



Use of Dried Distillers Grains in Preconditioning Programs for Weaned Beef Calves and Subsequent Impact on Wheat Pasture, Feedlot, and Carcass Performance¹

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ABSTRACT

To evaluate the effects of feeding increasing levels of dried distillers grains with solubles (DDGS) during preconditioning, weaned steer ($n = 64$) and heifer ($n = 64$) calves were stratified by BW and allotted to receiving pens for a randomized complete block design. Dietary treatments included DDGS at 0.30, 0.75, 1.20, or 1.65% of mean pen BW. Throughout 56 d, prairie hay (4.8% CP, 68.8% NDF) was fed *ad libitum*, and refusals were measured weekly. After 56 d, steer calves grazed wheat pasture before entering the feedlot; heifers were placed in the feedlot. Calves readily consumed DDGS at all levels fed. As DDGS level increased, ADG increased quadratically

($P < 0.01$), hay intake decreased linearly ($P < 0.01$) and G:F improved quadratically ($P < 0.01$). Wheat pasture ADG was greatest for steers fed the lowest DDGS level ($P < 0.01$) and decreased linearly across treatments ($P < 0.01$). For steers, hot carcass weight and marbling score increased numerically (linear, $P = 0.13$; linear, $P = 0.12$, respectively) with increasing DDGS during preconditioning. Other measured carcass characteristics were not influenced by DDGS level for steers or heifers ($P > 0.20$). Optimal G:F was estimated at 1.5 and 1.36% DDGS feeding for steers and heifers, respectively. At 1.65% of BW, visual symptoms of polioencephalomalacia were not observed. We suggest a maximum DDGS feeding rate of 1.25% of BW for growing calves consuming native tall grass prairie hay as long as maximum dietary sulfur concentrations are not exceeded.

Key words: distillers grain, receiving diet, sulfur, wheat pasture, feedlot performance

INTRODUCTION

Raising calves from spring-calving cow herds on wheat pasture before feedlot entry is a common management practice in the Southern Great Plains. In many instances, calves are weaned 1 to 2 mo before wheat pasture turnout, resulting in a 30- to 60-d preconditioning growing period. With the recent expansion of the ethanol industry, the supply of corn dried distillers grains with solubles (DDGS) has increased dramatically. Dried distillers grains with solubles is a high-protein, low-starch, high-energy feedstuff (Klopfenstein et al., 2008). As such, it could serve as a complementary supplement to native tall grass prairie hay, which is a primary ingredient fed during the preconditioning period in the Great Plains region of the country.

Previous work has shown that DDGS supplementation can enhance ADG of grazing cattle. When Morris et al. (2005) supplied varying

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amounts of DDGS (up to 0.95% of BW) to beef calves grazing low- or high-quality forage, ADG increased linearly and forage intake decreased linearly with increasing DDGS feeding level. Similar responses were observed in ADG and forage intake in yearling steers grazing native summer range and supplemented with increasing DDGS levels, up to 1.03% of BW; subsequent feedlot performance or carcass traits were not influenced by DDGS supplementation (Morris et al., 2006). Gustad et al. (2006) reported that ADG increased at a decreasing rate for weaned calves grazing corn residue with increasing DDGS supplementation levels up to 1.27% of BW. These reports suggest that excessive DDGS supplementation will reduce or replace forage consumption and may provide marginal increases in ADG.

Another concern with excessive supplementation is associated with the moderate to high concentration of S in DDGS (0.40% DM; NRC, 1996). Excessive dietary S can cause S-induced polioencephalomalacia (Niles et al., 2002). Moreover, a high level of S intake during the finishing phase can reduce growth and efficiency (Loneragan et al., 2001). Few data are available (Morris et al., 2006) evaluating potential lingering symptoms of polioencephalomalacia during the finishing phase, after cattle have been exposed to relatively high dietary S by feeding DDGS during preconditioning. The objectives of this study were to determine the effects

of feeding increasing levels of DDGS during the postweaning preconditioning phase on calf performance, prairie hay intake, subsequent grazing and feedlot performance, and carcass characteristics.

