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Effect of Dried Distillers Grains Supplementation on Calves Grazing Bermudagrass Pasture or Fed Low-Quality Hay

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ABSTRACT

The objective of the following experiments was to examine the effect of dried distillers grains plus solubles (DDGS) supplementation of calves grazing bermudagrass (Cynodon dactylon) pasture during summer (Exp. 1) or fed low-quality tall fescue hay (Exp. 2, Festuca arundinacea) during winter months. In Exp. 1, a total of 36 steers (261 kg) were randomly assigned to one of nine 0.81-ha pastures receiving 0, 0.9, or 1.8 kg/d DDGS (as-fed basis). Over the 84 d, supplementation increased ADG by 0.24 kg/d (P = 0.02); however, the 1.8 kg/d supplementation rate did not improve ADG above the 0.9 kg/d supplementation rate (P = 0.54). Supplementation increased pasture BW gains 98.5 kg/ha (P = 0.02) with a supplemental G:F of 0.22. In Exp. 2, a total of 84 steers (220 kg) were randomly assigned to 1 of 12 pens and given free-choice access to tall fescue hay plus 0, 0.3, 0.6, or 1.2% BW DDGS (as-fed basis). The DDGS increased ADG in a cubic manner (P = 0.01) over the 82-d supplementation period. Average daily gain increased by 0.4, 0.14, and 0.23 kg/d for the first, second, and third incremental increase in DDGS. Economic evaluation of Exp. 1 indicated the probability of at least breaking even when supplementation was 0.78 and 0.69 for the 0.9 and 1.8 kg/d supplementation rate, respectively. Economic evaluation of Exp. 2 indicated the probability of at least breaking even with supplementation was 0.99, 0.87, and 0.83 at 0.3, 0.6, and 1.2% BW DDGS, respectively.

Key words: beef calf, bermudagrass, dried distillers grains, tall fescue hay

INTRODUCTION

In recent years, the expansion of grain distillation facilities to produce fuel ethanol increased the availability and price competitiveness of distillers grains for cattle producers in the southeastern United States. Most of the distillers grain arriving in Arkansas is dried distillers grains plus solubles (**DDGS**), followed by modified distillers grains plus solubles. Dried distillers grains research has been reported with growing cattle fed in confinement (Klopfenstein et al., 2008) and grazing (Griffin et al., 2009). The forages used for grazing and haying in the southeastern United States are predominately improved warm-season grasses, such as bermudagrass (*Cynodon dactylon*), and the cool-season perennial, tall fescue (*Festuca arundinacea*). The nutrient content of improved forages found in the Southeast will generally differ from that of native grasses. Hawley et al. (2010) indicated there are few published studies examining the performance of cattle fed ethanol distillation by-products with bermudagrass. The first objective of this set of experiments was to examine the performance of stockers grazing bermudagrass pasture (Exp. 1) or fed low-quality tall fescue hay (Exp. 2) and supplemented with increasing levels of DDGS. The second objective of this study was to examine the probability of increasing returns from DDGS supplementation based on the

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Table 1. Nutrient composition of distillers grains plus solubles (DDGS) and forages available during the grazing and hay feeding studies

	Grazing study						Hay study	
		Pasture quality						
Item	DDGS	d 0	d 28	d 56	d 84	SE[1]	DDGS	Hay
DM, %	86.7						86.4	88.9
CP,[2] % of DM	31.9	21.2	16.6	13.4	17.2	0.60	30.2	10.3
NDF,[3] % of DM	31.1	75.6	69.9	76.9	76.0	1.81	32.8	68.5
ADF,[3] % of DM	14.3	35.1	27.8	37.8	32.6	2.32	14.8	43.5
Ether extract, % of DM	15.7						12.4	
S, % of DM	0.67						0.69	

[1]SE for pasture quality.

[2]Pasture quality quadratic day ($P < 0.05$) effect during the grazing study.

[3]Pasture quality cubic day effect ($P \leq 0.015$) during the grazing study.

Arkansas calf and feed price structure over the past 10 yr.

MATERIALS AND METHODS

Procedures conducted throughout the study were in accordance with the recommendations of the Consortium (1999) and were approved by the University of Arkansas Animal Care and Use Committee.

