

# Impacts of bunk management on steer performance and ruminal hydrogen sulfide concentrations in steers fed modified distillers grains with solubles<sup>1</sup>

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**ABSTRACT:** Two experiments were conducted to evaluate the impacts of bunk management on dry matter intake (DMI), growth performance, carcass characteristic, and hydrogen sulfide (H<sub>2</sub>S) concentrations in beef steers fed modified distillers grains with solubles (MDGS; DM basis). In Experiment 1, 139 steers (440.4 ± 31.0 kg) were randomly assigned to one of 16 pens with pen randomly assigned to one of two treatments: 1) Control (CON, bunks managed to be devoid of feed prior to feeding), or 2) Over-fed (OVF, bunks managed to have minimum of 2.54 cm of feed remaining each morning) during adaptation. Following adaptation all steers in Experiment 1 were transitioned to CON bunks and followed to finishing. In Experiment 2, 126 steers (445.4 ± 40.63 kg) were randomly assigned to one of 16 pens. Treatments in Experiment 2 were arranged in a 2 × 2 factorial and include the two bunk management strategies utilized in Experiment 1 (OVF or CON) and either 25% MDGS or 50% MDGS (DM basis). Ruminal H<sub>2</sub>S was measured via rumenocentesis during dietary adaptation. There were no differences ( $P \geq 0.13$ ) observed in either experiment for growth performance due to bunk management. In Experiment 1, OVF steers had greater ( $P = 0.001$ ) DMI during adaptation; however, overall DMI

was not different ( $P = 0.14$ ) between treatments. In Experiment 2, DMI (d 0 to 104) tended to decrease ( $P = 0.09$ ) with greater MDGS inclusion. Hot carcass weight, ribeye area, marbling score, and quality grade were not affected ( $P \geq 0.48$ ) by either bunk management or MDGS inclusion. In Experiment 2, back fat (1.30 vs. 1.17 ± 0.042 cm) and yield grade (3.2 vs. 3.0 ± 0.11) were greater ( $P = 0.03$ ) for CON steers compared with OVF but were not affected ( $P = 0.59$ ) by MDGS inclusion. In Experiment 1, H<sub>2</sub>S tended ( $P = 0.07$ ) to be greater in steers on OVF compared with CON. In Experiment 2, bunk management strategy did not impact ( $P = 0.82$ ) H<sub>2</sub>S concentrations. There was a MDGS inclusion × day interaction for H<sub>2</sub>S with steers fed 50% MDGS having greater ( $P < 0.01$ ) H<sub>2</sub>S concentrations compared with steers fed 25% MDGS on d 28 and 35. Bunk management strategy during adaptation did not impact growth performance but did reduce intake in Experiment 1. Yield grade decreased when OVF bunk management was applied throughout Experiment 2. Response of H<sub>2</sub>S concentrations in the rumen were variable and likely influenced by inconsistencies in bunk management and resulting DMI during the early portions of the feedlot study.

**Key words:** beef cattle, bunk management, hydrogen sulfide, modified distillers grains with solubles

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## INTRODUCTION

The transition period from roughage-based diets to grain-based diets is a critical time for rumen adaptation and the most likely time for increased occurrence of digestive upset in feedlot cattle (Schwartzkopf-Genswein et al., 2003). The relationship between distillers gains inclusion and hydrogen sulfide ( $H_2S$ ) is reasonably well defined (Neville et al., 2012; Felix et al., 2014) and links between dietary adaptation to high-concentrate diets and onset of polioencephalomalacia (PEM) have been proposed (Drewnoski et al., 2014). Associations between feedlot arrival, ruminal  $H_2S$ , and incidence of PEM have also been reported (Loneragan et al., 2005). Further links between acidosis and PEM have also been suggested (Galyean and Eng, 1998).

Bunk management systems are typically designed to decrease variation in dry matter intake (DMI; Pritchard and Burns, 2003; Schwartzkopf-Genswein et al., 2003) in a manner that decreases digestive disorders when feeding high-concentrate feedlot diets. However, bunk management did not result in differences in ruminal pH and did not increase incidence of acidosis (Erickson et al., 2003). The relationships between bunk management, DMI, and  $H_2S$  when feeding greater dietary sulfur in feedlot cattle have not been extensively researched and require further investigation.

