

THE EFFECTS OF PROTEIN SUPPLEMENTATION ON PERFORMANCE OF BEEF
CATTLE GRAZING NATIVE MIXEDGRASS RANGE IN WESTERN KANSAS

by

CARSON M^CMULLEN

B.S., Kansas State University, 2013

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Approved by:

Major Professor
John Jaeger

Copyright

CARSON M^CMULLEN

2015

Abstract

Cattle consuming low-protein forage (<7% CP) require additional supplemental protein to maintain BW and BCS. Daily delivery of protein supplements places undue financial burden on cattle producers. Supplementing cows as infrequently as once every 6 d) has resulted in similar changes cow BW and BCS when compared to daily supplementation. As calving season nears, producers may wish to increase supplementation frequency. The responses to a change in supplementation frequency during the third trimester of gestation have not been widely investigated. Therefore, our objective in Study 1 was to evaluate the effect of altering supplementation frequency during late gestation on performance of spring-calving cows grazing low-quality, dormant native range and supplemented with dried distillers grains with solubles (DDG). Angus × cows (n = 238; mean age = 6 ± 2.5 yr; average initial BW = 618 ± 56.2 kg; average initial BCS = 5.7 ± 0.03) were stratified by age, BW, BCS, and assigned randomly to 1 of 4 treatments: 1) DDG daily (**D1**); 2) DDG once every 6 d (**D6**); 3) DDG daily from d 1 to d 60 and then every 6 d (**D1-D6**); 4) DDG every 6 d from d 1 to d 60 and then daily (**D6-D1**). Treatments were initiated 100 d prior to expected onset of calving. Cow BW and BCS were measured every 28 d. Cows were sorted daily before supplementation at 0830 h. Supplement delivery was calculated to meet dietary CP requirements. Increasing supplementation frequency 28 d prepartum negatively affected final BW and BW change from d 61-88 for the D6-D1 supplementation group ($P < 0.05$) compared to other supplementation groups. Cow BW change for the study (d 1-88) was also less ($P < 0.02$) for the D6-D1 group compared to other groups but was also affected ($P < 0.01$) by year. Under the conditions of our study, increasing supplementation frequency 28 d before calving was not a viable means of increasing prepartum cow performance.

The development of replacement heifers is a significant expense for cow-calf producers. Reducing the cost of heifer development programs while achieving high pregnancy rates is an industry-wide goal. Therefore, our objective in Study 2 was to determine if DDGS was a viable replacement for an oilseed meal-based protein supplement when developing heifers on low-quality, dormant native range. Treatments consisted of daily supplementation of either 1.65 kg DM DDG (**DDG**; 0.57 kg CP) or 1.37 kg DM of a 73.6% soybean meal and 26.4% rolled sorghum grain mixture (**SBM-S**; 0.56 kg CP). Treatments were administered from 1/15 until 4/8 (84 d). Initial BW and BCS were not different between treatments ($P \geq 0.29$). Final BW and BCS also did not differ ($P \geq 0.55$) between treatments; moreover, rates of BW and BCS change were not different ($P > 0.30$) between treatments. Proportions of heifers pubertal before ovulation synchronization, first service conception rates, and final pregnancy rates were not affected ($P > 0.40$) by treatment. Under the conditions of our study supplemental CP fed at a rate of approximately 0.56 kg daily was sufficient to promote growth and BCS change adequate for optimal reproductive performance; moreover, supplement ruminal degradability of CP did not influence heifer performance over an 84-d development period.

Table of Contents

List of Tables	vii
Acknowledgements.....	viii
Dedication.....	ix
Chapter 1 - Review of Literature – Protein supplementation of Beef Cattle.....	1
Introduction.....	1
Effects of Supplementation.....	1
Protein Degradability	4
Frequency of Supplementation	9
Supplement Source	12
Dried Distiller’s Grains with Solubles.....	14
Summary.....	15
Literature Cited.....	16
Chapter 2 - Effects of Altering Supplementation Frequency during the Pre-partum Period of Beefs Cows Grazing Dormant Native Range	20
Abstract.....	21
Introduction.....	21
Materials and Methods.....	22
Results and Discussion	25
Implications	27
Literature Cited.....	28
Chapter 3 - Performance of beef replacement heifers supplemented with dried distillers grains or a mixture of soybean meal and ground sorghum grain.....	33
Kansas State University, Manhattan 66506.....	33
Abstract.....	34
Introduction.....	34
Materials and Methods.....	36
Results and Discussion	39
Implications	40