Grazing Study

Thirty-six crossbred steers (261 ± 4.7 kg) were allocated to one of nine 0.81-ha bermudagrass (*C. dactylon*) pastures to evaluate the effects of summer supplementation with DDGS. The study was located at the Livestock and Forestry Research Station near Batesville, Arkansas. The area is characterized as Peridge silt loam soil (deep and well drained; Ferguson et al., 1982). At the beginning of the growing season (mid-May), ammonium nitrate was broadcast, delivering 66.5 kg/ha N. Before turnout, calves were treated with 0.5 mg/kg BW of 5 mg/mL moxidectin (Cydectin Pour-On, Fort Dodge Animal Health, Fort Dodge, IA) to control internal parasites and were implanted with 40 mg trenbolone acetate and 8 mg estradiol (Revalor-G, Intervet Inc., Desoto, KS). Each pasture was randomly assigned to 1 of 3 supplemental feed levels. Supplemental feed level was a daily equivalent of 0, 0.9, or 1.8 kg (as-fed basis) per calf, hand-fed Monday through Friday. Grazing and supplementation were initiated in mid-June and continued for 84 d. The supplement contained 86.7% DM (Table 1), and feed offerings were completely consumed. All calves had free-choice access to a complete mineral containing 14.2% Ca, 6% P, 18% NaCl, 2.5% Mg, 0.3% S, 0.3% K, 9,000 ppm Zn, 6,500 ppm Mn, 3,000 ppm Cu, 184 ppm I, 39 ppm Se, and 25 ppm Co (Furst-McNess, Freeport, IL.). Calves were weighed before turnout and every 28 d, after an overnight shrink.

Forage mass was determined at 28-d intervals beginning just before grazing. Forage mass was calculated from measurements taken from 10 random locations within each paddock, using rising plate disk meter methodology (Michell and Large, 1983). The rising plate was calibrated by clipping 0.25-m^2 areas within sampling date representative of the range in rising plate heights at the time of sampling. Areas were clipped leaving a residual forage height of 5 cm.

Hay Study

Eighty-four crossbred steers (220 ± 5.5 kg) were allocated to 1 of 12 pens to evaluate the effect of increasing level of DDGS when calves were fed a basal diet of low-quality tall fescue hay. The pens were randomly allocated to 1 of 4 supplementation treatments. Calves used in the hay study arrived preconditioned, and growth-promoting implants and anthelmintics were administered as reported in the pasture study. Calves were given free-choice access to large round bales and were provided DDGS at a rate of 0, 0.3, 0.6, or 1.2% (as-fed basis) of initial BW. The study began in mid-November and continued for 82 d. The 7-d equivalent of DDGS was hand-fed Monday through Friday and feed offerings were completely consumed. Calves were weighed on d 0, 28, 56, and 82.

Nutrient Analysis

Pasture samples were collected on d 0, 28, 56, and 84 during grazing (Exp. 1), and hay samples were collected and composited during the hay study for nutrient analysis (Exp. 2). Pasture quality samples were collected by plucking forage samples at 10 random locations throughout each paddock, representative of apparent plant parts grazed. All forage samples were dried to a constant weight at 50°C in a forced-air oven and ground to pass a 2-mm screen in a Wiley laboratory mill (model 4, Thomas Scientific, Swedesboro, NJ) before storage for

Table 2. Price inputs for simulating the additional returns from dried distillers grains plus solubles (DDGS) during summer grazing and winter haying

Item	Minimum	Maximum	Mean	Median	SD	Normality test *P*-value[1]
DDGS	$/909 kg					
Summer	69.50	181.50	94.20	80.00	30.97	0.01
Winter	74.25	161.00	103.50	107.30	26.31	0.06
Calf price	$/45.45 kg					
Summer[2]						
June	73.62	141.50	103.94	104.22	15.53	0.52
September	74.75	143.35	103.62	104.59	15.95	0.24
Winter[2]						
November	75.62	137.25	98.38	97.88	15.25	0.18
February	76.88	148.08	102.69	101.00	13.96	0.13
Price slide[3]						
June			0.057			
September			0.069			
November			0.073			
February			0.089			
	Feed price ($/909 kg):calf price ($/45.45 kg)					
Summer price ratio[4]	0.60	1.60				
Winter price ratio[5]	0.63	1.33				

[1]*P*-value ($P < 0.05$) indicates nonnormality.

[2]Calf prices were simulated from a multivariate distribution based on the variance-covariance price matrix and mean prices.

[3]Price slide is the price adjustment used to correct the simulated calf price based on the average mean BW for market news prices to the treatment observed BW.

[4]Summer price ratio: average price for DDGS during the summer divided by the average price for a 261-kg June steer.

[5]Winter price ratio: average price for DDGS during the winter divided by the average price for a 216-kg November steer.

chemical analysis. Neutral detergent fiber and ADF were assayed by the batch procedures outlined by Ankom Technology Corp. (Fairport, NY). Nitrogen concentration was measured by rapid combustion (FP-528, Leco Corp., St. Joseph, MI) and CP was calculated as N% × 6.25.