We hypothesized that over-feeding steers because of less stringent bunk management during adaptation will increase  $H_2S$  concentrations in steers, with steers fed 50% modified distillers grains plus solubles (MDGS) having a more pronounced effect than those fed 25% MDGS. Our secondary hypothesis was that feeding MDGS at 50% of dietary DM will decrease DMI and bunk management strategy will have limited effects on feed efficiency. Our objectives were: 1) to evaluate the impacts of two bunk management methods on animal performance, carcass characteristics, and ruminal  $H_2S$  concentrations; 2) to evaluate the impacts of feeding either 25% or 50% MDGS under two bunk management methods on animal performance, carcass characteristics, and ruminal  $H_2S$

concentrations; and 3) to evaluate the interaction of bunk management and MDGS inclusion on animal performance, carcass characteristics, and ruminal  $H_2S$  concentrations.

## MATERIALS AND METHODS

These experiments were approved by the institutional animal care and use committee at North Dakota State University (#A18061 and #A19049).

### Experiment 1

One-hundred thirty-nine yearling Angus steers [initial body weight (BW)  $440.4 \pm 31.0$  kg] consolidated as part of North Dakota Angus University, a consignment feed-out program, were utilized for this experiment. Steers were stratified by initial weight and randomly assigned to one of 16 feedlot pens with pen randomly assigned to treatment ( $n = 8$ ). Pen space per animal averaged  $41.3m^2$ . Steers were weighed on two consecutive days at the beginning of the experiment, at the conclusion of adaptation to final finishing diet (d 28 and 29), and again at the conclusion of the project (d 96 and 97). Treatments were established by creating two divergent bunk management strategies 1) Control (CON)—bunks managed to be devoid of feed 1 h prior to feeding and 2) Over-fed (OVF)—bunks managed via visual estimates to have greater than 2.54 cm of feed remaining at the time of next feed delivery. Bunk management treatments were imposed throughout adaptation (d 0 to 28). Following dietary adaptation all steers were transitioned to CON bunk conditions until reaching market readiness (d 97). Feed delivery was recorded daily, and feed refusals were collected and weighed weekly for determination of DMI. All calves received a growth promotant implant (Synovex Choice, Zoetis Inc., Parsippany-Troy Hills, NJ) at the initiation of the experiment and received a parasiticide pour-on (Cydectin, Bayer Animal Health, Shawnee Mission, KS) at arrival.

Adaptation was accomplished through a series of five transition diets, with diets changed every 7 d until reaching the final finishing ration on d 28.

The first diet contained 22.3% dry-rolled corn, 25% MDGS, 36.0% silage, 14% wheat straw, 1.5% supplement, and 1.2% calcium carbonate (DM basis). The final finishing diets contained 57.1% dry-rolled corn, 25% MDGS, 10% corn silage, 5% wheat straw, 1.5% supplement, and 1.4% calcium carbonate on a DM basis. The MDGS utilized in this experiment averaged 31.25% crude protein (CP) and 0.77% sulfur (S). The supplement contained 81.1% grain screenings, 7.5% calcium carbonate, 3.8% molasses, 6.5% vitamin and trace mineral premixes, and 1.2% monensin premix. The supplement was fed to provide 330 mg of monensin  $\text{steer}^{-1}\cdot\text{d}^{-1}$ . The final finishing diet contained 1.32 Mcal/kg NEg based on estimated values obtained from [NASEM \(2016\)](#). Laboratory values for CP and S concentrations were 14.9% and 0.29%, respectively. All diets were supplemented with 100 mg of thiamin  $\text{steer}^{-1}\cdot\text{d}^{-1}$  to assist in the prevention of PEM.

At the conclusion of the experiment, cattle were shipped to a commercial abattoir, Tyson Fresh Meats, Dakota City, NE for slaughter and subsequent carcass data collection. Hot carcass weights were collected within 30 min of exsanguination. Ribeye area, 12th rib fat, and marbling score were measured via automated camera imaging, while quality grade was assigned by USDA grader. All carcass data reported were provided by the abattoir.