MATERIALS AND METHODS

Animals

All procedures for this experiment were conducted with an approved Oklahoma State University Animal Care and Use protocol (AG076). Spring-born English × Continental beef steer (n = 64; initial BW = 197 ± 25 kg) and heifer calves (n = 32; initial BW = 185 ± 20 kg; average calving date = March 13, 2006) were weaned at the Oklahoma State Range Cow Research Center, North Range Unit, on September 26, 2006, and transported to the Willard Sparks Beef Research Center, Stillwater, Oklahoma. The heifer portion of the study was repeated the following year (yr 2) because of the limited number of heifers available the first year (yr 1). In yr 2 (n = 32; initial BW = 175 ± 24 kg), fall-born English × Continental beef heifer calves (average calving date = September 25, 2007) were weaned at the Oklahoma State Range Cow Research Center, North Range Unit, on April 1, 2008, and transported to the Willard Sparks Beef Research Center. At weaning each year, calves were weighed and vaccinated with Ultra Choice 7 (Pfizer Animal

Health, New York, NY) and Bovi-Shield Gold 5 (Pfizer Animal Health).

On arrival at the Sparks facility, calves were subject to a 6-d adaptation period. During this period, calves were randomly sorted into two 24 × 30 m pens and were fed 0.68 kg DDGS (approximately 0.30% of BW) daily and provided prairie hay ad libitum (compositions provided in Table 1). After the adaptation period, calves were weighed after a 16-h removal from water and feed, and this BW was used as the trial allocation BW. Calves were revaccinated with Bovi-Shield Gold 5 (Pfizer Animal Health) and dewormed with Ivermectin injectable (Merial, Deluth, GA) on d 14. After the 56-d preconditioning period, cattle were fed a receiving diet (15% CP, 81% TDN; DM basis) at 2.0% of BW for 7 d to equalize rumen fill. After this 7-d period, cattle were weighed after a 16-h removal of water and feed, and this BW was used to calculate final preconditioning BW and performance.

Treatments and Diet Delivery

After the adaptation period, calves were blocked by BW and randomly allotted to receiving pens (4 animals/pen, 4 pens/treatment). Treatments included feeding DDGS at 0.30, 0.75, 1.20, and 1.65% of BW. The upper treatment level was selected to maximize DDGS intake while not exceeding the maximum tolerable dietary S concentration (0.40% of dietary DM) recommended by NRC (1996). The remaining 3 DDGS levels were assigned as equally spaced increments from the upper level of DDGS. Cattle were weighed every 14 d throughout the 56-d period, and the amount of DDGS fed was subsequently adjusted according to mean pen BW. A monensin-containing vitamin and trace mineral supplement (20% Ca, 3.50% P, 20.5% NaCl, 1.0% Mg, 1,000 ppm Cu, 26 ppm Se, 2,400 ppm Zn, 136,000 IU/kg vitamin A, 13,600 IU/kg vitamin D, 45 IU/kg vitamin E; DM basis; Vigortone Ag Products, Hiawatha, IA) was mixed with DDGS and provided monensin at 100 mg/d

Table 1. Average nutrient composition of dried distillers grains with solubles (DDGS) and prairie hay

Item, % (DM basis)	Yr 1		Yr 2	
	DDGS	Prairie hay	DDGS	Prairie hay
CP	33.2	5.9	30.6	5.4
ADF	17.6	43.9	16.2	46.3
NDF	44.8	67.4	35.8	74.8
Crude fat	10.6	1.7	13.2	1.9
TDN	82.7	55.0	81.0	52.0
Ca	0.03	0.63	0.05	0.52
P	0.78	0.07	0.86	0.05
S	0.52	0.08	0.59	0.08

per animal. The vitamin and mineral supplement was fed at a rate to meet the NRC (1996) requirements for growing cattle. Calves had ad libitum access to prairie hay and water throughout the trial. Average nutrient composition of prairie hay and DDGS for yr 1 and 2 are provided in Table 1. Step-up of DDGS feeding consisted of increments of 0.91 kg/d until the appropriate feeding level was achieved. Pens provided 4.6 m of bunk space that was divided in half with concrete bunk dividers. Hay was provided in one-half of the bunk and DDGS was delivered in the remaining portion.

Hay Intake, Dried Distillers Grains with Solubles Intake, and Nutrient Analysis

Distillers grains offered and any refusals were weighed daily to determine DDGS intake. Hay intake was measured directly; unconsumed hay was collected, cleaned out of pens, and weighed once a week to estimate hay intake. Subsamples of dietary treatments, hay, and orts were dried at 50°C for 48 h for determination of DM. Before laboratory analysis, hay was ground in a Wiley mill (Model-4, Thomas Scientific, Sweedesboro, NJ) to pass a 2-mm screen. Hay and DDGS were composited by pen, and composite subsamples were analyzed for ash, crude fat, CP, ADF, and NDF. Neutral detergent fiber and ADF content were determined using an Ankom fiber analyzer (Ankom Technology, 2006a,b; Ankom Technology, Macedon, NY). Crude protein was determined using a Leco NS-2000 N analyzer (Leco Corp., St. Joseph, MI), and crude fat was determined by ether extraction (AOAC, 1996).