Supplements within study were collected, composited, and sent to DairyOne Laboratory (Ithaca, NY) for nutrient analysis. Neutral detergent fiber and ADF were assayed by modified procedures outlined by Ankom Technology Corp. Nitrogen concentration was measured by rapid combustion (FP-528, Leco Corp.) and CP was calculated as N% × 6.25. Fat and DM were determined by methods 2003.05 and 930.15, respectively (AOAC, 1990). Mineral content was determined by inductively coupled plasma radial spectrometry after microwave digestion.

Statistical and Economic Analysis

The grazing study treatment effects on calf performance, forage mass, and forage quality were analyzed with JMP 8.0 software (SAS Institute Inc., Cary, NC). Pasture was treated as the experimental unit. Forage mass and quality were analyzed as repeated measures. The restricted maximum likelihood method was used and negative variance components were not permitted. Contrasts were used to compare nonsupplemented versus supplemented and 0.9 versus 1.8 kg/d supplementation rates. Results from the hay study were analyzed using the MIXED procedure (SAS Institute), with pen as the experimental unit. Orthogonal contrasts were constructed for unequally spaced treatments (Robson, 1959) to examine the linear, quadratic, or cubic response to increased rate of DDGS supplementation.

An economic evaluation of the additional return from providing DDGS during summer grazing or winter haying was constructed from simulation techniques in R software (Jones et al., 2009). The simulations were based on 2000 to 2009 average calf prices and DDGS prices (Table 2; Livestock and Grain Market News Database Portal, 2009). Calf prices represented Arkansas prices and DDGS prices represented Minneapolis, Minnesota, reported values. The calf prices came from a normal distribution (Table 2) and were simulated as a truncated multivariate normal distribution (Stefan and Manjunath, 2010) using a variance-covariance matrix of prices. Feed price was not normally distributed and was not correlated with calf price ($r = 0.05$; $P = 0.89$); therefore, feed price was simulated by randomly selecting a feed price from a vector of observed feed prices within summer or winter, corresponding to the appropriate study. Feed price was sampled independently of calf price; however, a feed price-to-calf price ratio was used to eliminate extremes based on the minimum and maximum price ratio determined from the initial price inputs. The Minneapolis feed prices were simply used to establish a distribution of feed prices. The final feed price included a markup of $60/909 kg to acquire a range of prices that more closely reflected the average and the range of prices paid by Arkansas producers after delivery. The grazing study data set was constructed by generating 500,000 random samples. September price was positively correlated (r = 0.97, respectively; $P < 0.01$) with June price; therefore, calf prices were generated to maintain a price correlation using a truncated multivariate sampling procedure. Truncation was used to eliminate prices generated from the normal distribution that exceeded minimums and maximums observed in the market news price data set. The final feed price reflected delivery and 6% interest on borrowed money. Because pasture size and stocking rate were constant, all other costs remained constant. The depreciated cost of feed bunks for supplementation was not included because of assumptions regarding activity of use outside summer supplementation. The final calf price included a 4% sales commission.

The additional return from DDGS with a hay-based diet was constructed similarly to that of the grazing study. November and February historical calf prices (Table 2) were used for the simulation. The fall and following spring calf prices were positively correlated (r = 0.97, $P < 0.01$), and multivariate price simulation was used to maintain the price correlation. Return from feeding DDGS was calculated as income based on the corresponding value of the final BW from supplementation (adjusted for a 4% sales commission) minus the initial calf cost minus the final feed price minus the return from hay only. For the hay study, additional return from providing DDGS also included the value of any predicted change in hay consumption. Because hay was fed as large round bales, hay intake for the economic analysis was predicted based on NRC level 1 equations (NRC, 1996). Hay intake at 0.0% BW DDGS was determined by adjusting the hay TDN and DMI until the predicted performance matched the observed performance and the estimated intake was equal to the NRC-predicted intake. The remaining predictions were based on the hay using the predicted TDN at 0.0% BW DDGS and the NRC (1996) NE value for DDGS, and the DMI of the supplement. As a result, the 0.3, 0.6, and 1.2% treatments were charged for +1.4, +0.9, and −0.68 kg/d of hay at \$0.059/kg. A reduction in hay intake with an increased level of DDGS is in agreement with the results of Morris et al. (2005), Loy et al. (2008), Winterholler et al. (2009), Griffin et al. (2009), and Leupp et al. (2009).

For the grazing study and the hay study, a binary response variable was constructed based on the additional return from providing DDGS by using 0 = negative return and 1 = no return or positive return to determine the probability of at least breaking even.