Ruminal  $\text{H}_2\text{S}$  was collected on days: 0, 7, 14, and 28 with collections occurring 4 h after feeding. Ruminal  $\text{H}_2\text{S}$  was collected on two steers from each of three pens per treatment. At each sampling point, duplicate measurements were taken from each steer, and the mean of the two samples was used to calculate a pen average for data analysis. Procedures for sampling ruminal  $\text{H}_2\text{S}$  and analysis with  $\text{H}_2\text{S}$  detector tubes (Gastec, Kanawaga, Japan) were previously outlined by [Gould et al. \(1997\)](#) and modified by [Neville et al. \(2010, 2012\)](#). If the detector tube failed to reach 100 ppm of  $\text{H}_2\text{S}$  (the least detectable concentration recommended by the manufacturer), the reading was treated as a zero. Hydrogen sulfide concentrations (ppm) were converted to  $\text{H}_2\text{S}$  grams per cubic meter through the following equations:  $\{[\text{H}_2\text{S} (\text{ppm}) \times 139.06]/1,000,000\}$  assuming standard temperature and pressure values ([Neville et al. 2010, 2012](#)).

### Experiment 2

One-hundred twenty-six yearling Angus steers (initial BW  $445.4 \pm 40.63$  kg) consigned to the North Dakota Angus University, a consignment feed-out program, were utilized to evaluate the objectives of

this experiment. Steers were stratified by weight and randomly assigned to pen with pens randomly assigned to treatment. Pen space per steers averaged 33.6  $\text{m}^2$ . Treatments were arranged in a  $2 \times 2$  factorial and included either 25% MDGS (25MGDS) or 50% MDGS (50MDGS; DM basis) and were managed under one of two bunk management systems: OVF or CON previously described in Experiment 1. Steers were weighed on two consecutive days at the beginning of the experiment and at the conclusion of the project (d 103 and 104). Unlike Experiment 1, treatments in Experiment 2 were imposed for the duration (d 0 to 104) of the experiment. Feed delivery was recorded daily, and feed refusals were collected and weighed weekly for determination of DMI. All calves received a growth promotant implant (Synovex Choice, Zoetis Inc., Parsippany-Troy Hills, NJ) at the initiation of the experiment and received a parasiticide pour-on (Cydectin, Bayer Animal Health, Shawnee Mission, KS) at arrival.

Adaptation was accomplished through a series of five transition diets, with diets changed every 7 d until reaching the final finishing ration on d 28. All steers started on a common diet which included 37.5% dry-rolled corn, 50% corn silage, 15% wheat straw, 1.5% supplement, and 1.0% calcium carbonate (DM basis). Final finishing diets contained 57.2% dry-rolled corn, 25% MDGS, 10% corn silage, 5% wheat straw, 1.5% supplement, and 1.3% calcium carbonate (DM basis) for steers on the 25MDGS treatment; or 31.9% dry-rolled corn, 50% MDGS, 10% corn silage, 5% wheat straw, 1.5% supplement, and 1.6% calcium carbonate (DM basis) for steers on the 50MDGS treatment. The supplement contained 81.1% grain screenings, 7.5% calcium carbonate, 3.8% molasses, 6.5% vitamin and trace mineral premixes, and 1.2% monensin premix. As in Experiment 1, the same supplements were used to provide 330 mg of monensin  $\text{steer}^{-1}\cdot\text{d}^{-1}$  and 100 mg of thiamin  $\text{steer}^{-1}\cdot\text{d}^{-1}$ . The final finishing diets were formulated to contain an average of 1.31 Mcal/kg NEg based on estimated values obtained from [NASEM \(2016\)](#). Laboratory values for CP were 15.6% and 20.1%, while S concentrations were 0.31% and 0.44% for the 25MDGS and 50MDGS treatments, respectively.

At the conclusion of the experiment, cattle were shipped to a commercial abattoir Tyson Fresh Meats, Dakota City, NE for slaughter and subsequent carcass data collection. Carcass data collection procedures followed those described in Experiment 1.

Ruminal  $\text{H}_2\text{S}$  was collected on two steers from each of four pens per treatment, with the

average score of the pen used for data analysis. Ruminant H<sub>2</sub>S was collected on days: 0, 7, 14, 21, 28, and 35 with collections occurring 4 h after feeding. Procedures for sampling rumen H<sub>2</sub>S gas and analysis of data followed those described in Experiment 1.

