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Effects of including Sweet Bran or modified distillers grains in the diet of feedlot steers and sorting at terminal implant on growth performance, feeding behavior, and liver abscess occurrence

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ABSTRACT

The objectives were to assess the effects of dietary Sweet Bran (Cargill Corn Milling, Blair, NE) on performance and feeding behavior of feedlot steers and determine if terminal implant pen sorting affects performance, feeding behavior, and liver abscess (LA) rate. Two hundred sixteen Angus-cross steers (253 ± 18 kg) were stratified by body weight (BW) to 36 pens. From d 0 to 60, diets contained 40% Sweet Bran (SWBR) or 25% modified distiller's grains and 15% dry rolled corn (MOD; n = 18 pens/treatment). On d 60, steers began transition within treatments to finishing diets containing 25% Sweet Bran or 25% modified distiller's grains (MDGS). On d 111, half of the pens for each dietary treatment were re-stratified by BW to pens (SORT) while the other half were returned to original pens (NOSORT; n = 9 pens/treatment). Steer BW and pen dry matter intake (DMI) were recorded monthly. Rate of feed disappearance was determined on d 5/6, 53/54, 104/105, and 117/118. Pen was the experimental unit for all analyses. The model included the fixed effect of diet for all pre-sort analyses; post-sort analyses included the fixed effects of diet, sort, and the interaction and the random effects of pen and the interaction of diet and pen. On d 60, SWBR had greater BW than MOD (P = 0.05), and SWBR had a greater average daily gain (ADG) from d 0 to 60 (P = 0.05). Though there were no differences after d 28, SWBR had greater DMI d 0 to 28 (P = 0.05). From d 60 to 88, SWBR tended to have lesser ADG than MOD (P = 0.09). Post-sort (d 111 to 196), SWBR tended to have lesser ADG than MOD (P = 0.06), and SORT had a greater rate of feed disappearance than NOSORT (d 117/118; P = 0.01); there were no differences on other dates (Diet: P ≥ 0.38). For final BW, there was a tendency for MOD to be greater than SWBR, and SORT tended to be greater than NOSORT (Diet: P = 0.06; Sort: P = 0.10). Pre- and post-sort ruminal pH had no treatment by day differences (P ≥ 0.77). LA incidence averaged 25%, though rate was not affected by diet, sorting, or the interaction (P ≥ 0.16). Overall, there were no dietary differences in feed disappearance rates, though SORT steers had greater rate of feed disappearance than NOSORT steers on d 117/118. Nominal differences in feeding behavior were noted and including Sweet Bran in the diet was beneficial in the growing period as cattle adjusted to the feedlot.

Key words: cattle, feeding behavior, feedlot, liver abscess, regrouping, Sweet Bran

INTRODUCTION

Sweet Bran, a branded wet corn gluten feed (Cargill Corn Milling, Blair, NE) has been shown to improve performance of feedlot steers and might affect feeding behavior (Parsons et al., 2007). RAMP (a complete starter ration produced by Cargill with high inclusion of Sweet Bran and low inclusion of forage) increased feed efficiency when fed to newly received steers during the growing period when compared to steers fed a traditional receiving diet containing hay, Sweet Bran, and dry-rolled corn (Schneider et al., 2013b). Including Sweet Bran in the diet of feedlot steers during adaptation to finishing diets increased dry matter intake (DMI) as well as meal size (Sarturi et al., 2011). Steers consuming RAMP before abruptly changing to a finishing diet containing Sweet Bran displayed no negative performance effects (Schneider et al., 2014) suggesting Sweet Bran might help buffer the rumen as dietary grain inclusion increases.

Cattle housed together will compete to gain access to a resource. A competitive environment can be triggered by overstocking pens or disrupting the group hierarchy through sorting of cattle to new pens. Feeding behavior can change when cattle are housed in a competitive environment. For instance, subordinate cows prefer to eat a low-palatability feed alone rather than stand next to a dominate cow and have access to a high-palatability feed (Rioja-Lang et al., 2012). Additionally, competition increases feeding rates (Collings et al., 2011), and greater rates of feed consumption might decrease saliva production in ruminants (Beauchemin et al., 2008). Saliva is critical for preventing ruminal acidosis (González et al., 2012). Ruminal acidosis can damage the ruminal epithelium and allow microbes which populate the rumen to escape into the portal blood, make their way to the liver, and form a pocket of infection (an abscess; Jensen et al., 1954). As such, increasing

competition might lead to greater occurrences of liver abscesses (LAs) through decreased ruminal pH.

The objectives of this study were to 1) assess inclusion of Sweet Bran in diets of feedlot steers on performance and feeding behavior and 2) examine the effects of sorting animals at terminal implant on performance, feeding behavior, and LA occurrence. We hypothesized that 1) Sweet Bran-fed steers would have greater performance and slower feed consumption rates and 2) sorted steers would have lesser growth performance and greater LA occurrence.

MATERIALS AND METHODS

All experimental procedures were approved by the Iowa State University Institutional Animal Care and Use Committee (IACUC Log Number 19-265).

Animals and Experimental Design

In October 2019, 240 Angus-cross steers arrived at Iowa State University Beef Nutrition Research Unit (Ames, IA) from a single ranch in Nebraska. Upon arrival (d –2), steers were offered hay top-dressed with a blend of corn silage and trace mineral premix. Steers were processed, stratified to pen by weight, and started treatment diets on d 0, 2 days after arrival to the feedlot. During processing, steers received new electronic and visual identification tags as well as vaccinations (Bovi-Shield Gold 5, Zoetis, Kalamazoo, MI; Vision 7 with SPUR, Merck Animal Health, Madison, NJ) and an injectable anthelmintic (Dectomax, Zoetis).

Two hundred and sixteen of the 240 steers (initial body weight [BW]: 253 ± 18 kg) were utilized in a 196-d trial. Steers were selected based on BW uniformity and visual health appraisal. Steers that had discharge from the nose or eyes, had a rectal temperature greater than 39.9 °C, and/or were displaying lameness were not considered for the trial. Steers were housed in 36 partially covered concrete pens ($n = 36$) at six steers per pen (7.4 m² per steer) and offered ad libitum water at all times via Ritchie waterers (Ritchie Industries Inc., Conrad, IA). The concrete feed bunks were altered using plywood so there was 30.5 cm of linear bunk space per steer in each pen. Steers received an initial implant (Component TE-IS; 80 mg trenbalone acetate + 16 mg estradiol; Elanco Animal Health, Greenfield, IN) on d 28 and a terminal implant on d 111 (Component TE-200; 200 mg trenbalone acetate + 20 mg estradiol; Elanco Animal Health).

This experiment was designed as a 2 × 2 factorial. The first factor was diet which contained either Sweet Bran (SWBR; Cargill Corn Milling, Blair, NE) or modified distiller's grain (MOD; Golden Grain Energy, Mason City, IA; Table 1). The second factor was whether or not the steers in a whole pen were resorted at terminal reimplantation (d 111; NOSORT vs. SORT). Steers in SORT were stratified using d 88 BW and when sorted on d 111 could not return to their original home pen or to a pen that had a previous pen mate in it. All steers in NOSORT were returned to their original home pens with their original pen mates after reimplant. Within each set of four contiguous pens, all possible treatment combinations were represented ($n = 9$ pens per treatment).