RESULTS AND DISCUSSION

The mean ± SD nutrient composition (DM basis) of the accumulated crop year for distillers grains reported by DairyOne Laboratory (Feed Composition Library Database, 2003) was 30.8 ± 4.0% CP, 16.9 ± 3.4% ADF, 33.8 ± 4.6% NDF, 13.0 ± 3.0% ether extract, and 0.64 ± 0.18% S. The nutrient composition of the DDGS used in the following studies, by comparison, are presented in Table 1. With the exception of ADF (grazing study and hay study) and ether extract (grazing study), the DDGS fed was within 10% of the mean values reported by DairyOne.

Grazing Study

Throughout the grazing study, temperatures were below normal (Figure 1) and precipitation was above normal (Figure 2). Forage quality did not differ among treatments, nor did it interact with treatments (data not shown). Forage quality changed throughout summer (Table 1). The CP content of the forage diminished from 21.2 to 13.4% by d 56 but increased to 17.2% by d 84 ($P < 0.01$). The fiber content of the forage responded cubically ($P < 0.01$), with the greatest values being measured on d 0 and 56. Based on a TDN equation for bermudagrass {87.46 + [0.2 × ((CP × 0.876) − 2.38)] − (0.96 × ADF)} the TDN:CP ratio ranged from 2.7 to 3.8, indicating that the forage contained a sufficient amount of CP for the available energy of the forage, if not an excess (Moore et al., 1999). The NDF content of the bermudagrass was quite high. By comparison, bermudagrass hay samples in Arkansas averaged

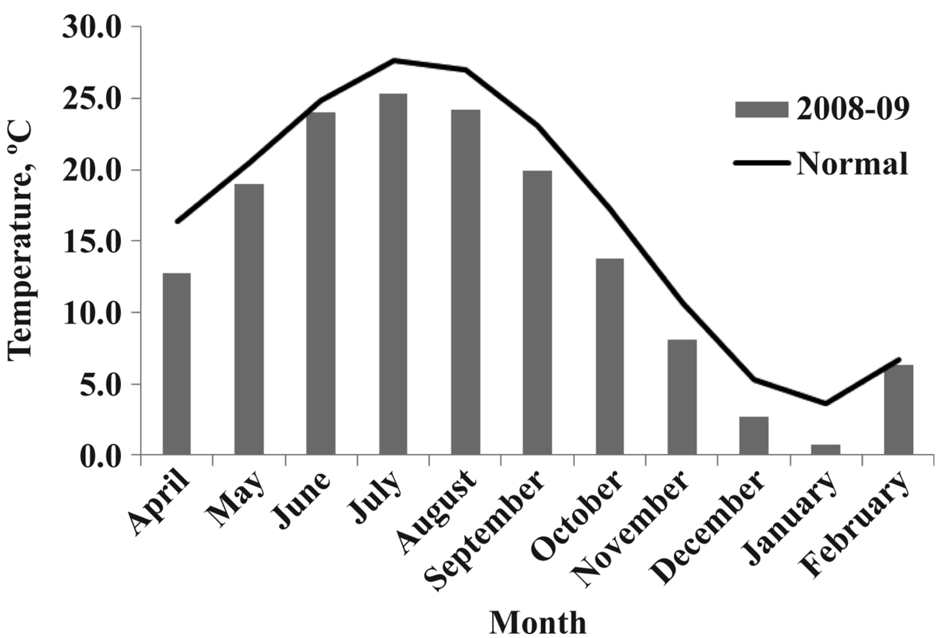

Figure 1. Temperature for April 2008 through February 2009 at the Livestock and Forestry Research Station (Batesville, AR; 35°50′ N, 91°48′ W).

32.7 ± 4.0% ADF and 71.4 ± 5.1% NDF (Arkansas Feed Analysis Database, 2008).

Forage mass did not differ among treatments, nor did it interact with treatments (data not shown). Because of the favorable weather, forage mass increased linearly ($P < 0.01$) throughout summer, with an initial amount of 248 kg forage available per calf at turnout and a final forage mass of 457 kg per calf available at the conclusion of the study. These values correspond to 1,839 and 3,385 kg/ha, respectively. The favorable temperature and precipitation resulted in a forage availability that would not be expected to limit animal performance.