Literature Cited..... 42

List of Tables

Table 2.1 Nutrient composition (DM basis) of native range and dried distillers grain with solubles (DDG).	30
Table 2.2 Performance of spring-calving beef cows supplemented with dried distillers grain (DDG) during the last trimester of gestation.	31
Table 3.1 Nutrient composition (DM basis) of native range, dried distiller’s grains with solubles (DDG), and a mixture of soybean meal and ground sorghum grain (SBM-S).	43
Table 3.2 Growth performance of beef replacement heifers supplemented with dried distillers grains with solubles (DDG) or a mixture of soybean meal and ground sorghum grain (SBM-S).. ..	44
Table 3.3 Reproductive performance of beef replacement heifers supplemented with dried distillers grains with solubles (DDG) or a mixture of soybean meal and ground sorghum grain (SBM-S).. ..	45

Acknowledgements

Graduating with an advanced degree from Kansas State University has been a goal of mine for some time now. Achieving this goal would have been impossible without the help of others. I would like to first thank my mother Karen M^cMullen Hageman, for all the sacrifices she made to give me the opportunities she never had. Without her support and guidance I would have never made it this far.

Working with the faculty at Kansas State University towards completing this degree has been a fantastic experience. Dr. Jaeger's guidance through this process has forced me to develop a critical thinking ability a skill set I will use for the rest of my life, not only in future job but in all phases of life. A big thanks to Dr. Olson as well. Dr. Olson not only helped get me into graduate school but has also help advise me through my six years at Kansas State. I would also like to thank Dr. Harmony and Dr. Waggoner for their guidance and support throughout my graduate studies.

I would also like to thank the staff at the Western Agriculture Research Center in Hays for their help with the research trials I was involved in. Justin Boltle, Wayne Schmidtberger, Tom Lang, and Matt Woydziak all spent the better part of a year to helping conduct the trials that are included in this report. Finally, I would like to thank Harvey Jansonius who like the others helped with the following research trials, but also taught me all the one-liners I know.

Dedication

I would like to dedicate this thesis to my late father Patrick M^cMullen who gave me his passion for agriculture.

Chapter 1 - Review of Literature – Protein supplementation of Beef Cattle

Introduction

Spring-calving beef cows grazing low-quality (< 7% CP) dormant forage during late gestation are typically unable to meet their maintenance requirements for protein. Insufficient dietary protein reduces forage intake, digestibility and cow performance; therefore, cow-calf producers typically provide a dietary protein supplement during these periods to ensure an acceptable level of animal performance. Nutrient supplementation when forage quality is poor or limited is one of the largest expenditures for forage-based beef producers (Dhuyvetter, 2012). Reducing supplementation frequency may reduce costs (i.e., labor and fuel) associated with supplementation. Recent research reported that low-cost byproducts were a viable replacement for traditional oilseed-based protein supplements (Bennett et al., 2013). Combined, these strategies can result in an economical and efficient means of protein supplementation for cows grazing low-quality dormant forage.

Effects of Supplementation

Ruminant animals have a unique synergistic relationship with their ruminal microbial population. Ruminants ingest feedstuffs that are not capable of being broken down by mammalian enzyme systems in the abomasum and small intestine; however, contact with the microbial enzyme systems within the rumen alters ingested feedstuffs allowing for digestion prior to the time they enter the hindgut. The majority of a grazing cow's diet is carbohydrates in the form of plant fiber. Inside the rumen, cellulose, hemicellulose, and pectin are broken down into hexoses, chiefly glucose. Hexoses are then fermented (the microbial metabolism of organic

substances in the absence of oxygen) resulting in the end products of volatile fatty acids (VFA), CO₂, and CH₄. The gases are expelled via eructation while the VFA are either absorbed across the ruminal wall and used as an energy source by the host animal or combined with free NH₃ in the rumen to synthesize microbial protein.

Free NH₃ in the rumen is the result of protein catabolism. Ingested ruminally-degradable protein (RDP) is subject to microbial enzymatic attack in the rumen that liberates individual amino acids (AA). The liberated AA is then further catabolized, resulting in NH₃ and a VFA. The first-limiting nutrient of cattle grazing dormant native range is protein, more specifically RDP. When dietary protein is less than 7% of plant DM, the rumen may become nitrogen deficient, resulting in decreased microbial activity, reduced intake, and reduced diet digestibility (Mathis and Sawyer, 2007). Dormant forages are also often highly-lignified, which presents a physical barrier to attack by ruminal microbial enzymes further limiting NH₃ availability (Russell and Hespell, 1981).