Cattle Management After Preconditioning

After preconditioning, steers grazed wheat pasture before feedlot entry, although in yr 1, heifers entered the feed yard shortly after termination of the preconditioning treatments. Because of circumstances beyond our control, feed yard performance

and carcass data were not available for heifers in yr 2. Accordingly, the management protocols beyond preconditioning for steers and heifers are described independently.

Steers. Steers were placed on wheat pasture at the Oklahoma State University Wheat Pasture Research Unit near Marshall, Oklahoma, on December 4, 2006. Before wheat pasture turnout, steers were implanted with Component E-S (VetLife, Des Moines, IA). Steers grazed wheat pasture until April 11, 2007, and then were placed on feed at the Willard Sparks Beef Research Center, Stillwater, Oklahoma, until July 18, 2007.

All wheat pasture BW measurements were obtained after overnight removal of steers from feed and water. On arrival at the Sparks facility, steers were implanted with Revalor-S (Intervet/Schering-Plough, Millsboro, DE) and fed a 94% concentrate (DM basis) finishing ration (86.8% DM, 13.9% CP, 16.3% NDF, 5.9% fat, 0.7% Ca, and 0.43% P; DM basis) until reaching approximately 1.25-cm 12th-rib fat thickness as determined by visual evaluation. At the completion of the feeding period, cattle were weighed and a 4% pencil shrink was applied to determine final BW. Steers were transported 333 km to Tyson Fresh Meats, Emporia, Kansas, for slaughter. Carcass data were collected after a 24-h chill and included 12th-rib fat thickness, 12th-rib LM area, KPH, marbling score, and QG. Data were collected by Kansas State University Meat Science personnel.

Heifers. In yr 1, heifers were placed directly on feed at Wheeler Brothers Feedyard in Watonga, Oklahoma, on December 4, 2006, and were on feed through June 6, 2007. Heifer calves were implanted with Revalor-IH (Intervet/Schering-Plough) on arrival at the feed yard and were reimplanted 75 d later with Revalor-H (Intervet/Schering-Plough). Heifers were fed a 96% concentrate (DM basis) finishing ration (88% DM, 13.2% CP, 10.7% NDF, 6.7% fat, 0.7% Ca, and 0.34% P; DM basis). At the completion of the feeding period, cattle were weighed and a 4% pencil shrink

was applied to determine final BW. Heifers were transported 373 km to Tyson Fresh Meats, Emporia, Kansas, for slaughter. Carcass data were collected after a 24-h chill and included 12th-rib fat thickness, 12th-rib LM area, KPH, marbling score, and QG. Data were collected by Kansas State University Meat Science personnel.

The data reported for heifers in yr 2 are from the preconditioning phase only. Because of uncontrollable circumstances, we were unable to obtain adequate data on finishing performance or carcass characteristics of heifer calves in yr 2.

Statistical Analysis

All data for this study were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC) for a randomized complete block design. For preconditioning phase data, treatment and block were included in the model as fixed effects and pen served as the experimental unit. For analysis of heifer data collected during the preconditioning period, year was included in the model as a random effect. Treatment means were separated using linear and quadratic orthogonal polynomial contrasts across feeding levels of DDGS. To analyze data for growth performance after the preconditioning phase and carcass data, individual animal was the experimental unit, and treatment means were separated using linear and quadratic orthogonal polynomial contrasts with respect to increasing feeding levels of DDGS during the preconditioning phase. For all analyses, differences in treatment means were assessed at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Preconditioning Phase

Preconditioning performance for steers is reported in Table 2 and pooled data for heifer performance in yr 1 and yr 2 are provided in Table 3. As the level of DDGS increased, ADG improved quadratically ($P < 0.01$). Second-derivative calculations of the

Table 2. Effect of level of dried distillers grains with solubles (DDGS) during preconditioning on performance and hay intake of beef steers

Item	DDGS, % of BW				SEM	P-value	
	0.30	0.75	1.20	1.65		Linear	Quadratic
n ¹	4	4	4	4	—	—	—
Initial wt, kg	198	197	198	196	19.9	0.32	0.91
Final wt, kg	229	249	260	267	20.5	<0.01	0.02
Total BW gain, kg	30	52	62	71	1.33	<0.01	<0.01
56-d ADG, kg	0.54	0.93	1.10	1.27	0.02	<0.01	<0.01
Avg daily hay intake, kg	4.24	4.19	3.56	3.37	0.17	<0.01	0.69
Hay intake, % of BW ²	1.97	1.87	1.54	1.44	0.07	<0.01	0.99
Avg daily DDGS, kg	0.67	1.63	2.61	3.49	0.001	<0.01	0.58
Total DMI, kg	4.90	5.82	6.17	6.86	0.17	<0.01	0.54
G:F	0.11	0.16	0.18	0.19	0.02	<0.01	<0.01

¹Each receiving pen included 4 animals/treatment; pen was the experimental unit.