The quantity and quality of the available forage produced positive BW gains. Nonsupplemented calves averaged 0.79 kg/d over the 84-d grazing period (Table 3). Supplementation increased ($P < 0.02$) ADG by 0.24 kg/d. Increasing supplemental feed from 0.9 to 1.8 kg resulted in a nonsignificant increase in ADG. Supplemental G:F averaged 0.22 kg/kg; feed efficiency was numerically greater at 0.9 kg/d of supplementation versus 1.8 kg/d of supplementation. Overall, providing DDGS supplementation to calves grazing bermudagrass resulted in 98.5 kg/ha more BW produced compared with grazing alone. By comparison, Lomas and Moyer (2008) reported that calves grazing bermudagrass pastures for 89 d before finishing consumed 0, 2, or 3.9 kg distillers grains per calf daily. Within the good growing conditions of their study, nonsupplemented calves gained 1.02 kg BW/d. Calves consuming 2 kg distillers grains gained only 0.025 kg/d more than nonsupplemented calves, and increasing the supplementation rate to 3.9 kg/d increased BW gains by an additional 0.17 kg/d. These increases in BW gain were reported to be statistically nonsignificant improvements, and the resulting feed conversions were very poor, 19.4 and 76.4 kg feed/kg additional BW gain for the high and low supplementation rates, respectively. Griffin et al. (2009) conducted a meta-analysis of DDGS level with pasture supplementation. Their analysis included bermudagrass and smooth bromegrass grazing studies in Kansas as well as smooth bromegrass and Sandhills range in Nebraska. There was a linear response of ADG to supplementation rates up to 1.2% BW. From 0.0 to 0.2% BW, supplementation increased ADG by 0.11 kg/d. The additional BW gains from 0.2 to 0.4% BW and from 0.4 to 0.6% BW DDGS were 0.09 and 0.07 kg/d, respectively. The additional BW gain from 0.2 to 0.5% BW DDGS equivalent in the current study was 0.05 kg and was nonsignificant. In a similar study using cottonseed cake as a supplement for calves grazing bermudagrass during summer months, Gadberry et al. (2009) observed a 0.3 kg/d improvement in ADG at a 2 kg/d supplementation rate; however, increasing the supplementation rate to 4 kg/d resulted in an additional nonsignificant BW gain response of 0.1 kg/d. The BW gain response observed in this study closely resembled the response observed by Gadberry et al. (2009) with cottonseed cake at the same location, despite the weather conditions resulting in forage mass declining throughout summer in that study versus accumulating in the present study. The nonsupplemented control group gained 0.8 kg/d in the cottonseed cake study, mimicking the BW gain reported herein.

Hawley et al. (2010) examined distillers grains fed to calves grazing bermudagrass at 0.5% BW (as-fed basis) in comparison with soybean hulls or corn. The distillers grains in that study produced BW gains similar to the other supplements. The results of that study indicate that cattle grazing bermudagrass are likely benefiting from the additional energy from distillers grains versus its supplemental protein value. As mentioned earlier, the estimated TDN:CP ratio would suggest energy to be first limiting in these bermudagrass paddocks.

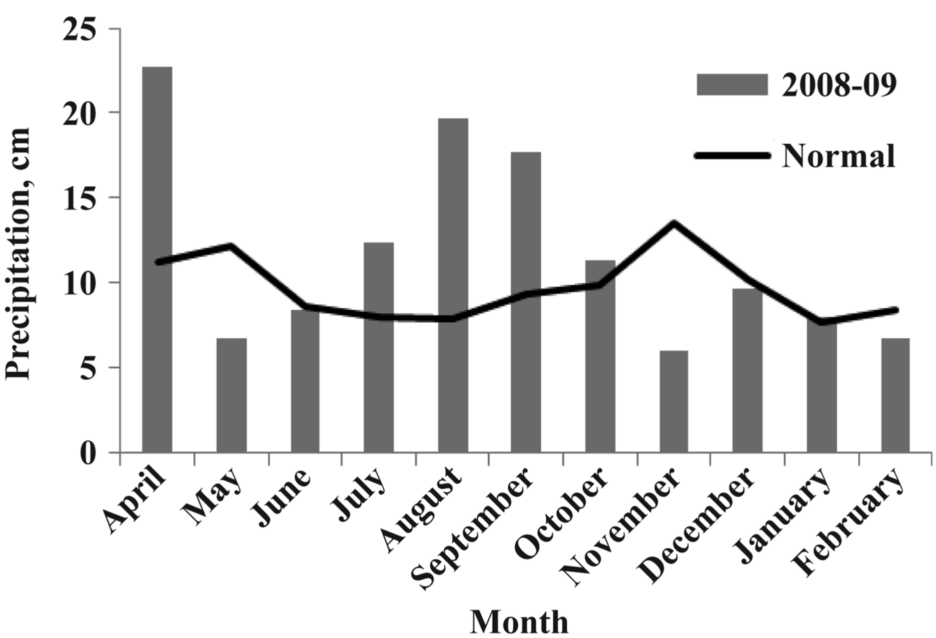

Figure 2. Rainfall for April 2008 through February 2009 at the Livestock and Forestry Research Station (Batesville, AR; 35°50′ N, 91°48′ W).