Sample Collection

Growth performance and carcass characteristics. Individual steer BW was recorded pre-feeding on d 0, 28, 60, 88, 111, 125, 139/140, 167, and 195/196. On d 139/140, steers from half of the contiguous pens were weighed on d

Table 1. Growing and finishing diets for SWBR- and MOD-fed steers

	Growing		Finishing	
	SWBR[1]	MOD[2]	SWBR	MOD
DM, % as fed	57.7	56.7	66.0	64.2
Ingredient, %DM				
Corn silage	40.0	40.0	16.0	16.0
Sweet Bran[3]	40.0	—	25.0	—
Modified distiller's grains[4]	—	25.0	—	25.0
Dry rolled corn	—	15.0	54.0	54.0
Dried distiller's grains	15.0	15.0	—	—
Microingredient premix[5]	5.0	5.0	5.0	5.0
Analyzed composition[6], %DM				
Crude protein	18.4	17.9	12.2	13.8
NDF	31.4	26.5	19.0	16.1
Ether extract	5.8	6.8	4.6	5.6

[1]Sweet Bran included in the diet; branded wet corn gluten feed (Cargill Corn Milling, Blair, NE).
[2]Modified distillers grains with solubles included in the diet.
[3]Branded wet corn gluten feed (Cargill Corn Milling, Blair, NE). The ingredient NDF, fat, and crude protein were 32.1, 2.9, and 21.7%, respectively.
[4]The average ingredient NDF, sulfur, fat, and crude protein concentrations were Growing: 25.9%, 1.03%, 8.6%, and 32.2% DM, and Finishing: 23.9, 0.73, 9.5, and 30.9% DM, respectively (From MDGS analysis by Dairyland, Inc.).
[5]Vitamin and mineral premix provided per kilogram of the diet DM: 0.15 mg Co (cobalt carbonate), 10 mg Cu (copper sulfate), 20 mg Mn (manganese sulfate), 0.1 mg Se (sodium selenite), 30 mg Zn (zinc sulfate), 0.5 mg I (calcium iodate), and 2,200 IU vitamin A and 25 IU vitamin E (DSM Nutritional Products, Ames, IA). Provided as a percentage of total diet DM: dried distillers grain (3.05%), limestone (1.50%), salt (0.31%), Rumensin 90 (0.0135%).
[6]From TMR analysis by Dairyland, Inc. (Arcadia, WI).

139 while the other half were weighed on d 140 to prevent extensive time withheld from feed; treatments were evenly represented on both days. The net energy for gain (NEg) was calculated using the average BW, overall average daily gain (ADG), and average pen DMI for the finishing period as described in Plascencia et al. (1999) and Russell et al. (2016). Steers were harvested on two consecutive days at the end of April 2020 (d 196 and 197) at Upper Iowa Beef (Lime Springs, IA). As such, steers were weighed on d 195 (pens 1–14 and 33–36) and 196 (pens 15–32) prior to shipping. At harvest, LA score and hot carcass weight were recorded by a single University personnel member using the Elanco LA classification system (Elanco Animal Health, 2022). On d 200 after 3 days of chilling for pens 15–32 and 4 days of chilling for pens 1–14 and 33–36, all carcasses from both harvest dates had backfat, ribeye area, and kidney, pelvic, and heart (KPH) fat percentage measured by University personnel, and marbling scores were noted as called by the United States Department of Agriculture grader. Calculated yield grade is reported.

Ruminal pH. On d 60, one sampler steer from each pen was dosed with a pH bolus (eCow, Kirkcaldy, UK). This bolus recorded the pH of the rumen every 15 min. Data were downloaded from the boluses using a receiver at every BW date and then uploaded to a portal where data for each individual bolus could be downloaded in a spreadsheet format. Data were compiled into periods of transition/beginning of finishing, pre-sort, and post-sort. Due to early bolus battery failure, several pH boluses were not able to be downloaded

after the d 139/140 BW. On d 111, all pens designated SORT were assigned a pH sampler steer to assure that each pen housed a steer with a pH bolus. Boluses were retrieved at harvest.

Behavior. Sixteen pens of steers were utilized to examine feeding behavior differences among treatments. These pens were located toward the far end of the middle barn section, away from the feed room so there was minimal foot traffic. This block of pens was chosen for its minimal foot traffic and proximity to outlets for mounted cameras. Feeding behavior was analyzed using video captured from mounted cameras placed at the front of pens. Cameras (LaView Security, Industry, CA) were mounted on the wall in front of the bunk and adjusted so that animals could be seen from the back gate of the pen to the bunk at the front of the pen. There were three periods of video recording: beginning of growing (d 1 to 4), end of growing (d 56 to 59), and post-sort (d 112 to 115). The beginning of growing period was used to determine a baseline for bunk attendance of these newly received steers. The end of growing period was used to determine bunk attendance after being on the treatment diets for approximately two months. The post-sort period was used to determine how regrouping steers at sorting or if inclusion of Sweet Bran or MODs affected bunk attendance. For these periods, trained observers conducted a scan sample every 15 min for 72 consecutive hours for bunk attendance in a randomized pen order for each period. Videos were played back using a VLC media player and paused at each 15 min interval to count the cattle at the bunk. Bunk attendance was defined so that the steer had his head, including his ears, over or in the bunk. Mitlohner et al. (2001) found scan samples of feeding behavior every 15 min was as accurate as continuous sampling in feedlot heifers. To assess the rate of feed disappearance, the feed in the sixteen behavior pens' bunks was weighed every 2 h for 12 consecutive hours during eight days in four behavior periods (d 5 and 6 [beginning of growing], 53 and 54 [end of growing], 104 and 105 [pre-sort], and 117 and 118 [post-sort]). This is similar to the procedure described in Parsons et al. (2007). All steers in the behavior pens were equipped with CowManager tags (Select Sires, Inc., Plain City, OH) on d 0. Tags recorded rumination, eating, active, and non-active minutes for each steer each day. When sentinel steers were dosed with a ruminal pH bolus on d 56, sentinel steers were also equipped with CowManger tags.

Liver enzyme analysis. Blood was collected via jugular venipuncture on d 111, 125, and 139/140 and sent to the Iowa State University Veterinary Diagnostic Laboratory (ISUVDL; Ames, IA) for the large animal liver profile (Ortho Vitros 4600, Raritan, NJ), which included analysis of blood urea nitrogen (BUN), total protein, albumin, aspartate aminotransferase, creatine kinase, alkaline phosphatase, and gamma-glutamyl transferase. There were 11 blood samplers per treatment, 9 of which had a ruminal pH bolus. Vacutainer serum tubes were allowed to clot at room temperature and then centrifuged at $1,000 \times g$ for 20 min at 4 °C. Serum was stored at –80 °C before being sent to ISUVDL for analysis.

DMI. Ingredient and diet samples were collected weekly to be analyzed for dry matter (DM) throughout the trial. For 48 h, samples were placed in a 70 °C forced-air oven to dry until all the moisture had evaporated. Dried total mixed ration (TMR) samples were ground and composited by feeding period (growing and finishing); TMR composites were analyzed for nutrient composition at Dairyland Laboratories (Arcadia, WI; methods 990.03 and 920.39, AOAC, 1996). DMI was calculated on a pen basis using the weekly dietary DM value. Feed efficiency (gain to feed, G:F) was calculated using the pen ADG and the average DMI for a period.