### Laboratory Analysis

Diet and ort samples were dried using a forced air oven (65 °C; The Grieve Corporation, Round Lake, IL) for a minimum of 48 h for determination of DM content. Dried feed samples were ground using a Wiley Mill (Arthur H. Thomas Co., Philadelphia, PA) to pass a 2-mm screen. Feed samples were analyzed for DM, ash, CP, phosphorus, calcium, (methods 934.01, 942.05, 2001.11, 965.17, and 968.08, respectively; AOAC, 2010). Sulfur was analyzed on a Combustion Analyzer (LECO CNS928; St. Joseph, MI). Concentrations of NDF (Van Soest et al., 1991; as modified by Ankom Technology, Fairport, NY) and ADF (Goering and Van Soest, 1970, as modified by Ankom Technology) were determined using an Ankom 200 Fiber Analyzer (Ankom Technology, Macedon, NY).

### Statistical Analysis

For all analyses, pen served as the experimental unit. Body weight, average daily gain (ADG), and carcass characteristic data were collected on an individual animal basis, and then a pen value was calculated by averaging the respective individual animal values within a pen. Dry matter intake and growth performance data for both adaptation and the full project, and carcass trait data were analyzed using the MIXED procedure of SAS (SAS Ins. Inc., Cary, NC). In all experiments pen served as the experimental unit. Fixed effects included bunk management (Experiment 1) or the factorial arrangement of bunk management and MDGS inclusion (Experiment 2). In Experiment 1, H<sub>2</sub>S was analyzed using the MIXED procedure of SAS using repeated measures with treatment (bunk management strategy), day, and the treatment by day interaction included in the model. In Experiment 2, H<sub>2</sub>S data were analyzed using the MIXED procedure of SAS using repeated measures with bunk management, MDGS level, day, bunk management by day, MDGS inclusion by day, bunk management by MDGS inclusion, and bunk management by MDGS inclusion by day in the original model. In both Experiment 1 and Experiment 2, the covariance structure for repeated measures analysis was determined for each variable using the

information criteria of SAS. If the *F*-test was significant, means were separated using LS means generated by PDIFF option of SAS. Significance was declared at  $P \leq 0.05$ . Tendencies will be discussed at ( $P > 0.05$  and  $P \leq 0.10$ ).

## RESULTS

### Experiment 1

No differences were observed for initial or final BW, ADG, or gain to feed ration (G:F) during adaptation ( $P \geq 0.13$ ; Table 1). However, as anticipated given methods by which feed bunks were managed, steers on OVF treatment consumed more feed compared with steers fed under control bunk management during the 28-d adaptation period (12.5 and 11.4 ± 0.19 kg/d, respectively;  $P < 0.01$ ). When evaluated over the entirety of the project (d 0 to 97), no differences due to bunk management were observed in ADG, DMI, or G:F were observed ( $P \geq 0.14$ ). Carcass characteristics were not affected by bunk management ( $P \geq 0.53$ ), which was an expected outcome as for most of the feeding period cattle were, in fact, treated the same.

Hydrogen sulfide concentrations increased over time ( $P < 0.01$ ) and tended to differ between treatments ( $P = 0.07$ ) during dietary adaptation, this was largely driven by an apparent difference ( $P = 0.04$ ) between CON and OVF H<sub>2</sub>S concentrations on d 14 (0.20 and 0.34 ± 0.04 g/m<sup>3</sup>, respectively; Fig. 1). Peak concentrations of H<sub>2</sub>S were observed on d 14 for OVF steers and on d 28 (0.21 ± 0.044 g/m<sup>3</sup>) for CON. Samples were not collected on d 21 due to adverse weather causing feed availability issues delaying feeding.