²Hay intake expressed as percentage of average trial weight.

response function indicated that ADG for steers would be maximized with DDGS feeding at 2.0% of BW. This level is beyond our range of treatments and would not be advisable because of the concern for excessive dietary S. In contrast, the response function for heifers was maximized with DDGS feeding at 1.44% BW, which may suggest a lower tolerance in heifers for high levels of DDGS feeding. Gustad et al. (2006) found that ADG was maximized with DDGS feeding at approximately 1.1% BW for steer calves grazing corn residue, and they suggested this level as a practical limit. Together, these studies suggest possible interactions among forage type, calf sex, and DDGS feeding level.

In other similarly designed studies in which calves consuming forage ad libitum were fed increasing levels of DDGS, linear responses in ADG were observed when the maximum feeding level of DDGS was approximately 0.95 or 0.61% of BW (Morris et al., 2005; MacDonald et al., 2007). The lack of a quadratic effect in each of these 2 experiments can be attributed to a higher maximum feeding level of DDGS in our study.

A quadratic response in BW gain efficiency was observed ($P < 0.01$) for both steers and heifers. According to the response functions, BW gain

efficiency was maximized with DDGS feeding at 1.50% of BW for steers and 1.36% BW for heifers.

When expressed as a percentage of mean trial BW, prairie hay intake decreased linearly ($P < 0.01$). The linear response function indicates that for every 1.0 kg of DDGS that was consumed, prairie hay intake decreased by 0.34 kg for steers ($R^2 = 0.90$) and 0.29 kg for heifers ($R^2 = 0.96$; Figures 1 and 2, respectively). Total DMI increased linearly ($P <$

0.01) as level of DDGS increased. Our response was similar to that of Morris et al. (2005), who demonstrated that when forage intake was measured directly, intake of low-quality forage was reduced by 0.32 kg for every additional kilogram of DDGS fed. Interestingly, in the study of Morris et al. (2005), there was a greater magnitude of reduction in forage intake (0.53 kg/kg of DDGS) for calves consuming high-quality forage. Loy et al. (2007) indicated that supplementation

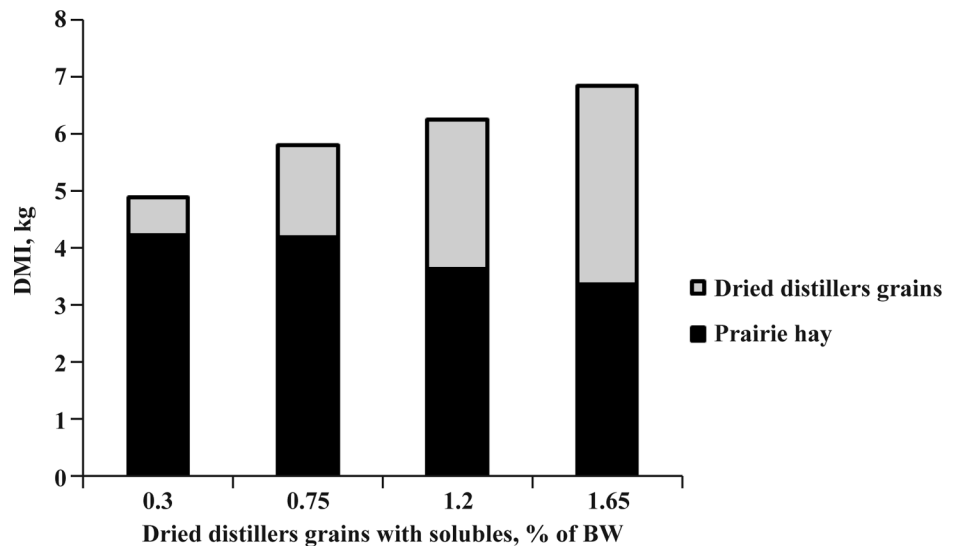


Figure 1. The partitioning of DMI during preconditioning for steers, measured directly. Prairie hay intake decreased linearly as level of dried distillers grains with solubles (DDGS) increased ($P < 0.01$); the substitution of DDGS for prairie hay was 0.34 kg.