Statistical analysis. Proc Mixed of SAS 9.4 was used for all analyses, except health where Proc GLIMMIX was used. All models pre-sort included the fixed effect of diet, while all models post-sort included the fixed effects of diet, sort, and the interaction, and the random effects of pen and the interaction of pen and diet. Individual BW, ADG, and harvest data were analyzed with repeated measures using compound symmetry with the subject of pen nested within diet. For pre-sort BW and ADG, d 0 BW was applied as a covariate; post-sort BW, ADG, DMI, G:F, and NEg utilized d 111 BW as a covariate, and harvest data utilized d 111 BW and harvest day as covariates. Pen DMI was analyzed using repeated measures with month as the repeated value for the pre-sort and post-sort periods. Feed disappearance was analyzed within each period as repeated measures in two-hour intervals. Percent of hour spent ruminating, eating, active, and non-active was calculated from CowManager data and compiled by hour; repeated measures was used for analysis with the repeated effect of hour. The pH bolus data were averaged by hour and area under the curve (AUC) was calculated using R. The AUC values were then analyzed by day using repeated measures during the transition period, the 2 weeks prior to sort, and the 2 weeks after sort. Bunk attendance AUC values were calculated using *R* for each period and then analyzed as repeated measures with day as the repeated value. Liver enzyme parameters were analyzed as repeated measures over day with the fixed effect of diet, sort, and the interaction. For all repeated measures analysis, the interaction of diet, sort, and time was tested. Level of significance was defined at $P \leq 0.05$; tendencies were determined at $0.05 < P \leq 0.10$.

RESULTS

Growth Performance and DMI

Growth performance for the pre-sort period is reported in Table 2; pre-sort period DMI is displayed in Figure 1. During this period, SWBR had increased BW compared to MOD on d 60 ($P < 0.05$). BW did not differ between treatments on d 28, 88, or 111 ($P \geq 0.29$). ADG was greater in SWBR from d 0 to 60 ($P \leq 0.05$) and tended to be lesser in SWBR from d 60 to 88 ($P = 0.09$). There were no treatment differences in other ADG timeframes during the pre-sort period ($P \geq 0.22$). G:F did not differ between treatments ($P \geq 0.31$). Steers fed SWBR had increased DMI versus MOD during the first month of growing (d 0–28; $P \leq 0.05$). There was no difference in the percent of steers treated for illness during the pre-sort period ($P = 0.85$).

The post-sort period growth performance and DMI are reported in Table 3. There was no effect of the interaction of diet and sort on post-sort BW (Diet × Sort: $P \geq 0.60$). There was no dietary effect on d 111 BW post-sort (Diet: $P = 0.52$), though there was a tendency for MOD steers to have greater BW on d 196 (Diet: $P = 0.06$). Similarly, there was no effect of SORT on d 111 BW (Sort: $P = 0.28$), but SORT steers tended to have greater BW on d 196 than NOSORT steers (Sort: $P = 0.10$). There was no interaction effect of diet and sort on post-sort ADG (Diet × Sort: $P = 0.61$), though

Table 2. Pen average body weights, average daily gains, and feed efficiency from pre-sort period (d 0 to 111) of feedlot steers fed either SWBR or MOD

	Diet			P-value	
	SWBR[1]	MOD[2]	SEM[3]	Diet	d 0 BW[4]
	n = 18 pens	n = 18 pens			
BW[5], kg					
d 0[6]	253	252	1.1	0.58	—
d 28	298	296	1.0	0.29	0.01
d 60	359[a]	355[b]	1.4	0.05	0.01
d 88	417	416	1.8	0.96	0.01
d 111	461	461	2.4	0.93	0.01
ADG[7], kg/d					
d 0–28	1.61	1.56	0.04	0.29	0.01
d 28–60	1.92	1.84	0.05	0.22	0.02
d 0–60	1.78[a]	1.71[b]	0.02	0.05	0.51
d 60–88	2.05[y]	2.19[x]	0.05	0.09	0.05
d 0–88	1.86	1.86	0.02	0.96	0.49
d 88–111	1.91	1.93	0.08	0.85	0.10
d 0–111	1.88	1.88	0.02	0.93	0.45
G:F[8]					
d 0–60	0.208	0.205	0.002	0.31	-
d 60–111	0.204	0.208	0.004	0.53	-
Health					
Treated, %	16.7	15.7	3.6	0.85	-

[1]Sweet Bran included in the diet; branded wet corn gluten feed (Cargill Corn Milling, Blair, NE).
[2]Modified distillers grains with solubles included in the diet.
[3]Standard error of the mean.
[4]BW and ADG were covariate adjusted using d 0 BW.
[5]Body weight—a 4% pencil shrink was applied to all weights.
[6]Growing period—d 0 to 60; Transition period—d 60 to 78; Finishing period (pre-sort)—d 78 to 111
[7]Average daily gain.
[8]Gain to feed.
[a,b]Means with different superscripts in the same row differ ($P \leq 0.05$).
[x,y]Means with different superscripts in the same row tend to differ ($0.05 < P \leq 0.10$).

MOD tended to have greater ADG than SWBR (Diet: $P = 0.06$), and SORT steers tended to have greater ADG than NOSORT steers (Sort: $P = 0.10$). There was no effect of diet or the interaction of diet and sort on feed efficiency (Diet: $P = 0.15$; Diet × Sort: $P = 0.55$), but SORT steers had greater feed efficiency than NOSORT steer (Sort: $P = 0.03$). There was a tendency for MOD steers to have greater DMI than SWBR steers (Sort: $P = 0.07$), though there were no effects of sort or the interaction of diet and sort on DMI during the entirety of the post-sort period (Diet × Sort: $P \geq 0.17$). There were too few incidences of sick steers after d 111 for statistical analysis.

Behavior

Feed disappearance is displayed in Figure 2. There was an interaction of diet by hour on feed disappearance during all four periods (Diet × Timepoint: $P < 0.01$). During Period 1 (d 5/6), SWBR steers had more rapid feed disappearance between 6 and 8 h post-feeding while SWBR had slower feed disappearance rate from 10 to 12 h post-feeding. Steers
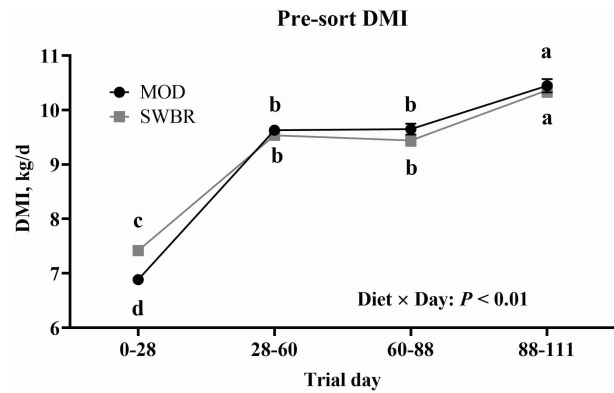
Figure 1. Dry matter intake (DMI) of feedlot steers fed either modified distillers grains (MOD) or Sweet Bran (SWBR) during the pre-sort period including growing (d 0–60), transition (d 60–88), and the first month of the finishing period (d 88–111). *Means with a different superscript are different ($P \leq 0.05$).

fed SWBR had greater feed disappearance during 0 to 2 h post-feeding during Period 2 (d 53/54); however, SWBR had lesser rate of feed disappearance during 8 to 10 h post-feeding. Likewise, during Period 3 (d 104/105), SWBR steers consumed more feed between 6 and 8 h post-feeding than MOD steers. Similar to Period 1, SWBR had lesser feed disappearance during hours 10 to 12 post-feeding when compared to MOD. Period 4 (d 117/118) feed disappearance was not affected by the interaction of diet and sort (Diet × Sort: $P = 0.19$). However, SWBR continued to have greater feed disappearance during the 6 to 8 h post-feeding, and SWBR had lesser rate of feed disappearance during 10 to 12 h post-feeding. Overall, rate of feed disappearance was affected by Sort where NOSORT ate more slowly than SORT (Sort: $P = 0.01$).