### Experiment 2

Growth performance and carcass characteristics in Experiment 2 were not influenced by a bunk management × MDGS inclusion interaction ( $P \geq 0.17$ ). Bunk management did not affect initial or final BW, ADG, DMI during adaptation, overall DMI, or G:F in Experiment 2 ( $P \geq 0.17$ ; Table 2). In addition, inclusion rate of MDGS did not influence initial or final BW, ADG, DMI during adaptation, or G:F ( $P \geq 0.43$ ). However, DMI over the duration of the experiment tended to be negatively impacted by greater MDGS inclusion (13.4 and 12.9 ± 0.19 kg/d for 25% and 50% inclusion, respectively;  $P = 0.09$ ). Steers fed under CON management had greater back fat ( $P = 0.04$ ; 1.30 and 1.17 ± 0.042 cm, respectively) compared with those on OVF management. This translated into greater carcass yield grade for CON

**Table 1.** Feedlot performance and carcass characteristics of steers fed 25% MDGS (DM basis) under two bunk management systems

|                                  | Bunk management <sup>1</sup> |       | SE    | P-Value |
|----------------------------------|------------------------------|-------|-------|---------|
|                                  | CON                          | OVF   |       |         |
| Adaptation (d 0–28) <sup>3</sup> |                              |       |       |         |
| Initial BW, kg                   | 441.7                        | 438.1 | 7.53  | 0.75    |
| Final BW, kg                     | 508.1                        | 509.3 | 8.21  | 0.92    |
| ADG, kg/d                        | 2.4                          | 2.5   | 0.07  | 0.13    |
| DMI, kg/d                        | 11.4                         | 12.5  | 0.19  | <0.01   |
| G:F <sup>2</sup>                 | 0.21                         | 0.20  | 0.006 | 0.47    |
| Overall (d 0–97) <sup>3</sup>    |                              |       |       |         |
| Initial BW, kg                   | 441.7                        | 438.1 | 7.53  | 0.75    |
| Final BW, kg                     | 633.1                        | 630.3 | 8.44  | 0.82    |
| ADG, kg/d                        | 2.0                          | 2.0   | 0.03  | 0.89    |
| DMI, kg/d                        | 12.7                         | 13.2  | 0.21  | 0.14    |
| G:F <sup>2</sup>                 | 0.14                         | 0.13  | 0.003 | 0.24    |
| Carcass characteristics          |                              |       |       |         |
| HCW <sup>4</sup> , kg            | 378.7                        | 378.2 | 5.71  | 0.98    |
| Ribeye area, cm <sup>2</sup>     | 87.7                         | 87.4  | 0.77  | 0.78    |
| Marbling score <sup>5</sup>      | 517                          | 515   | 13.9  | 0.91    |
| Back fat, cm                     | 1.3                          | 1.4   | 0.10  | 0.55    |
| Yield grade                      | 3.3                          | 3.4   | 0.09  | 0.53    |
| Quality grade <sup>6</sup>       | 10.7                         | 10.6  | 0.15  | 0.85    |

<sup>1</sup>Treatment abbreviations: CON = bunks devoid of feed prior to next feeding, OVF = bunks with >2.54 cm of feed remaining at time of next feeding.

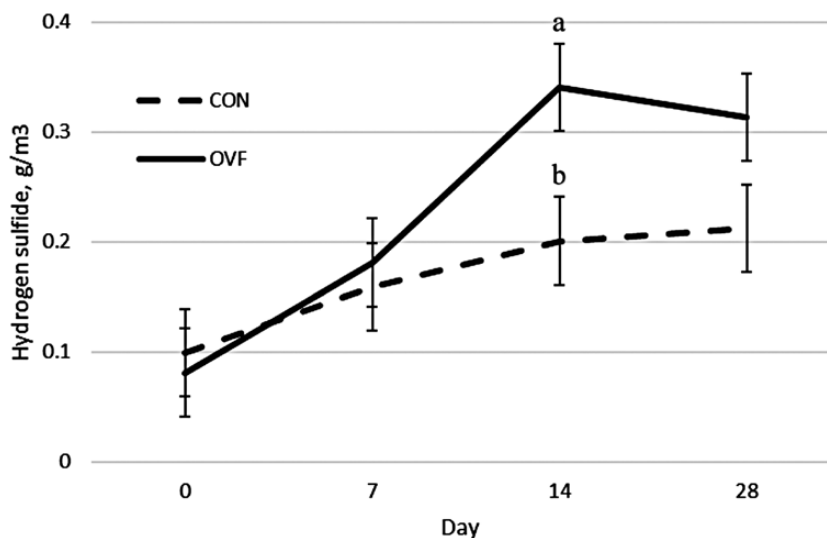
<sup>2</sup>G:F = kg of weight gain:kg of dry feed intake.

