEM during the study. Final carcass-adjusted BW was not affected by R, S, or their interaction (*P* ≥ 0.40), and averaged 1,407 lb across treatments. Dry matter intake increased linearly (*P* = 0.01) with increasing R, and averaged 21.8, 23.2, and 23.6 lb/d for LR, MR, and HR, respectively. Increased dietary S concentration decreased (*P* = 0.02) DMI, averaging 23.4 and 22.3 lb/d for LS and HS, respectively. Average daily gain was not affected (*P* ≥ 0.24) by R, S, or their interaction, and averaged 3.18 lb across treatments (Table 2). Feed:gain was not affected by dietary S concentration or S x R interaction (*P* ≥ 0.31) and increased linearly (*P* = 0.01) with increasing R, averaging 6.59, 6.94, and 7.56 for LR, MR, and HR, respectively.

Hot carcass weight (911 lb across treatments), ribeye area (15.5 in^2), 12^{th} rib fat thickness (0.46 in), marbling score (459), or frequency of individual USDA quality grades were not affected by S, R, or their interaction (*P* ≥ 0.12; Table 3). A tendency (*P* = 0.07) for a decrease in USDA yield grade 1 and 2 carcasses was observed with increasing R and averaged 60.8, 50.1, and 43.0% for LR, MR, and HR, respectively. No other effects on individual USDA yield grades were observed (*P* ≥ 0.15).

Our experiment confirmed that steers could be fed up to 0.56% dietary S while avoiding acute S toxicity signs. However, feeding the HS treatments did decrease DMI, which could be a sign of subacuate S toxicity. Previous research reported similar differences in DMI when dietary DG increased from 20% to 60% and dietary S concentrations increased from 0.6 to 0.9% of dietary DM with different corn processing methods (Neville et al., 2011). In our experiment, we expected steers fed HS and LR to exhibit reduced performance due to the combination of inadequate roughage and high S. We also expected that this reduction in performance may be alleviated in steers fed the MR or HR treatments with HS. However, steers fed the LR and HS treatment performed as well as all other treatments.

In summary, high dietary S concentrations did not reduce animal performance, though a reduction in DMI with high dietary S was observed. We also observed an increase in DMI and a concurrent increase in feed:gain with increasing dietary roughage. It was expected that high dietary S with low roughage would result in greater possibility of PEM cases and/or reduced performance due to excess S. However, this negative effect of feeding high dietary S concentrations was not observed.

Implications

Feeding diets containing 0.56% S had a reducing effect on dry matter intake with no impact on gain or carcass characteristics. Feeding steers diets containing 0.28% or 0.56% S did not respond to feeding roughage concentrations ranging from 5% to 15% other than the expected increase in intake with increases in roughage concentration. As expected, this increase in intake with increasing roughage concentration led to lower feed efficiency. Neither dietary S or roughage concentrations affected carcass characteristics. Results from this study demonstrate that feeding cattle dietary concentrations of S up to 0.56% were not detrimental to performance. At inclusion rates used in this experiment, and assigning average S concentration values for non distillers grains and solubles ingredients, the source of distillers grains and solubles could contain as much as 1.10% S. Interestingly, S concentrations in distillers grains and solubles are actually lower in recent surveys. This is the direct result of proactive applications of alternative fermentation management interventions at ethanol plants.

Acknowledgements

Sincere thanks to the Minnesota Corn Growers Research & Promotion Council and the Agricultural Utilization and Research Institute for supporting this research. A special note of thanks to Big River Energy, LLC for making modified distillers grains available at a discount for this experiment. Appreciation is extended to the staff at the University of Minnesota Rosemount Beef Unit for their invaluable assistance in completing this experiment.

Literature Cited

Crawford G.I., C. D. Keeler , J. J Wagner, C. R. Krehbiel, G. E. Erickson, M. B. Crombie, G. A. Nunnery. 2008. Effects of calcium magnesium carbonate and roughage level on feedlot performance, ruminal metabolism, and site and extent of digestion in steers fed high-grain diets. J. Anim. Sci. 86:2998-3013.

Depenbusch, B. E., C. M. Coleman, J. J. Higgins and J. S. Drouillard. 2009. Effects of increasing levels of dried corn distillers grains with solubles on growth performance, carcass characteristics, and meat quality of yearling heifers. J. Anim. Sci. 87:2653-2663.

DiLorenzo, N. and M.L Galyean. 2010. Applying technology with newer feed ingredients in feedlot diets. Do the old paradigms apply?. J. Anim. Sci. 88:E123-E132.

Klopfenstein, T. J., G. E. Erickson, and V. R. Bremer. 2008. Board-invited review: Use of distillers byproducts in the cattle feeding industry. J.Anim. Sci. 86:1223-1231.

Kung, Jr., L., J. P. Bracht, A. O. Hession, and J. Y. Tavares. 1998. High sulfate induced polioencephalomalacia (PEM) in cattle-burping can be dangerous if you are a ruminant. Proc. Chr. Hansen's Technical Symposium. Pacific Northwest Nutrition Conference. Vancouver, BC, Canada. http://ag.udel.edu/anfs/faculty/kung/H2S.htm.

Neville, B. W., G.P Lardy, K.K Karges, S. R Eckerman, P. T. Berg, and C. S. Schauer. 2011. Interaction of corn processing and distillers dried grains with soluble on health and performance of steers. J. Anim. Sci. published ahead of print. Available: http://jas.fass.org/content/early/2011/09/16/jas.2010-3798.full.pdf.

NRC. 1996. Nutrient Requirements of Beef Cattle (7th Ed.). National Academy Press. Washington, D.C.