Bunk attendance is displayed in Figures 3 and 4. In the beginning of the growing period (d 1 to 3), bunk attendance increased after d 1 regardless of dietary treatment (Time: $P < 0.01$), though MOD had greater bunk attendance than SWBR on d 3 (Diet: $P < 0.01$). However, when looking at the first 3 h post-feeding on d 1 to 3, MOD had lesser bunk attendance than SWBW on d 2 (Diet: $P < 0.01$). At the end of growing (d 56 to 58), there was no difference in bunk attendance between treatments or days ($P \geq 0.69$). Though when assessing the first 3 h post-feeding, MOD tended to have greater bunk attendance than SWBR (Diet: $P = 0.09$) during d 56 to 58. During the period directly following the sorting event (d 112 to 114), MOD tended to have greater bunk attendance than SWBR (Diet: $P = 0.08$), though there was no effect of sort, day, or the interaction of diet, sort, and day ($P \geq 0.19$). Likewise, there was a tendency for MOD to have greater bunk attendance in the first 3 h post-feeding during d 112 to 114 (Diet: $P = 0.09$), but all other effects were non-significant ($P \geq 0.11$). CowManager data are displayed in Supplemental Figures S1 and S2; nominal differences in CowManager recorded behaviors were observed in Period 1 (d 5/6) or Period 2 (d 53/54). In Period 2, both dietary treatments displayed bimodal activity where activity was increased in the early morning and late afternoon, though MOD was more active earlier in the morning (Diet × Time: $P = 0.01$).

Table 3. Pen average body weights, average daily gains, and feed efficiency from post-sort period (d 111 to 196) of feedlot steers fed either SWBR or MOD and either not sorted (NOSORT) or sorted (SORT) on d 111

	Diet			Sort			P-value[6]		
	SWBR[1]	MOD[2]	SEM[3]	NOSORT[4]	SORT[5]	SEM[3]	Diet	Sort	d 111 BW[7]
	n = 18 pens	n = 18 pens		n = 18 pens	n = 18 pens				
BW[8], kg									
d 111	480	482	2.4	483	479	2.4	0.52	0.28	—
d 196	609	617	2.6	610	616	2.6	0.06	0.10	0.01
ADG[9], kg/d									
d 111–196	1.75	1.84	0.03	1.76	1.83	0.03	0.06	0.10	0.01
DMI[10], kg/d									
d 111-196	10.3	10.6	0.12	10.4	10.5	0.13	0.07	0.51	0.01
G:F[11]									
d 111–196	0.160	0.164	0.002	0.157	0.166	0.003	0.15	0.03	0.44
NEg[12], Mcal/kg									
d 111–196	1.59	1.63	0.020	1.59	1.64	0.020	0.14	0.11	0.56

[1]Sweet Bran included in the diet; branded wet corn gluten feed (Cargill Corn Milling, Blair, NE) .
[2]Modified distillers grains with solubles included in the diet.
[3]Standard error of the mean.
[4]Steers not sorted at terminal implant (d 111) and returned to original home pen.
[5]Steers sorted at terminal implant (d 111) into a new pen with all new penmates.
[6]The interaction of Diet and Sort was not significant for BW ($P \geq 0.60$), ADG ($P = 0.61$), DMI ($P = 0.71$), G:F ($P = 0.55$), or NEg ($P = 0.34$).
[7]Covariate adjusted using d 111 BW.
[8]Body weight—a 4% pencil shrink was applied to all weights.
[9]Average daily gain.
[10]Dry matter intake.
[11]Gain to feed.
[12]NEg calculated based on the overall ADG, the average BW, and average pen DMI for the finishing period as described in Plascencia et al. (1999) and Russell et al. (2016).

Liver Enzymes and pH

Blood metabolite parameters are reported in Table 5. There was no diet effect on BUN concentrations (Diet: $P = 0.43$), though BUN was greater in NOSORT than SORT (Sort: $P = 0.01$). Aspartate aminotransferase tended to be greater in SWBR than MOD (Diet: $P = 0.09$) but was not affected by sort, day, or the interaction of diet, sort, and day ($P \geq 0.21$). There was no effect of diet, sort, or day on any other blood metabolites ($P \geq 0.14$). The interaction of diet and sort was not significant for any parameter ($P \geq 0.15$) nor was the interaction of diet, sort, and day ($P \geq 0.13$).

The pH AUC data are displayed in Figure 5, where greater AUC indicates greater pH. During transition (d 60 to 76), there was a day effect where pH declined over the transition period (Time: $P < 0.01$). There was also a tendency for an interaction of diet and day where SWBR had greater pH on d 3 and 4 of transition (Diet × Time: $P < 0.06$). During the pre-sort period (d 98 to 111), pH gradually decreased over the 2 weeks prior to sort (Time: $P < 0.01$); there was no interaction of diet and day (Diet × Day: $P = 0.94$). The post-sort (d 112 to 125) period was affected by day (Time: $P < 0.01$) where pH was lower for all groups two day after sort.

Carcass Characteristics

Carcass data are reported in Table 4. There were no effects of diet, sort, or the interaction in dressing percent, backfat, KPH fat, marbling, or frequency of LA ($P \geq 0.13$). Hot carcass weight was lesser in SWBR steers than MOD (Diet: $P = 0.02$), though there was no SORT effect (Sort: $P = 0.15$) or interaction of diet and sort (Diet × Sort: $P = 0.87$). Ribeye area was largest in SWBR-SORT, while the other three treatments had similar ribeye areas (Diet × Sort: $P = 0.03$). Yield grade was lesser in SWBR steers than MOD steers (Diet: $P = 0.02$) but was not affected by sort or the interaction of diet and sort ($P \geq 0.16$).