<sup>3</sup>BW = body weight, DMI = dry matter intake, ADG = average daily gain, G:F = kg of weight gain:kg of dry feed intake.

<sup>4</sup>Hot carcass weight.

<sup>5</sup>Marbling score based on 400 = Small<sup>00</sup>, 500 = Modest<sup>00</sup>.

<sup>6</sup>Quality grades based on Low Choice (Ch<sup>-</sup>) = 10, High Prime (Pr<sup>+</sup>) = 15.



**Figure 1.** Change in ruminal H<sub>2</sub>S concentrations (g/m<sup>3</sup>) caused by divergent bunk management treatments: CON = control, bunks devoid of feed prior to next feeding; OVF = over-fed, bunks containing >2.54 cm of feed at time of next feed delivery. P-Values: bunk management,  $P = 0.07$ ; day,  $P < 0.01$ ; bunk management  $\times$  day,  $P = 0.30$ ). Superscripts indicate means within a day differ  $P \leq 0.05$ ). Concentrations of ruminal H<sub>2</sub>S measured via rumenocentesis on H<sub>2</sub>S detector tubes (Gastec, Kanawaga, Japan).

steers ( $P = 0.03$ ) compared with OVF. Hot carcass weight, ribeye area, marbling, and quality grade were not affected by bunk management ( $P \geq 0.67$ ) or MDGS inclusion ( $P \geq 0.48$ ).

The bunk management strategies imposed in this experiment did not influence ruminal H<sub>2</sub>S concentrations ( $P = 0.82$ ), nor did bunk management have significant interactions with MDGS

**Table 2.** Impacts of bunk management and either 25% or 50% dietary MDGS inclusion (DM basis) on feedlot performance and carcass characteristics of steers

|                                  | Bunk management <sup>1</sup> |       | MDGS inclusion <sup>2</sup> |       | SE    | P-Values <sup>3</sup> |      |             |
|----------------------------------|------------------------------|-------|-----------------------------|-------|-------|-----------------------|------|-------------|
|                                  | CON                          | OVF   | 25                          | 50    |       | Bunk                  | MDGS | Bunk × MDGS |
| Feedlot performance <sup>4</sup> |                              |       |                             |       |       |                       |      |             |
| Initial BW, kg                   | 444.6                        | 446.9 | 447.7                       | 443.9 | 5.04  | 0.75                  | 0.60 | 0.78        |
| Final BW, kg                     | 635.5                        | 635.0 | 637.4                       | 632.9 | 6.60  | 0.96                  | 0.65 | 0.53        |
| DMI d 0–28, kg/d                 | 9.6                          | 10.2  | 9.4                         | 9.7   | 0.30  | 0.17                  | 0.50 | 0.17        |
| DMI d 0–104, kg/d                | 13.0                         | 13.3  | 13.4                        | 12.9  | 0.19  | 0.37                  | 0.09 | 0.87        |
| ADG, kg/d                        | 1.9                          | 1.8   | 1.8                         | 1.8   | 0.05  | 0.67                  | 0.94 | 0.56        |
| G:F <sup>5</sup>                 | 0.14                         | 0.14  | 0.14                        | 0.14  | 0.006 | 0.39                  | 0.43 | 0.67        |
| Carcass characteristics          |                              |       |                             |       |       |                       |      |             |
| HCV <sup>6</sup> , kg            | 384.4                        | 385.4 | 386.3                       | 383.6 | 3.92  | 0.86                  | 0.63 | 0.68        |
| Ribeye area, cm <sup>2</sup>     | 83.8                         | 77.9  | 83.7                        | 84.5  | 1.36  | 0.76                  | 0.73 | 0.48        |
| Marbling score <sup>7</sup>      | 502                          | 496   | 499                         | 500   | 11.5  | 0.72                  | 0.97 | 0.82        |
| Back fat, cm                     | 1.30                         | 1.17  | 1.25                        | 1.22  | 0.042 | 0.04                  | 0.59 | 0.56        |
| Yield grade                      | 3.2                          | 3.0   | 3.1                         | 3.1   | 0.08  | 0.03                  | 0.94 | 0.33        |
| Quality grade <sup>8</sup>       | 10.5                         | 10.4  | 10.5                        | 10.4  | 0.11  | 0.67                  | 0.48 | 0.64        |

<sup>1</sup>Treatment abbreviations: CON = bunks devoid of feed prior to next feeding, LONG = bunks with >2.54 cm of feed remaining at time of next feeding.