Hay Study

During the hay study from November to early February, calves experienced below normal temperatures (Figure 1) and near normal rainfall (Figure 2). The forage provided during the hay study contained 10.3% CP, 68.5% NDF, and 43.5% ADF (Table 1). This hay was very high in ADF content compared with the average bermudagrass (32.7 ± 4.0), mixed grass (37.9 ± 4.5%), or fescue (38.1 ± 4.9%) hay observed in Arkansas (Arkansas Feed Analysis Database, 2008).

Table 3. Effect of dried distillers grains plus solubles supplementation rate on the performance of steers grazing bermudagrass during the summer months

Item	Supplementation rate, kg/d (as fed)			SE	Contrast *P*-value	
	0.0	0.9	1.8		0 vs. Supplemented[1]	0.9 vs. 1.8
Mean forage allowance, kg/kg BW	1.17	1.19	1.13	0.11	0.93	0.73
Forage allowance, kg/calf	354	367	356	19.2	0.87	0.83
Initial BW, kg	262	261	262	4.7	0.97	0.87
Final BW, kg	328	345	351	6.0	0.01	0.50
ADG, kg	0.79	1.00	1.05	0.06	0.02	0.54
BW gain, kg/ha	328	415	438	24.9	0.02	0.54
Additional G:F, kg/kg		0.27	0.17	0.04		0.15

[1]Contrast: 0 vs. Supplemented = unsupplemented control vs. supplemented at 0.9 and 1.8 kg/d (as fed) rates.

Calves that were fed hay gained only 0.05 kg/d (Table 4). The low-quality hay offered under the environmental conditions of the study was barely capable of meeting the energy maintenance requirement. These calves even lost BW during the final 26-d period. Increasing DDGS supplementation resulted in a cubic increase ($P < 0.01$) in overall ADG. Supplementation at 0.3% BW increased ADG by 0.4 kg/d, increasing DDGS to 0.6% BW increased ADG by an additional 0.14 kg/d, and increasing DDGS to 1.2% BW increased ADG to 0.23 kg/d above the previous level. The first increment of DDGS resulted in the greatest change in BW. By comparison, Winterholler et al. (2009) reported that steer and heifer BW gain increased quadratically from 0.3 to 1.65% BW DDGS when a prairie hay diet was fed (0.5 to 1.3 kg/d and 0.3 to 0.87 kg/d BW gain for steers and heifers, respectively). Morris et al. (2005) reported a linear increase in ADG of heifers fed a brome (0.12 kg/d) or alfalfa sorghum silage (0.09 kg/d). The intermediate levels of DDGS in the current study (0.3 to 0.6% BW) had a slower rate of BW change compared with similar rates observed by Winterholler et al. (2009) and Morris et al. (2005). The rate of BW change at supplementation rates of 0.6 to 1.2% BW in the current study was greater than the rate of BW change at similar intake rates observed by Winterholler et al. (2009) and was intermediate to the brome and alfalfa-sorghum silage diets of Morris et al. (2005).

The feed efficiency, calculated as the ratio of additional BW gain above that of nonsupplemented calves to the amount of DDGS apparently consumed, decreased quadratically ($P = 0.03$) as DDGS intake increased. The overall net reduction in additional BW gain per day and G:F between 0.3 and 1.2% BW also suggests the potential for a positive associative effect at the low rate or a negative associative effect at the high rate. Over the entire feeding period, the actual DDGS intake was 0.25, 0.5, and 0.96% BW (DM basis). Based on an observed DDGS intake of 0.96% BW and a mean 82-d BW of 255 kg, the threshold hay intake to minimize

Table 4. Effect of dried distillers grains plus solubles supplementation rate on the performance of steers fed low-quality hay during the winter months

Item	Supplementation rate, % of BW (as fed)				SE	*P*-value[1]
	0	0.3	0.6	1.2		
Initial BW, kg	220.6	218.2	219.8	220.7	5.51	0.99
Final BW, kg	224.7	254.7	267.9	288.4	2.33	<0.01 Q
ADG, kg						
d 0 to 28	0.11	0.58	0.67	0.64	0.05	<0.01 Q
d 28 to 56	0.10	0.30	0.59	0.99	0.05	<0.01 L
d 56 to 82	−0.06	0.45	0.48	0.84	0.08	0.04 C
d 0 to 82	0.05	0.45	0.59	0.82	0.02	0.01 C
Additional G:F,[2] kg/kg		0.67	0.44	0.32	0.03	0.03 Q

[1]*P*-value for orthogonal contrast of unequally spaced treatments: L = linear; Q = quadratic; C = cubic.

[2]Supplemental gain to feed.

the negative effect of fat (Hess et al., 2008) on forage intake and digestibility was 10 kg, or 80% of the dietary DM. Winterholler et al. (2009) exceeded this ratio when DDGS exceeded 0.75% BW. As a result of our feeding rate exceeding 0.75% BW, the diminishing benefit of the incremental G:F may be attributed to losses in digestion efficiency associated with excessive fat consumption.