Table 3. Effect of level of dried distillers grains with solubles (DDGS) during preconditioning on performance and hay intake of beef heifers

Item	DDGS, % of BW				SEM	P-value	
	0.30	0.75	1.20	1.65		Linear	Quadratic
n ¹	4	4	4	4	—	—	—
Initial wt, kg	174	175	175	174	9.66	0.98	0.51
Final wt, kg	194	217	231	229	10.67	<0.01	<0.01
Total BW gain, kg	20	42	56	55	2.47	<0.01	<0.01
56-d ADG, kg	0.32	0.67	0.88	0.87	0.04	<0.01	<0.01
Avg daily hay intake, kg	4.03	3.81	3.55	3.21	0.20	<0.01	0.47
Hay intake, ² % of BW	2.12	1.91	1.72	1.57	0.07	<0.01	0.63
Avg daily DDGS, kg	0.44	1.12	1.76	2.36	0.35	<0.01	0.82
Total DMI, kg	4.47	4.93	5.32	5.56	0.45	<0.01	0.60
G:F	0.08	0.15	0.19	0.18	0.01	<0.01	<0.01

¹Each receiving pen included 4 animals/treatment; pen was the experimental unit.

²Hay intake expressed as percentage of average trial weight.

of DDGS to medium-quality forage (8.2% CP, 56% in vitro OM disappearance) at 0.4% of BW reduced hay DMI by 0.22% of BW compared with no supplementation. Likewise, when forage intake was calculated based on NE equations (NRC, 1996), MacDonald et al. (2007), feeding DDGS at incremental levels up to approximately 0.60% of BW, speculated that intake of smooth bromegrass pasture would be decreased by 0.50 kg for

every additional kilogram of DDGS consumed [AU1: Sentence correct as edited?].

Compared with feedstuffs that are traditionally provided as supplements to forage diets, the fat content of DDGS is high. Previous research has revealed the negative effects of high fat levels on forage intake and digestibility (Moore et al., 1986; Whitney et al., 2000; Hess et al., 2001). Further, in a recent review, Hess et al. (2008)

indicated that to optimize forage utilization, supplemental fat intake should not exceed 4.5 to 5.0% of DM. In our study, when expressed as a percentage of average DMI, fat intake was 2.08, 4.09, 5.30, and 6.21%, respectively, across increasing levels of DDGS. Based on these percentages, which represent the average among steers and heifers, the additional fat from DDGS could contribute to the reduction in forage intake that we observed.

A large contribution of energy in DDGS is from the rapidly fermented, nonstructural carbohydrate as well as from fat. Excessive supplementation or feeding of forage-fed cattle is expected to reduce forage intake (Horn and McCollum, 1987). More clearly defining the effects of supplementation on forage intake, Moore et al. (1999) concluded that forage intake was reduced when supplemental TDN intake was >0.7% of BW. In our study, when expressed as a percentage of mean feeding BW and mean DDGS intake, the intake of supplemental TDN averaged among steers and heifers corresponded to 0.23, 0.54, 0.83, and 1.11% of BW. Together, the reduction in forage intake and increase in cattle performance as a result of feeding increasing levels of DDGS should be considered when producers wish to increase stocking