<sup>2</sup>MDGS inclusion was 25% of 50% DM basis.

<sup>3</sup>P-Values for effects of bunk management (Bunk), MDGS inclusion rate (MDGS), and the interaction of bunk management and MDGS inclusion.

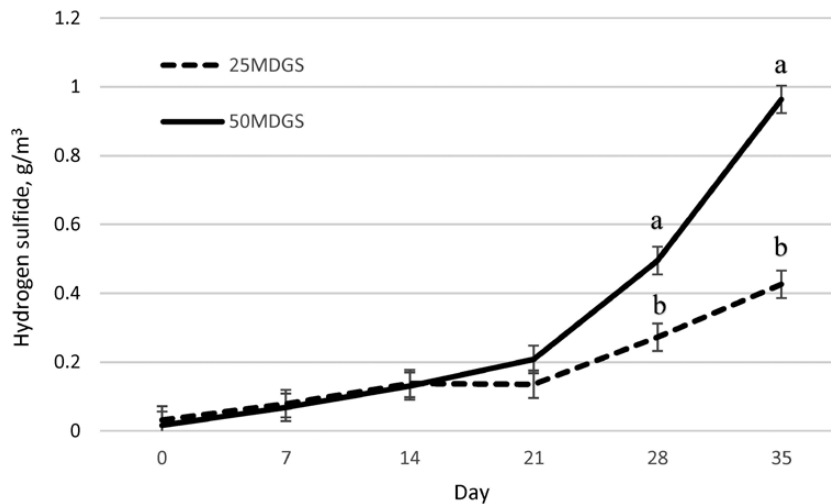
<sup>4</sup>BW = body weight, DMI = dry matter intake, ADG = average daily gain.

<sup>5</sup>G:F = kg of weight gain:kg of dry feed intake for d 0 to 104.

<sup>6</sup>Hot carcass weight.

<sup>7</sup>Marbling score based on 400 = Small<sup>00</sup>, 500 = Modest<sup>00</sup>.

<sup>8</sup>Quality grades based on Low Choice (Ch<sup>-</sup>) = 10, High Prime (Pr<sup>+</sup>) = 15.



**Figure 2.** Change in ruminal H<sub>2</sub>S concentrations (g/m<sup>3</sup>) caused by increasing dietary modified distillers grains with solubles (MDGS) inclusion during dietary adaptation to final finishing diet. Treatments were 25MDGS = 25% MDGS DM basis, and 50MDGS = 50% MDGS inclusion DM basis. P-Values: MDGS inclusion,  $P < 0.01$ ; day,  $P < 0.01$ ; MDGS × day,  $P < 0.01$ ). Superscripts indicate differences within day between treatments ( $P < 0.01$ ). Concentrations of ruminal H<sub>2</sub>S measured via rumenocentesis on H<sub>2</sub>S detector tubes (Gastec, Kanawaga, Japan).

inclusion, day, or the three-way interaction ( $P \geq 0.19$ ). Therefore, bunk management was removed from statistical models, and only the effects associated with MDGS inclusion are being presented. As anticipated, the concentration of ruminal H<sub>2</sub>S increased throughout adaptation ( $P < 0.01$ ; Fig. 2) which is consistent with findings in Experiment

1. There was a MDGS inclusion × day interaction for H<sub>2</sub>S where steers fed 50% MDGS had greater ( $P < 0.01$ ) H<sub>2</sub>S concentrations compared with the steers fed 25% MDGS on d 28 and 35. One steer on the OVF-50% MDGS treatment exhibited signs of PEM and was euthanized with subsequent histological confirmation of PEM.