NRC. 2005. Mineral Tolerances of Animals. (2nd Rev. Ed.). National Academy Press, Washington, DC.

RFA. 2011.Ethanol industry statistics. Renewable Fuels Association. Available: http://www.ethanolrfa.org/pages/statistics .

Vasconcelos, J. T., and M. L. Galyean. 2007. Nutritional recommendations of feedlot consulting nutritionists. The 2007 Texas Tech University survey. J. Anim. Sci. 85:2772-2781.

Table 1. Ingredient and nutrient composition for finishing diets (DM basis)[1].

	Low Sulfur			High Sulfur		
Item	LR	MR	HR	LR	MR	HR
Dry-rolled corn, %	45.5	40.5	35.5	45.5	40.5	35.5
Modified DGS[2], %	40.0	40.0	40.0	40.0	40.0	40.0
Grass hay, %	5.0	10.0	15.0	5.0	10.0	15.0
Liquid supp.[3], %	3.5	3.5	3.5	3.5	3.5	3.5
Gypsum supp.[4], %	.	.	.	6.0	6.0	6.0
Limestone supp.[5], %	6.0	6.0	6.0	.	.	.
NEg Mcal/cwt	63.6	61.5	59.3	63.3	61.2	59.0
CP, %	17.6	17.6	17.7	17.6	17.6	17.7
NDF, %	20.2	22.9	25.6	20.2	22.9	25.6
DIP, % of DM	8.7	8.9	9.0	8.7	8.9	9.0
Ca, %	1.14	1.17	1.19	1.14	1.17	1.19
P, %	0.50	0.49	0.49	0.50	0.49	0.49
Fat, %	7.4	7.3	7.3	7.4	7.3	7.3
S, %	0.28	0.28	0.28	0.56	0.56	0.56

[1]LR = Low roughage; MR = moderate roughage; HR = high roughage

[2]Modified distillers grains with solubles (approximately 48% DM) sourced from Western Wisconsin Energy, Boyceville, WI (now Big River Energy, LLC).

[3]Liquid supplement sourced from Quality Liquid Feeds, Dodgeville, WI.

[4]Gypsum (calcium sulfate) dry supplement with ground corn carrier.

[5]Limestone dry supplement with ground corn carrier.

Table 2. Effects of dietary roughage and sulfur concentrations on feedlot performance of beef steers.

	Dietary Roughage Concentration			Dietary S Concentration			*P*-values[1]			
Item	5%	10%	15%	0.28%	0.56%	SEM[2]	R Linear	R Quad	S	R x S
Initial BW, lb	1,012	1,018	1,018	1,018	1,014	36	0.72	0.90	0.82	1.00
Final BW, lb	1,406	1,418	1,393	1,411	1,402	8.4	0.60	0.40	0.62	0.96
DMI, lb/d	21.8	23.2	23.6	23.4	22.3	0.4	0.01	0.30	0.02	0.93
ADG, lb	3.22	3.28	3.04	3.20	3.15	0.22	0.24	0.40	0.45	0.96
Feed:Gain	6.59	6.94	7.56	7.07	6.97	0.54	0.01	0.59	0.31	0.99

[1] R Linear = Linear effect of dietary roughage concentration; R Quad = quadratic effect of dietary roughage concentration; S = main effect of dietary S concentration; R x S = interaction between dietary roughage and S concentrations.

[2] Standard error of the mean.

Table 3. Effects of dietary roughage and sulfur concentrations on carcass characteristics of beef feedlot steers.

	Dietary Roughage Concentration			Dietary S Concentration			*P*-values[1]			
Item	5%	10%	15%	0.28%	0.56%	SEM[2]	R Linear	R Quad	S	R x S
HCW, lb	915	917	902	917	906	5	0.45	0.52	0.44	1.00
Backfat, in	0.40	0.50	0.47	0.48	0.44	0.28	0.59	0.78	0.12	0.91
REA[3], in^2	15.4	15.8	15.4	15.6	15.4	6.5	0.99	0.26	0.47	0.85
Marbling[4]	450	469	457	466	451	85	0.79	0.49	0.45	0.14
USDA YG[5]	2.47	2.29	2.43	2.42	2.37	0.36	0.79	0.16	0.66	0.95
YG 1, %	9.2	23.4	16.3	12.72	19.87	0.49	0.15	0.15	0.31	0.25
YG 2, %	51.7	26.7	26.7	39.8	30.2	8.1	0.03	0.20	0.30	0.06
YG 3, %	27.9	35.1	38.7	29.1	38.7	7.9	0.33	0.85	0.29	0.12
YG 4, %	11.2	14.8	18.4	18.4	11.2	5.0	0.31	1.00	0.21	0.22
Prime QG[6], %	6.88	14.02	6.88	10.45	8.07	3.86	1.00	0.13	0.59	0.31
Choice QG, %	39.7	46.8	46.8	42.1	46.8	8.4	0.54	0.72	0.62	0.37
Select QG, %	53.6	35.7	42.8	42.9	45.2	7.8	0.32	0.18	0.79	0.93
No Roll QG, %	0.00	3.41	3.41	4.60	0.00	2.78	0.36	0.60	0.14	0.57

[1] R Linear = Linear effect of dietary roughage concentration; R Quad = quadratic effect of dietary roughage concentration; S = main effect of dietary S concentration; R x S = interaction between dietary roughage and S concentrations.

[2] Standard error.

[3] Ribeye (longissimus muscle) area measured at the 12th rib.

[4] Marbling score assessed by USDA grader where 400 = $Small^0$, 500 = $Modest^0$, etc.

[5] USDA yield grade assessed by USDA grader.

[6] USDA quality grade assessed by USDA grader.