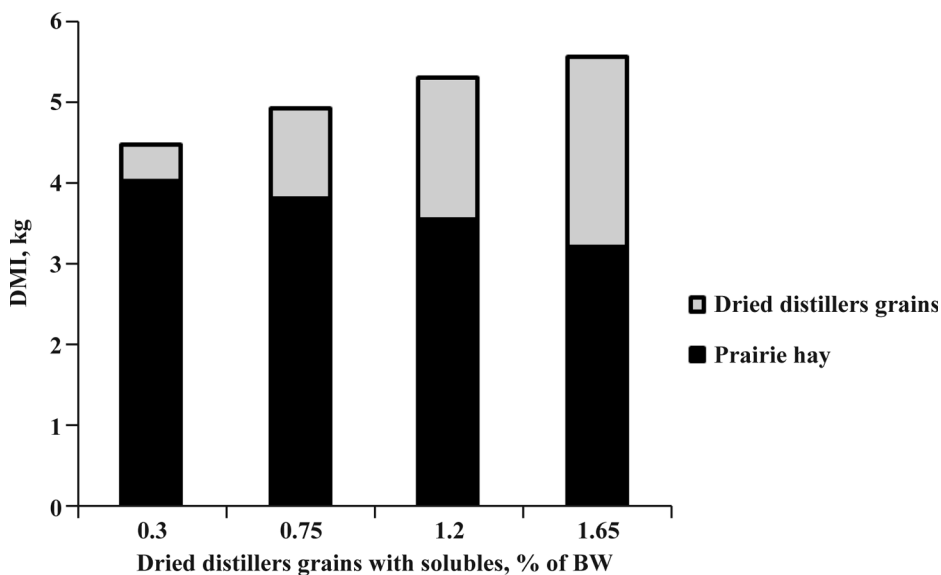


Figure 2. The partitioning of DMI during preconditioning for heifers, measured directly. Prairie hay intake decreased linearly as level of dried distillers grains with solubles (DDGS) increased ($P < 0.01$); the substitution of DDGS for prairie hay was 0.29 kg.

Table 4. Effect of level of dried distillers grains with solubles (DDGS) during the preconditioning phase on performance of steers on wheat pasture

Item	DDGS, % of BW				SEM	P-value	
	0.30	0.75	1.20	1.65		Linear	Quadratic
n	16	16	16	16	—	—	—
Initial BW, kg	221	247	259	266	7.29	<0.01	0.18
Final BW, kg	397	419	418	431	8.91	0.01	0.63
Total BW gain, kg	176	172	159	165	5.17	<0.01	0.12
128-d ADG, kg	1.38	1.34	1.24	1.29	0.03	<0.01	0.12

density, when hay price is high, or when forage availability is low.

Additionally, in comparison with feedstuffs that are traditionally supplemented to cattle consuming low-quality forage such as cottonseed meal, the percentage of degradable intake protein (**DIP**) is substantially lower in DDGS (Winterholler et al., 2009). In low-quality forage diets, DIP is a key component in growth of the rumen microbial population as it relates to increasing digestibility and utilization of forage (McCollum and Galyean, 1985; Köster et al., 1996; Bandyk et al., 2001). Intuitively, it could be speculated that because of the added energy and low concentration of DIP in DDGS, DIP could be limited and detrimental to growth

performance and forage utilization. However, the addition of urea to DDGS to meet requirements for DIP in heifers consuming medium-quality forage (7.4% CP, 58.1% TDN) did not influence ADG or BW gain efficiency compared with heifers receiving DDGS only (Stalker et al., 2007). These researchers speculated that ruminal N recycling in heifers consuming DDGS without supplemental DIP was sufficient to meet microbial demands (Stalker et al., 2007).

In contrast, N recycling was not observed with DDGS supplementation to wether lambs consuming chopped bromegrass hay (8.44% CP), as measured by urea N flux (Archibeque et al. 2008), which could be attributed to the stage of production

because these lambs were mature and required no additional nutrients above maintenance. However, in the same study, DDGS supplementation to chopped bromegrass hay increased the release of α -amino N by the portal drained viscera; together with other nutrient flux data, evidence was provided that α -amino N utilization was increased by DDGS compared with corn (Archibeque et al., 2008). According to the NRC (1996) model level 1, and using the mean feeding BW for both steers and heifers in the present study, feeding DDGS at 1.65% of BW met requirements for DIP, whereas feeding lower levels of DDGS resulted in a diet projected to be deficient in DIP. It is interesting that ADG and G:F were estimated to be optimized with DDGS feeding at 1.44 and 1.35% of BW, respectively, for heifers. Moreover, G:F was estimated to be optimized in steers with DDGS feeding at 1.5% of BW. According to the NRC (1996) model, the heifers were projected to be deficient in DIP at this level of DDGS. This suggests N recycling was adequate to meet microbial N requirements, whereas the NRC (1996) model estimated that ruminally available N would limit performance at these feeding levels.