## DISCUSSION

The CON bunk management treatment reduced DMI during adaptation by 1.1 and 0.59 kg compared with OVF in Experiment 1 and Experiment 2, respectively. While the goal of our project was not to restrict DMI, the reduction in DMI during adaptation fell within the 0.5 to 1 kg criteria for feed restriction (Schwartzkopf-Genswein et al., 2003). It is possible that differences between our data and that of previous researchers are due to varying methods used to score bunks, while the current experiments used a single bunk score daily, collected immediately prior to feeding to adjust feed other studies have had more rigorous monitoring. The limited impacts of bunk management early in the feeding period on ADG and feed efficiency in the current experiments are consistent with previous research (Schwartzkopf-Genswein et al., 2004; Relling et al., 2020). Schwartzkopf-Genswein et al. (2004) examined the impacts of fluctuation in DMI and time of delivery but did not report any differences in ADG or feed efficiency. In a pair of studies Erickson et al. (2003) observed that clean-bunk management did not impact DMI, ADG, or feed efficiency during summer, but decreased DMI and ADG during the winter. Part of the differences between our data and previous research could be type of cattle.

Decreased DMI when feeding a diet containing 50% MDGS (DM basis) was expected and is consistent with previous research. Klopfenstein et al. (2008) observed a decrease in DMI when wet distillers grains with solubles was fed at concentrations greater than 30% in finishing rations. Furthermore, DMI decreased from 11.5 to 10.7 kg/d as MDGS inclusion increased from 35% to 65% (Jolly-Breithaupt et al., 2018). The lack of differences between 25% and 50% MDGS inclusion in ADG and G:F in the current experiment contradict results from previous research where other distillers grains products were fed (Klopfenstein et al., 2008). In our experiment, we utilized yearling steers weighing 440 to 445 kg at arrival, had these treatments been imposed on steers more typical to weaned calves in the fall the results of this experiments may have been vastly different due to type of cattle and season. The limited experimental power of the current study also likely decreased our ability to observe any differences in performance data.

It is not known why bunk management in Experiment 2 did not impact ruminal  $H_2S$ ; however, initial evaluations seem to indicate that the separation in DMI observed in Experiment 1 was not achieved in Experiment 2, potentially explaining differences between our two experiments. Interestingly,

following adaptation in Experiment 1, cattle were transitioned back to CON, or clean bunks, resulting in  $H_2S$  concentrations being similar between the two groups (data not shown) indicating that perhaps  $H_2S$  may be altered via bunk management or DMI. These data indicate that further research is necessary to evaluate if the risk of PEM may be manipulated through bunk management or DMI.

Including 50% MDGS in diets fed to steers in the current experiment increased ruminal  $H_2S$  compared with steers fed 25% MDGS. The increased concentration of  $H_2S$  exhibited when greater concentrations of MDGS are fed during dietary adaptation in the current experiment are similar to results reported in previous research with dried distillers grains plus solubles (Neville et al. 2011, 2012; Drewnoski et al., 2012; Felix et al., 2014). The lack of interaction between bunk management and MDGS inclusion was possibly a result of decreased separation in DMI in experiment 2. Future research with similar treatments may potentially find different results if separation in DMI is archived.

It is important to note that the overall S content of the rations ( $\leq 0.44\%$  S) and peak  $H_2S$  concentrations ( $0.96 \pm 0.040$  g/m<sup>3</sup>  $H_2S$ , 50MDGS in Experiment 2) were less than values previously reported in feedlot steers fed 20% to 60% DDGS or 0.6% to 0.9% dietary S and ruminal  $H_2S$  1.38 g/m<sup>3</sup> (Neville et al., 2012). The differences in S content of corn-ethanol coproducts emphasize the continued need to evaluate risks of PEM due to S from coproducts or corn-ethanol production.

In conclusion bunk management strategy during adaptation did not impact growth performance but did reduce intake in Experiment 1. Yield grade decreased in steers on OVF bunk management throughout the duration of the feeding period. Response of  $H_2S$  concentrations in the rumen were variable and likely influenced by inconsistencies in DMI between similar bunk management treatments during the early portions of these experiments. Continued research on the impacts of bunk management during adaptation are still needed to make broader recommendations about managing cattle when fed finishing diets containing greater quantities of corn-ethanol coproducts.

*Conflict of interest statement.* None declared.

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