DISCUSSION

This study spanned the growing (d 0 to 59), transition (d 60 to 76), and finishing (d 77 to 196) phases. Steers were newly weaned at arrival and had not been previously exposed to a TMR. Steers receiving SWBR grew better during the growing phase compared with MOD steers, as noted in increased BW and ADG. Others have also noted the inclusion of Sweet Bran improves performance of newly received steers (Schneider et al., 2013b). Because the MOD diet fed in the present study during the growing phase contained more starch than the SWBR diet, this might have led to more rapid adjustment to feed by SWBR cattle as suggested by others (Sarturi et al., 2011; Schneider et al., 2013a, 2014, 2017). Steers fed the SWBR diet had greater time spent ruminating at the beginning and end of growing. This may be due to the increased neutral detergent fiber (NDF) in the SWBR diet as Beauchemin and Yang (2005) found that increasing dietary physically effective fiber tended to increase number of minutes spent ruminating each day. Likewise, the increased DMI seen in the SWBR steers in the first month of the trial may have increased rumination minutes (Galvani et al., 2010). Time spent eating each day was decreased when physically effective NDF was decreased in the diet of dairy cows (Kröger et al., 2019), further indicating dietary NDF can affect feeding behavior.
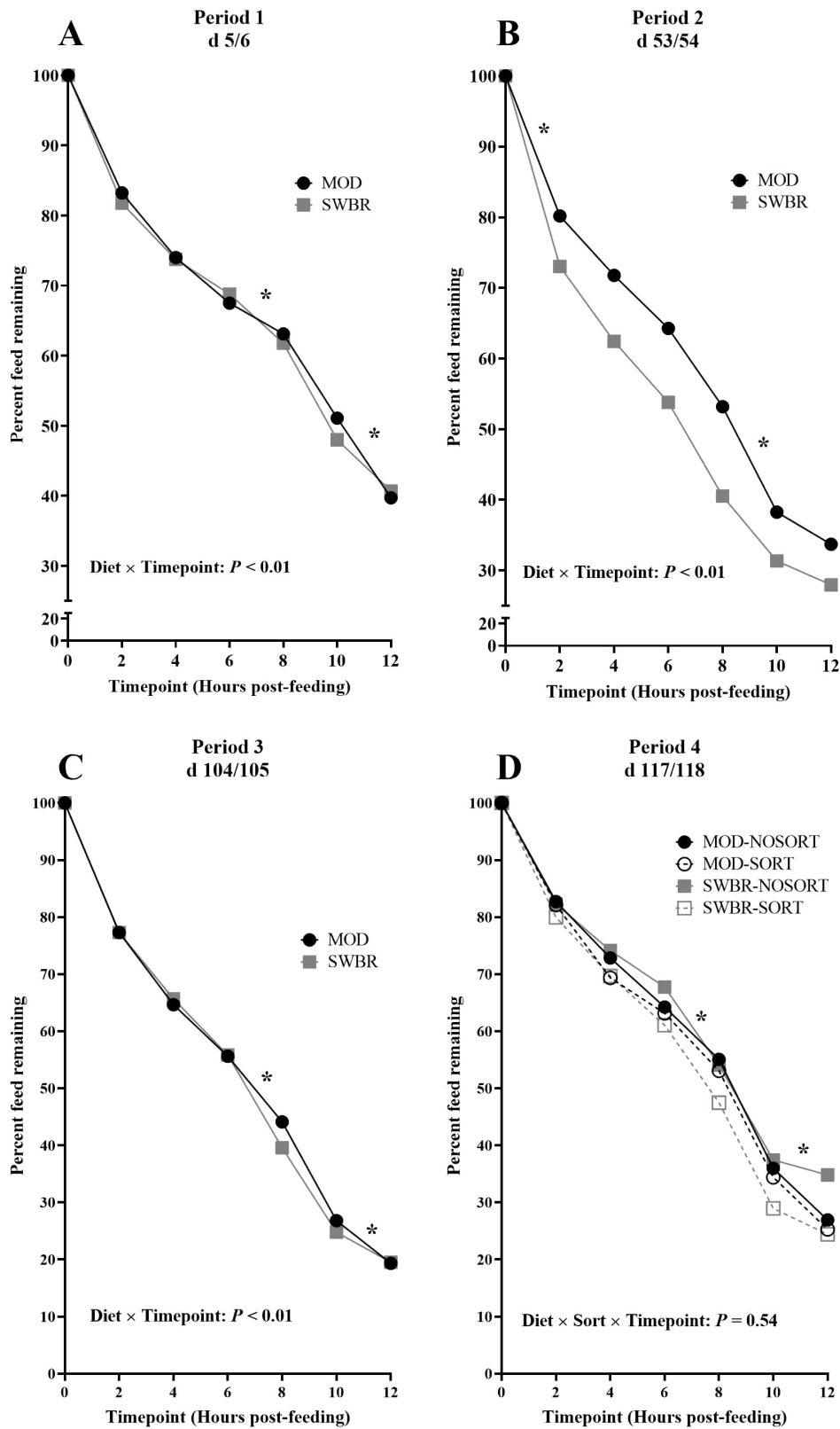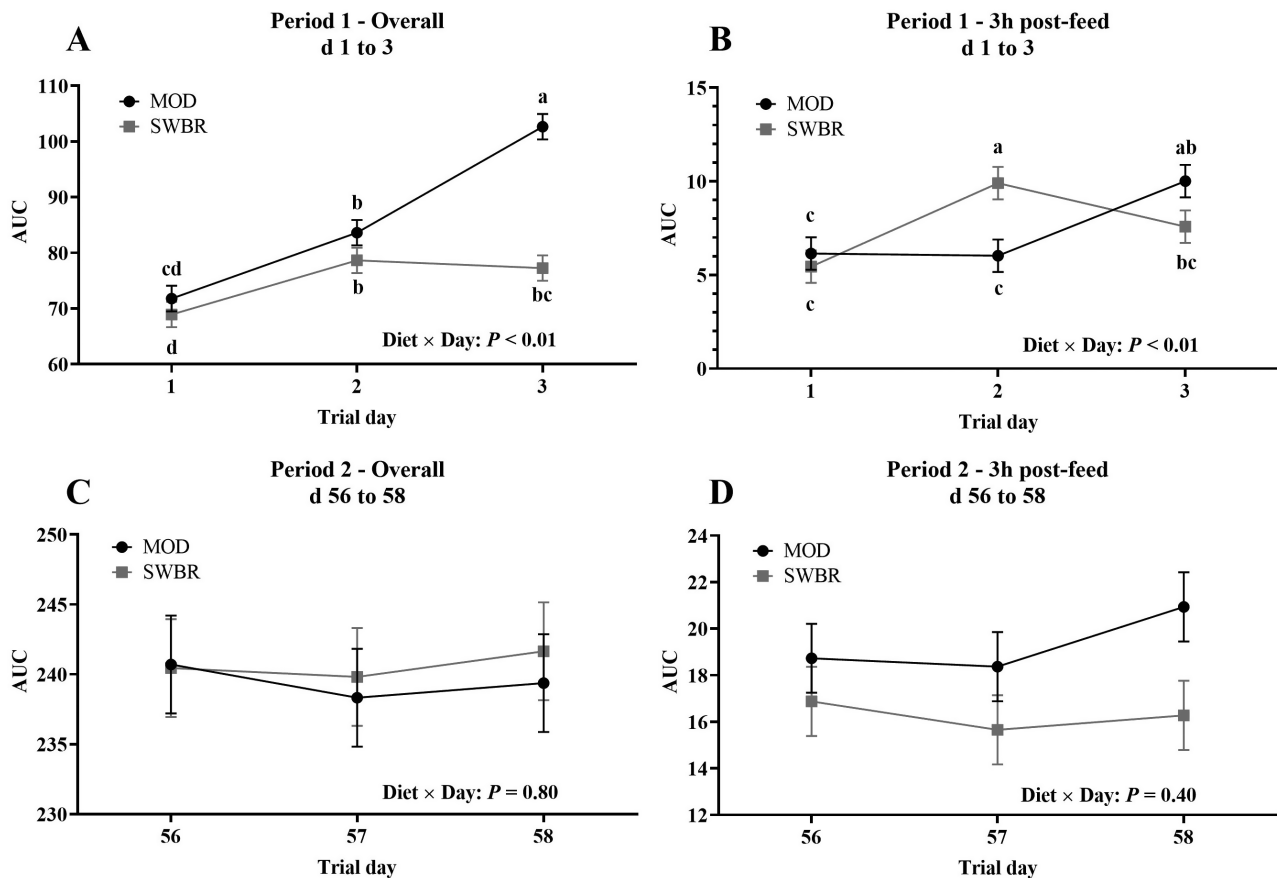
Figure 2. Rate of feed disappearance across the experiment for steers fed either Sweet Bran (SWBR) or modified distiller's grain (MOD) and either sorted (SORT) or not sorted (NOSORT) into new pens at terminal implant administration (d 111). (A) The early growing period (d 5/6); (B) The late growing period (d 53/54); (C) Pre-sort period (d 104/105); (D) Post-sort period (d 117/118). Overall rate of feed disappearance on d 117/118 was lesser for NOSORT than SORT ($P = 0.01$; 5.47 and 6.13 percent disappearance per hour, respectively). *An asterisk between two timepoints indicates that the rates of feed disappearance differ between dietary treatments at that interval ($P \leq 0.05$).