Exposure to high levels of S can induce polioencephalomalacia (Jeffrey et al., 1994). In finishing diets, ADG, G:F, and some carcass characteristics are negatively affected by high S intake (Zinn et al., 1997; Loneragan et al., 2001). In our study, by experimental design, S intake did not exceed 0.40% of dietary DM (NRC, 1996). For steers fed DDGS at 1.65% of BW,

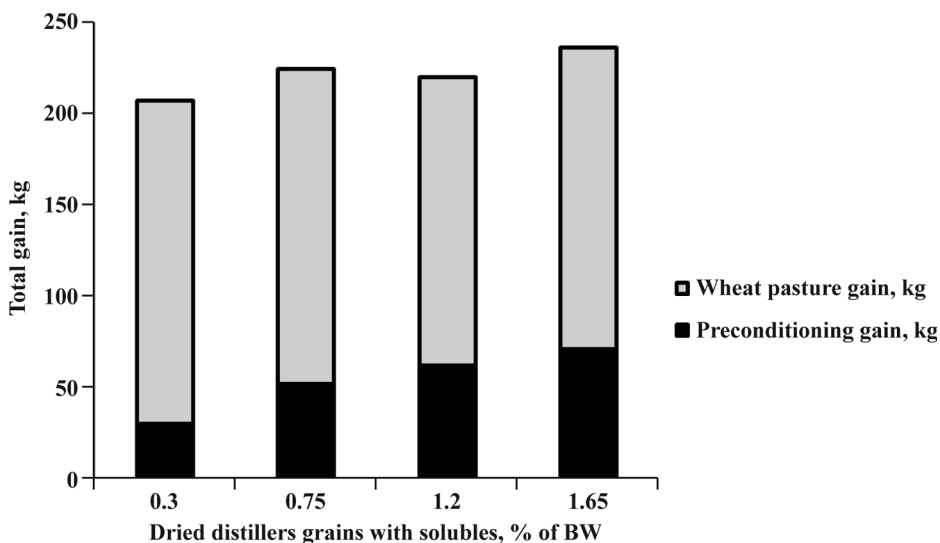


Figure 3. The effect of feeding level of dried distillers grains with solubles (DDGS) on the partitioning of preconditioning and wheat pasture BW gain. Total BW gain for preconditioning increased linearly with increasing level of DDGS ($P < 0.05$). Total wheat pasture BW gain linearly decreased as feeding level of DDGS during preconditioning increased ($P < 0.05$).

Table 5. Effect of level of dried distillers grains with solubles (DDGS) during the preconditioning phase on steer feedlot performance and carcass characteristics

Item	DDGS, % of BW				SEM	P-value	
	0.30	0.75	1.20	1.65		Linear	Quadratic
n	16	16	16	15	—	—	—
Initial wt, kg	406	429	429	445	8.78	<0.01	0.69
Final wt, kg	565	585	580	598	9.91	0.04	0.91
Total BW gain, kg	159	156	151	153	4.05	0.22	0.55
97-d ADG, kg	1.64	1.61	1.55	1.58	0.04	0.21	0.55
Hot carcass wt, kg	361	377	367	380	6.86	0.13	0.77
Dressing percent	63.86	64.47	63.35	63.55	0.53	0.39	0.60
Marbling score ¹	533	525	535	580	21.4	0.12	0.22
12th-rib fat, cm	1.02	1.12	1.24	1.04	0.08	0.57	0.11
Ribeye area, cm ²	85.94	89.99	87.03	90.97	2.39	0.27	0.96
KPH, %	2.25	2.38	2.34	2.30	0.07	0.72	0.26
USDA YG	2.7	2.8	2.9	2.7	0.16	0.91	0.32

¹Small (low choice) = 500.

the maximum S intake calculated from intake of DDGS at the end of the preconditioning period was equal to 0.38% of dietary DM. We observed no symptoms of S-induced polioencephalomalacia at this level. It is not known whether the lack of improvement in BW gain for the heifers at the highest level of DDGS feeding is due to subclinical polioencephalomalacia, although this is certainly a possibility, and further research seems warranted.

Wheat Pasture, Feedlot, and Carcass Performance

Data for wheat pasture performance is provided in Table 4. For steers that grazed wheat pasture after the preconditioning period, ADG decreased linearly as the level of DDGS during preconditioning increased ($P < 0.01$). Average daily gain of steers grazing wheat pasture was reduced by 0.16 kg for each 1 kg/d increase in preconditioning BW gain. Steers fed DDGS at 0.30% of BW during preconditioning exhibited the fastest rate of growth while grazing wheat pasture; however, BW at the end of the 128-d wheat pasture grazing period was still greater (34 kg) for steers fed 1.65% of BW during preconditioning (Figure 3). This response was similar to

that of White et al. (1987), in which nutrient-restricted calves had greater ADG during a subsequent grazing phase than calves without nutrient restriction.