Arkansas hays average 0.2 ± 0.06%, 0.3 ± 0.10%, and 0.2 ± 0.05% S for mixed grass, bermudagrass, and fescue, respectively (Arkansas Feed Analysis Database, 2008). The DDGS in the hay study contained 0.69% S. If the DDGS exceeded 25% of the dietary DM, the potential for S exceeding the NRC (1996)-suggested maximal tolerable level would be plausible; however, no clinical effects associated with high dietary S were observed in these cattle over the 82-d feeding period.

Grazing Economics

Grazing economic results are presented in Table 5. The simulation data set examining the additional return from supplementation consisted of 500,000 initial samples generated using the parameters presented in Table 2. After adjusting for the observed feed price-to-calf price ratio, 464,997 observations remained in the final data set. The final delivered feed cost without interest ranged from a minimum of $129.50/909 kg to $241.50/909 kg. The calculated additional return from the 0.9 kg/d supplementation rate was (mean ± SD) $19.28 ± 25.21 per calf, which was greater than ($P < 0.01$) the calculated additional return from the 1.8 kg/d supplementation rate ($12.87 ± 25.64 per calf). In a similar study, Gadberry et al. (2009) indicated greater returns from steers fed 2 versus 4 kg/d (DM basis) cottonseed cake with steers grazing bermudagrass pastures under similar conditions. Additional return was highly variable in the current study. This resulted in the overall probabilities of at least a break-even on supplemental feed cost being 0.78 and 0.69 for the 0.9 and 1.8 kg/d supplementation rates when the mean feed price, including delivery, was $148/909 kg, respectively. As feed cost increased, the probability of a break-even decreased. The rate of change in probability was −0.007 and −0.013 as feed cost increased for the 0.9 and 1.8 kg/d supplementation rates, respectively. At a feed price of $130/909 kg, the break-even probability-based feed cost for 0.9 kg/d supplementation was 0.8. The break-even probability fell to 0.65 as feed price approached $206/909 kg.

Table 5. Simulated means ± SD for additional return from providing dried distillers grains plus solubles to calves grazing bermudagrass pasture

	Supplementation rate, kg/d (as fed)		
Item	0.0	0.9	1.8
Calf cost, $/calf	580.60 ± 52.65	580.60 ± 52.65	580.60 ± 52.65
Income, $/calf	642.90 ± 56.11	674.80 ± 55.97	681.00 ± 56.85
Feed cost, $/calf		12.45 ± 0.79	24.89 ± 3.58
Initial return,[1] $/calf	62.34 ± 28.24	81.75 ± 37.02	75.51 ± 37.57
Feed interest, $/calf		0.17 ± 0.02	0.34 ± 0.05
Added return,[2] $/calf		19.28 ± 25.21	12.87 ± 25.64
Break-even probability[3]	0.99	0.99	0.98
Added value probability[4]		0.78	0.69
Break-even probability at feed price,[5] $/909 kg			
130		0.80	0.74
140		0.79	0.72
184		0.73	0.59
206		0.65	0.52

[1]Initial return = income − calf and feed cost.

[2]Added return = initial return − feed interest − return of 0.0% BW treatment.

[3]Break-even probability is the percentage of times a break-even or positive return above initial calf cost and supplement cost was observed.

[4]Added value probability was the percentage of times the additional value from the supplemented calves was greater than or equal to zero after deducting the return from nonsupplemented calves.

[5]Break-even probability at feed price is the probability of a break-even on additional feed cost as feed price increased, determined by binomial fit analysis.

Winter Feeding Economics

Winter calf prices and feed prices were simulated based on the data presented in Table 2. Of the 500,000 original values generated, 451,468 remained after adjusting for the winter feed price-to-calf price ratio. Final delivered feed cost ranged from $134 to $221/909 kg. As stated in the methods section, hay disappearance was not measured but predicted from NRC (1996) equations. As a result, the 0.3, 0.6, and 1.2% treatments were charged for +1.4, +0.9, and −0.68 kg/d hay at $0.059/kg. A reduction in hay intake with an increased level of DDGS is in agreement with the results of Morris et al. (2005), Loy et al. (2008), Griffin et al. (2009), Leupp et al. (2009), and Winterholler et al. (2009). Both the 0.3 and 0.6% treatments were charged for a predicted increase in hay consumption compared with 0.0% DDGS. This contradicts the change in hay intake reported by Griffin et al. (2009) and Leupp et al. (2009). Griffin et al. (2009) reported a slight quadratic reduction in hay consumption as supplement intake increased. Their equation however was

Table 6. Simulated means ± SD for additional return from providing dried distillers grains plus solubles to calves consuming low-quality hay