During the first 28 days on trial, SWBR had greater DMI than MOD. Similarly, Schneider et al. (2013b) observed steers fed RAMP, which contains a high amount of SWBR, had greater DMI in the receiving period when compared to steers fed a diet containing 30% Sweet Bran. There were no differences in DMI throughout the rest of the trial. At the end of growing (d 56 to 58) and directly after the sorting event (d 112 to 114), there was no difference in overall bunk attendance, though there was a tendency for SWBR to have lesser bunk attendance than MOD in the first 3 h post-feed delivery. Since there was no difference in the rate of feed disappearance in the first 4 h post-feed delivery at the end of growing and after the sorting event and MOD had greater minutes spent eating during the beginning and end of growing, MOD steers were likely eating smaller but more frequent meals in the hours directly following feed delivery, similar to the observations of Salim et al. (2014).

Diets were formulated so DM and rumen-degradable protein were similar between treatments. At the end of the growing phase, SWBR-fed steers had greater rate of feed disappearance earlier in the day compared to MOD-fed steers that appeared to consume more feed in the late afternoon and early evening hours. This is different from previous research which showed cattle-fed diets containing Sweet Bran had fewer steers at the bunk during the first hour after feeding, though the rate of feed disappearance was similar to steers fed a diet without wet corn gluten feed (Parsons et al., 2007). The MOD steers were always fed approximately one hour before SWBR steers each day of this trial. As such, SWBR steers may have been highly motivated to access feed after seeing neighboring pens receive feed (DeVries and von Keyserlingk, 2005). Future research should consider alternating which treatment receives feed first during behavior observation periods. The rates of feed disappearance concur with the minutes spent active as SWBR steers were more active during the morning peak feeding time while MOD steers were more active in the late peak feeding time at the end of growing. Typically, pasture-based cattle will choose to have their peak feeding times at sunrise and sunset (Kilgour et al., 2012). The steers in this study displayed that same diurnal effect as seen in the eating and active minutes for early and end of growing. When examing feeding behavior in future research, the diurnal effect of peak feeding times should be considered to more efficiently observe steer feeding behavior.

Sarturi et al. (2011) saw steers being transitioned to a finishing diet during a metabolism trial had greater meal size when transitioned with Sweet Bran than when transitioned with wet distiller's grains, potentially indicating a greater palatability for Sweet Bran as these steers also had greater DMI during transition when compared to the wet distiller's grains diets. When looking at the rate of feed disappearance over all 12 hours for each period in the present study, there were no treatment differences in Period 1, 2, or 3.

Figure 3. Dietary effects for steers fed either Sweet Bran (SWBR) or modified distiller's grain (MOD) on steer bunk attendance in the early (d 1 to 3) and late (d 56 to 58) growing period. (A) Overall bunk attendance for the early growing period; (B) Bunk attendance for the first 3 h post-feed delivery in the early growing period; (C) Overall bunk attendance during the late growing period; (D) Bunk attendance during the late growing period for the 3 h post-feed delivery.
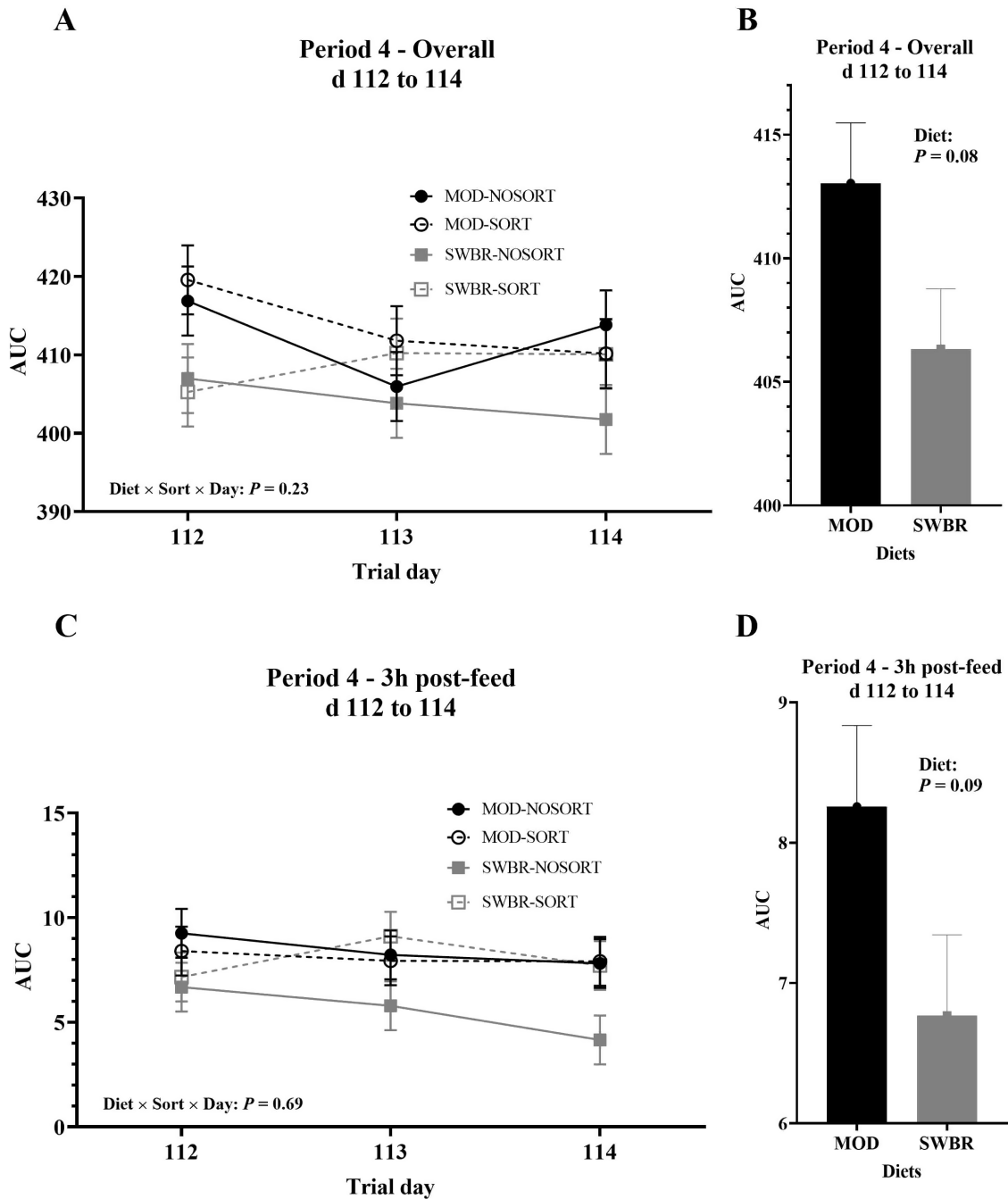
Figure 4. Dietary and sorting effects for steers fed either Sweet Bran (SWBR) or modified distiller's grain (MOD) and either sorted (SORT) or not sorted (NOSORT) into new pens at terminal implant (d 111) on bunk attendance. (A) The overall 24-h period bunk attendance; (B) The effect of diet on overall bunk attendance after the sorting event; (C) The 3 h post-feed delivery period bunk attendance; (D) Dietary effect on steer bunk attendance the first 3-h post-feed delivery.