Mathis et al. (1999) found that protein supplementation improved total-tract DM digestibility of low-quality forage diets which in turn, increased animal performance when grazing low-quality forage. In a digestion trial, 20 ruminally-fistulated steers were fed a basal diet of tallgrass-prairie hay (5.3% CP) and 1 of 4 levels of soybean meal (SBM; 48.5% CP). Increasing levels of soybean meal supplementation resulted in a quadratic increase in OM and NDF digestibility. In a related cow-performance trial, 120 beef cows (369 kg) grazing dormant tallgrass-prairie (2.7% CP) were supplemented with 1 of 8 levels of SBM ranging from 0.08 to 0.48% of BW. Supplements were fed for 69 d from early December until the start of calving season. Body condition score (BCS) and BW increased quadratically, with cows receiving SBM at 0.08% of BW losing the most weight and condition. Losses diminished as SBM

supplementation increased to 0.32% of BW. Additional SBM did not improve BW or BCS when compared to supplemental SBM supplied at 0.32% of BW.

The diminishing-return effect of protein supplementation reported by Mathis et al. (1999) led to the development of a broken line model that shows the need for supplemental protein to cattle that consume forages less than 7% CP. Researchers also strived to identify the optimal range of CP concentration for protein supplements. Less CP-dense supplements may not provide enough N per unit of weight to optimize forage intake and digestibility. DelCurto and others (1990) evaluated supplementation of graded concentrations of CP to third trimester spring-calving beef cattle grazing dormant native range. They provided one of three isocaloric protein supplements 13, 25, and 39% CP, designed to supply 40.6, 81.3, and 121.9% of CP requirements respectively. These researchers noted a quadratic relationship between BW change and protein concentration from the beginning of the trial (mid-November) until the onset of calving in February. In a similar experiment, Beaty and others (1994) reported that cattle receiving supplements with 12% CP had longer calving intervals than cows receiving supplements with 20, 30, or 39% CP. They also noted linear effects of CP concentrations on DM intake, DM digestibility, and NDF digestibility.

These results agree with previous research (Hannah et al., 1991) which reported that moderate-CP supplements (27.1%) increased forage intake, digestion, and duodenal N flow compared to low-CP supplements (12.8%). Wickersham et al. (2008a) noted that changes in N metabolism for grazing cattle were driven by dietary RDP availability. Increased intake and digestion resulted from increased supplemental N intake and increased availability of forage energy; however, DelCurto et al. (1990) clearly demonstrated that low-CP supplements generally did not contain enough N to achieve an acceptable level of performance. Therefore, to optimize

forage intake and digestibility, protein supplements should contain at least 30% CP (Heldt, 1998). Heldt, using meta-analysis techniques, summarized the results of 141 treatment averages from 31 studies; and concluded that cattle consuming supplements with greater than 30% CP had approximately 50% greater forage OM intake than unsupplemented cattle; moreover, OM intake was greater for supplements containing 30% CP than for those containing 30 to 20% CP, 15 to 20% CP, or < 15% CP. Low-CP supplements (< 15% CP) produced only marginal increases in OMI over no supplementation.

Protein Degradability

When cattle graze protein-deficient forages, ruminal ammonia is typically below the level required for optimal forage intake and digestibility; therefore, animals require supplemental protein to increase forage intake and digestibility. In such cases, it is important to select supplements that are degraded ruminally and, if needed, also supply protein that is not degraded ruminally and is capable of supplying specific amino acids to the small intestine (NRC, 1985). Unlike RDP, ruminally-undegradable protein (RUP) undergoes degradation to dipeptides and amino acids in the duodenum which can then be absorbed from the lumen of the gut. Post-absorption, these dipeptides and amino acids can be utilized by the animal in α -amino form or catabolized to NH_3 and VFA. While NH_3 cannot be used on a cellular level, it can be transported to the liver, packaged as urea, and recycled back to the rumen where it can contribute to the ruminal ammonia pool (Bandyk et al., 2001). The differences in sites of degradation and absorption between RDP and RUP could potentially affect how ruminants consuming protein-deficient forages will perform when supplemented various protein sources.

Köster et al. (1996) demonstrated the importance of supplementing RDP to a N-deficient rumen. These researchers used 5 ruminally-fistulated steers in a 5×5 Latin square experiment.

Tallgrass-prairie hay (1.9% CP) intake, ruminal fermentation, and extent of digestion were measured when increasing amounts of supplemental RDP were provided. Forage OMI increased quadratically with increasing supplemental RDP and peaked when 540 g/d RDP was provided. Ruminal OM and NDF digestion increased with the first addition of RDP (180 g RDP/D) but exhibited only moderate and somewhat variable responses when additional RDP was provided.