Although we were unable to measure BW gain efficiency during the wheat pasture phase, it has been well documented that after a period of nutrient restriction, rate of BW gain and BW gain efficiency are increased by refeeding (Fox et al., 1972; Phillips et al., 1991). Sainz et al. (1995) indicated that compensatory growth rate is related to several mechanisms but that increased DMI was the most significant variable. The dramatic increase in growth rate of calves fed the lower levels of DDGS during preconditioning while on wheat pasture might be attributed to greater DMI and the subsequent increase in protein and energy intake while grazing wheat pasture.

Data for feedlot performance and carcass characteristics for steers and heifers are provided in Tables 5 and 6, respectively. For steers, initial and final BW increased linearly with feeding level of DDGS during preconditioning ($P < 0.05$) but did not influence ADG ($P = 0.21$). Although final BW of heifers was not affected by level of DDGS during preconditioning ($P = 0.53$), ADG during the finishing

phase decreased linearly with increasing levels of DDGS during preconditioning ($P = 0.05$). These experiments were not designed to elucidate the mechanism by which postweaning preconditioning performance may have been affected. There is no way to determine if the increase in feedlot ADG in heifers, or the increase in wheat pasture grazing ADG in steers fed lower levels of DDGS during preconditioning, can be attributed to compensatory growth (White et al., 1987; Sainz et al., 1995; Choat et al., 2003) or to the possible lingering effects of subclinical polioencephalomalacia for cattle fed higher levels of DDGS during preconditioning (Niles et al., 2002). However, it is interesting that despite dramatic increases in BW by steers on wheat pasture fed DDGS at 0.30% of BW during preconditioning, there was still a linear increase in final BW with increasing levels of DDGS during preconditioning. The faster rate of wheat pasture growth exhibited by the steers fed DDGS at 0.30% of BW during preconditioning was not great enough to overcome nutrient restriction during the preconditioning growing phase.

Carcass measurements did not differ ($P > 0.10$) among treatments for steers or heifers (Tables 5 and 6). Similarly, previous research with

Table 6. Effect of dried distillers grains with solubles (DDGS) during preconditioning on heifer feedlot performance and carcass characteristics (yr 1)

Item	DDGS, % of BW				SEM	P-value	
	0.30	0.75	1.20	1.65		Linear	Quadratic
n	6	8	8	7	—	—	—
Initial wt, kg	201	231	244	243	8.72	<0.01	0.10
Final wt, kg	496	492	500	507	14.5	0.53	0.69
Total BW gain, kg	295	261	256	264	10.5	0.05	0.05
ADG, kg	1.57	1.38	1.36	1.40	0.05	0.05	0.05
Hot carcass wt, kg	323	319	320	326	9.99	0.78	0.57
Dressing percent	65.16	64.83	63.95	64.32	0.59	0.22	0.55
Marbling score ¹	653	593	685	633	41.1	0.87	0.92
12th-rib fat, cm	1.50	1.52	1.45	1.45	0.13	0.69	0.99
Ribeye area, cm ²	81.09	78.64	77.74	80.39	3.94	0.87	0.53
KPH, %	2.17	2.31	2.31	2.29	0.17	0.66	0.62
USDA YG	3.1	3.2	3.2	3.1	0.24	0.94	0.74

¹Small (low Choice) = 500.

feeding increasing levels of DDGS up to 1.03% of BW as a supplement to yearling cattle grazing native range indicated that level of DDGS supplementation did not influence carcass characteristics (Morris et al., 2006). In a recent meta-analysis, Klopfenstein et al. (2008) indicated that some feedlot performance measures and carcass characteristics were decreased by the inclusion of DDGS at 40% of dietary DM in finishing diets. We report no potential carryover effect of high levels of DDGS during preconditioning for these variables, although the possibility of a type II error exists because of the relatively low number of experimental units available in this study.

IMPLICATIONS

Corn DDGS can be used with native tall grass prairie hay as an effective preconditioning diet. Performance of heifers did not improve when DDGS was fed at 1.65% of BW compared with 1.2% of BW, and the optimal marginal improvement in BW gain per unit of feed consumed was estimated at DDGS of approximately 1.4% of BW for both steers and heifers. Therefore, we suggest that DDGS at approximately 1.25% of BW feeding should be used as a

conservative maximum feeding level for growing cattle consuming native tall grass prairie hay. Higher feeding levels during the postweaning preconditioning period will likely result in reduced wheat pasture grazing BW gain and, when calves are placed directly on a finishing diet after preconditioning, reduced feedlot BW gain. Carcass characteristics do not appear to be substantially affected by varying DDGS feeding levels during preconditioning. To avoid excess S, the nutrient composition of DDGS should be closely monitored, and the S concentration of water and the total diet should be taken into account.

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