However, there was an effect of SORT on rate of feed disappearance after the sorting event (Period 4) where steers that were sorted ate quicker than steers that were not sorted. This may indicate sorting steers at terminal implant increases competition at the feed bunk as cattle housed in competitive environments will eat faster than cattle housed in noncompetitive environments (Collings et al., 2011). Further research is needed to determine how sorting steers affects competition at the feed bunk.

Regardless of dietary treatment, bunk attendance increased after d 1 of treatment diets being fed. The steers in this trial

had not been previously exposed to a TMR (novel food) and had arrived on-farm only 2 days before the start of trial (novel environment). Novelty can affect steer behavior and may include novel foods or novel environments. Heifer feeding behavior was affected when various concentrations of eucalyptus oil (a novel food) were added to their feed (Herskin et al., 2003). However, novelty can be overcome with consistent exposure (Hemsworth et al., 1996).

One steer per pen was chosen to receive a ruminal pH bolus at the beginning of transition (d 60). Ruminal pH declined gradually throughout transition period, as anticipated (Bevans

Table 5. The effect of diet and terminal sorting on blood metabolites

	Diet			Sort			P-value[5,6]		
	SWBR[1]	MOD[2]	SEM	NOSORT[3]	SORT[4]	SEM	Diet	Sort	Day
	n = 18 pens	n = 18 pens		n = 18 pens	n = 18 pens				
Blood metabolite									
Blood urea nitrogen, mg/dL	8.7	10.0	1.11	9.7	9.0	0.77	0.43	0.01	0.01
Albumin, gm/dL	3.1	3.1	0.03	3.1	3.1	0.03	0.89	0.59	0.91
Aspartate aminotransferase[7], IU/L	109.3	101.7	13.7	108.3	102.7	13.1	0.09	0.21	0.79
Creatine kinase[7], IU/L	154.5	175.0	24.0	159.1	169.8	23.9	0.22	0.52	0.28
Alkaline Phosphatase, IU/L	146.5	192.1	22.4	171.8	166.8	15.5	0.14	0.44	0.49
Gamma-glutamyl transferase[7], IU/L	49.6	48.9	8.2	49.8	48.7	8.0	0.81	0.69	0.88

[1]Sweet Bran included in the diet; branded wet corn gluten feed (Cargill Corn Milling, Blair, NE).
[2]Modified distillers grains with solubles included in the diet.
[3]Steers not sorted at terminal implant (d 111) and returned to original home pen.
[4]Steers sorted at terminal implant (d 111) into a new pen with all new penmates.
[5]The effect of Diet × Sort × Day was not significant on any parameter ($P \geq 0.13$).
[6]The effect of Diet × Sort was not significant on any parameter ($P \geq 0.15$).
[7]Back-transformed values reported.
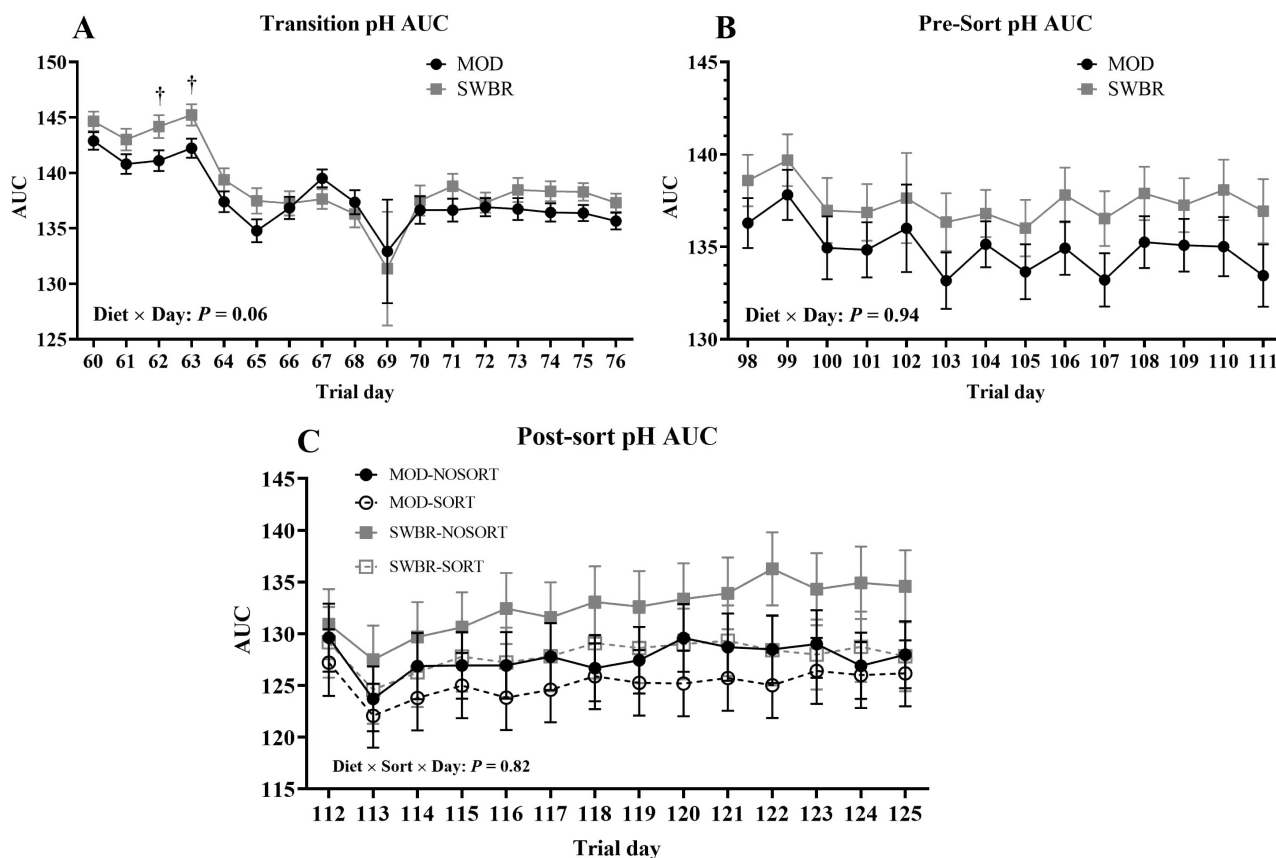
Figure 5. Ruminal pH area under the curve (AUC) for steers fed either Sweet Bran (SWBR) or modified distiller's grain (MOD) and either sorted (SORT) or not sorted (NOSORT) into new pens at terminal implant (d 111); a greater AUC indicates a greater pH. (A) The effect of diet on transition period (d 60 to 76; transition diet 1 fed d 60 to 68, transition diet 2 fed d 69 to 76) ruminal pH AUC; (B) Ruminal pH AUC during the two weeks (d 98 to 111) directly before the sorting event; (C) The effects of diet and sort on ruminal pH AUC in feedlot steers for the 2 weeks directly post-sort event (d 112 to 125). [†]Dagger indicates a tendency for dietary differences on that day ($P = 0.06$).

et al., 2005). On d 3 and 4 of transition, SWBR tended to have greater pH than MOD, likely due to MOD having 10% more dry-rolled corn in the diet compared to the SWBR diet. Brown et al. (2006) suggest feedlot cattle have decreased performance when they are fed ad libitum and stepped-up to finishing diets in 14 days or less. The steers in the present study were fed ad libitum during transition and went from approximately 14% to 43% and 25% to 43% starch in the SWBR and MOD diets, respectively, over 18 total days. Therefore, SWBR had a 29% increase in starch compared to an 18% increase in MOD from growing to finishing diets. This increase in starch did not appear to negatively affect cattle