	Supplementation rate, % of BW (as fed)			
Item	0.0	0.3	0.6	1.2
Calf cost, $/calf	524.20 ± 41.47	524.20 ± 41.47	524.20 ± 41.47	524.20 ± 41.47
Income, $/calf	541.70 ± 43.31	578.80 ± 47.69	576.60 ± 50.16	591.00 ± 49.95
Feed cost, $/calf		9.79 ± 1.31	19.58 ± 2.62	39.15 ± 5.24
Initial return,[1] $/calf	17.50 ± 11.43	44.81 ± 14.90	32.82 ± 16.48	27.65 ± 18.43
Feed interest, $/calf		0.13 ± 0.02	0.26 ± 0.04	0.53 ± 0.07
Hay adjustment,[2] $/calf		−6.64	−4.43	+3.32
Added return,[3] $/calf		20.54 ± 7.38	10.63 ± 9.33	12.92 ± 13.35
Break-even probability[4]	0.94	0.99	0.98	0.93
Added value probability[5]		0.99	0.87	0.83
Break-even probability at feed price,[6] $/909 kg				
135		0.99	0.92	0.93
167		0.99	0.86	0.82
185		0.99	0.81	0.71
221		0.99	0.68	0.45

[1]Initial return = income − calf and feed cost.

[2]Hay adjustment represents the value of additional hay consumed or conserved based on NRC (1996) level 1 intake prediction.

[3]Added return = initial return + hay adjustment − feed interest − return of 0.0% BW treatment.

[4]Break-even probability is the percentage of times a break-even or positive return above initial calf cost and supplement cost was observed.

[5]Added value probability was the percentage of times the additional value from the supplemented calves was greater than or equal to zero after deducting the return from nonsupplemented calves.

[6]Break-even probability at feed price is the probability of a break-even on additional feed cost as feed price increased, determined by binomial fit analysis.

based on a 0.5 kg/d ADG response for nonsupplemented cattle among 28 treatment means. Leupp et al. (2009) reported a linear reduction in DMI. Their DMI was based on a digestion study and there was not a corresponding performance study. The performance of nonsupplemented calves in the present study was 0.45 kg/d less than that reported by Griffin et al. (2009), yet the first-level supplementation response was 0.13 kg/d greater for cattle in this study. This may suggest a possible positive associative effect in the current study between the low-level DDGS supplementation and hay intake. Therefore, NRC (1996) level 1 predictions were chosen to model the changes in hay consumption for economic comparisons.

Providing DDGS in addition to hay at 0.3% BW resulted in an additional return of $20.54 ± 7.38 (Table 6). Compared with nonsupplemented calves, providing DDGS at 0.6% BW increased return by $10.63 ± 9.33 and 1.2% BW DDGS returned $12.92 ± 13.35 per calf. Increasing DDGS increased return variability. Both the 0.6 and 1.2% BW supplementation rates had a lower additional return than the 0.3% BW supplementation rate. Although the 1.2% BW provided the greatest increase in BW gain, the additional value of BW gain may not be sufficient to compensate for the greater feed cost. The interpretation of the costs and returns at the higher DDGS rate can be influenced by the interpretation of hay cost versus DDGS cost and whether the value of hay is considered a cost savings because of supplementation or whether the value of hay is considered a loss if unused hay cannot be conserved for future use.

The value of calves in February was greater than the November value of calves wintered on hay only 94% of the time. The average return above the initial calf cost ($17.50) would be easily absorbed by hay and other variable costs. The supplemented groups had a break-even or positive return above initial calf and supplement costs 93 to 98% of the time, with a greater return above specified costs available for hay and other variable costs. After factoring in the added calf value without supplementation, the probability of increasing return was 0.99, 0.87, and 0.83 for the 0.3, 0.6, and 1.2% BW supplementation rates, respectively. Supplement price had the greatest effect on return at the 1.2% BW supplementation rate. Because of the net improvement in BW gain at the 0.3% BW supplementation rate, supplementation with DDGS was profitable even at prices exceeding $200/909 kg. However, binomial regression analysis indicated that the probability of a break-even decreased ($P < 0.01$) by 0.019 and 0.032 as DDGS price increased for the

0.6 and 1.2% BW supplementation rates, respectively.

IMPLICATIONS

Supplementing calves grazing bermudagrass with DDGS when adequate forage was available still increased performance and returns at the 0.9 kg/d supplementation rate (as-fed basis), but returns diminished at the 1.8 kg/d supplementation rate. Increasing DDGS up to 1.2% BW for stocker calves fed low-quality hay increased growth performance and returns. However, the 0.6 or 1.2% BW rate may not be as profitable as the 0.3% BW rate when the DDGS price is high.

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