Table 4. Effects of dietary inclusion of Sweet Bran and social stress on carcass characteristics

	MOD[1]		SWBR[2]		SEM[3]	P-value[4]				
	NOSORT[5]	SORT[6]	NOSORT	SORT		Diet	Sort	Diet × Sort	d 111 BW	Harvest day
	n = 9 pens	n = 9 pens	n = 9 pens	n = 9 pens						
HCW[7], kg	368.7	372.5	364.2	367.0	2.18	0.02	0.15	0.87	0.01	0.06
Dressing, %	60.0	60.2	60.2	59.8	0.18	0.52	0.73	0.28	0.04	0.01
Ribeye area, cm²	79.7[b]	79.5[b]	79.3[b]	82.4[a]	0.74	0.09	0.05	0.03	0.01	0.01
Backfat, cm	1.72	1.68	1.64	1.54	0.067	0.13	0.29	0.59	0.01	0.89
KPH[8], %	1.64	1.59	1.62	1.58	0.039	0.64	0.20	0.95	0.01	0.41
Marbling[9]	502	501	499	515	9.38	0.54	0.41	0.34	0.12	0.01
Yield grade	3.66	3.65	3.57	3.32	0.089	0.02	0.16	0.18	0.01	0.34
LAS, % per pen	35.1	28.5	22.0	17.9	7.38	0.41	0.16	0.84	0.11	0.09

[1]Modified distillers grains with solubles included in the diet.
[2]Sweet Bran included in the diet; branded wet corn gluten feed (Cargill Corn Milling, Blair, NE).
[3]Standard error of the mean.
[4]Day of harvest and d 111 BW were included in the model.
[5]Steers not sorted at terminal implant (d 111) and returned to original home pen.
[6]Steers sorted at terminal implant (d 111) into a new pen with all new penmates.
[7]Hot carcass weight.
[8]Kidney, pelvic, and heart fat.
[9]Marbling scores: small = 400, modest = 500.
[a,b]Means with different superscripts in the same row and factor differ ($P \leq 0.05$).

performance in either treatment, as gains during transition increased over growing as dietary energy increased. However, MOD steers had a greater increase in ADG from growing to finishing, driving the loss of the SWBR weight advantage and the tendency for MOD to have greater ADG during this period. In all treatments, DMI remained similar from postsort to harvest leading to a tendency for MOD to have greater feed efficiency.

Beyond initial treatment differences during the first week of transition, treatments had similar pH for the rest of transition and finishing. Previous research has shown steers fed diets containing wet corn gluten feed had greater pH than steers without wet corn gluten feed in the diet (Krehbiel et al., 1995). Likewise, Salim et al. (2014) found as distiller's grains, either dry or modified, were increased in the diet, ruminal pH at harvest linearly increased, potentially due to the increased NDF in the diet at the greater inclusion rates. Since both finishing diets in the present study had similar NDF composition (SWBR: 19.0; MOD: 16.1), this may have prevented differences in ruminal pH between dietary treatments.

Contrary to our hypothesis, there were no differences in frequency of LA occurrence among treatments. The leading proposed mechanism of LA formation is lesions in the rumen caused by low ruminal pH, allowing ruminal microbiota to escape, enter circulation, and become sequestered by the liver and form an abscess (Jensen et al., 1954). Ruminal pH can be altered by feeding behavior as increased eating rate can lower ruminal pH through less buffering saliva entering the rumen (Beauchemin et al., 2008). We expected differences in feeding rates between dietary treatments and therefore anticipated differences in ruminal pH. However, there were no differences in feeding behavior or ruminal pH. This is similar to a study where MODs were kept at a constant inclusion of 30% DM, while wet corn gluten feed was included at 0, 15, or 30% of the diet DM; there were no differences in the percent of LA seen among treatments (Benton et al., 2009). Salim et al. (2014) found liver abscess score (LAS) were greater in

steers fed diets without distiller's grain, likely caused by the increased rate of inclusion of dry whole corn, compared to the steers fed distiller's grains, either dried or modified. The current study might not have seen differences in the LA frequency since the NDF of both the SWBR and MOD diets were similar during finishing. Future research should investigate the effect of including Sweet Bran in the diet on behavior and LA rate when compared to a diet with lesser NDF/more starch. There were no differences in LA occurrence or ruminal pH between NOSORT and SORT. von Keyserlingk et al. (2008) showed that dairy cows had increased aggressive interactions at the feed bunk on the day of regrouping but had returned to previous aggressive frequencies by d 3 of regrouping. Similarly, 14-month-old Holstein-Friesian steers that were regrouped multiple times had fewer behavioral changes after multiple regroupings indicating cattle can adapt to this kind of social stress (Gupta et al., 2008). Because the stress of regrouping may not be long-lasting, future research should consider examining the effects of more acute stresses (transit, weaning) on feeding behavior and performance of steers fed Sweet Bran.

Beyond initial sorting into pens upon arrival to the feedlot, some cattle feeders further sort cattle into new pens based on anticipated days to harvest at terminal implant time. On d 111, steers from half of the pens were sorted at terminal implant, and the pen social hierarchies deliberately broken. Selection of new pen mates was conducted based on BW recorded on d 88, and BW were similar across treatments after sorting on d 111. Since hierarchies need to be reestablished after regrouping, competition will increase. In competitive feeding environments, cattle will increase their feeding rate to compensate for the likelihood of displacement from the bunk (Collings et al., 2011), and subordinate dairy cows prefer to eat a low-quality feed rather than stand next to a dominant cow and have access to a high-quality feed, potentially leading to poor nutrition and performance for the subordinate cow (Rioja-Lang et al., 2009). In the present study, SORT steers

had increased rate of feed disappearance, due to sorting which causes disruption of the group hierarchy and increases competition. It was thought SORT steers would have decreased performance in the weeks following the sorting event as they adjusted to their new pen dynamics. However, there was a tendency for SORT steers to have greater ADG than NOSORT steers in the post-sorting period (d 111 to 196). Previous research in heifers has suggested familiar groups of cattle may have a calming effect on others (Takeda et al., 2003). As such, it may be that the NOSORT steers had a similar calming effect on the steer that were sorted. Steers in SWBR-SORT had greater ribeye area than steers in all other treatments. This is different from Benton et al. (2009) who noted steers fed wet corn gluten feed at 0%, 15%, or 30% of the diet, with MOD inclusion consistently at 30% of the diet, did not have any differences in ribeye area. There were minimal differences in other carcass characteristics. The blood metabolites measured in the current study (such as albumin and aspartate aminotransferase) have been linked to LA occurrence and severity (Herrick et al., 2020). There were minimal differences in blood metabolites which supports the similarity of LA occurrence across treatments.

In summary, SWBR-fed steers had greater DMI in the first 28 days of growing and greater BW and ADG during the overall growing period (d 0 to 59). However, the performance advantage did not persist beyond transition. The peak rate of feed disappearance was in the few hours post-feeding for SWBR-fed steers and around dusk for the MOD-fed steers. Minimal differences were noted in the finishing period and overall feeding behavior, though Sweet Bran can be beneficial in growing period diets.

Supplementary Data

Supplementary data are available at *Translational Animal Science* online.

Acknowledgments

Conflict of interest statement

The authors declare no conflicts of interest.

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