Sletomoen-Olson and others (2000) reported that pre-partum beef cows supplemented with a constant amount of RDP (211 g/kg DM) plus 1 of 3 levels of RUP (53, 233, or 412 g/kg DM) had similar forage OMI, BW, and BCS between treatments when consuming low-protein prairie hay (5.8% CP). In a subsequent study, Bailey et al. (2011) fed pregnant cows grazing dormant native range (2.31% CP) 1 of 3 protein supplements that supplied similar amounts of RDP (0.09% BW/d) but different amounts of RUP (0.05%, 0.07%, or 0.09% BW/d). These researchers reported no treatment differences in BCS, ADG, pregnancy rate, calf birth weight, or weaning weight between supplements. In a complementary digestion study, cows were fed the same supplements while consuming tallgrass-prairie hay (2.13% CP). Forage DMI, total DMI, and total digestible DMI of cows consuming the low RUP supplement were greater than that of cows consuming the supplements with moderate or high rates of RUP. Total tract DM digestibility by cows fed the highest level of RUP was greater than by cows fed the lowest level of RUP; however, differences were minor and of questionable biological significance. These results were interpreted to suggest that when dietary RDP is sufficient to maximize ruminal fermentation within the constraints of dietary energy availability, additional supplemental RUP appears unwarranted.

Bandyk et al. (2001) examined the effects of RDP and RUP supplementation by infusing casein (89.9% CP), a highly-degradable protein source, either ruminally or post-ruminally to

fistulated steers consuming tallgrass-prairie hay (3.4% CP). Prior to supplementation, steers were adapted to the hay diet without supplemental protein for 7 d. Casein was infused into either the rumen or the abomasum from d 8 to 14. Forage OMI increased from d 8 to d 14 in steers receiving the ruminal casein infusion; however, forage OMI did not increase until d 12 to 14 for steers receiving the abomasal casein infusion. In addition, the increase in forage OMI among the steers receiving the abomasal casein infusion was roughly half the magnitude of that by the ruminally-infused steers. These data were interpreted to suggest that direct ruminal availability of N allowed immediate increases in ruminal fermentation which were followed by a rapid intake response. In contrast, post-ruminal infusion of protein requires that amino acids in excess of the metabolic requirement to be deaminated, with resulting ammonia incorporated into urea in the liver. The lag in intake response occurred because of the delay in delivery of urea being recycled to the rumen.

Wickersham et al. (2004) examined the effects of combinations of ruminal and post-ruminal infusions of casein to steers consuming low-protein hay (5.3% CP). The steers were used in a two-treatment, two-period cross-over design nested within a 6-treatment completely randomized experiment. Ruminally-infused casein (0 to 1.45 g CP/kg BW daily) was used in combination with 2 levels of post-ruminal casein infusion (0 or 0.87 g CP/kg BW daily). Protein infused into the rumen resulted in a linear increase in hay OMI, total digestible OMI, and OMD. Protein infused post-ruminally tended to increase hay OMI, total digestible OMI, and OMD. A quadratic increase in NDF digestion occurred with ruminal protein infusion while post-ruminal protein infusion did not affect NDF digestion. These authors concluded that both ruminal and post-ruminal protein infusion improved forage intake and digestion; however, the response from ruminal infusion was greater than for post-ruminal infusion.

Atkinson and others (2010a) examined the effect of protein degradability and supplementation frequency on intake and digestibility of crested wheatgrass hay (4.2% CP) by supplementing wethers with either RDP (isolated soy protein) every 24 h, RDP every 48 h, RUP (corn gluten meal) every 48 h, or a 50:50 mix of RDP and RUP every 48 h. Wethers supplemented with the 50:50 mixture of RDP and RUP every 48 h had greater OMD than other treatments but, unlike previous research (Bandyk et al. 2001), OMI was not different between the RDP and RUP treatments. These contradictory results may have occurred because of differences in the nature of forage protein degradability between cool-season and warm-season grass hays or because of inherent differences in intake and protein requirements between cattle and sheep. Alternatively, a mixture of RDP and RUP supplemented every 48 h may improve ruminal digestion over either RDP or RUP alone. The observed increment of ruminal digestion may have been the result of a more stable N supply to the ruminal microbes.

Wickersham and others (2008b) evaluated the effect of frequency and amount of RDP supplementation on urea recycling in steers consuming low-protein forage (4.7% CP). Steers were ruminally infused with casein daily (61 or 183 mg of N/kg BW) or every third day (61, 183, or 549 mg of N/kg BW). Supplementation with RDP resulted in a linear increase in forage OMI and TDOMI independent of supplementation frequency. In a subsequent study, Wickersham and others (2009) examined the effects of RUP supplementation on urea kinetics in steers consuming low-quality forage (4.7% CP). Casein was infused abomasally (0, 62, 124, or 186 mg N/kg BW daily). Forage OMI and TDOMI increased linearly as post-ruminal protein supply increased.

Non-protein nitrogen, often fed in the form of urea, can be used to replace part of the natural protein component of a supplement because it is less expensive per unit of nitrogen.

Fibrolytic microbes require ammonia as an N source. When urea is ingested, it is degraded to ammonia and CO₂ in the rumen; however, feeding urea improperly can result in impaired performance or ammonia toxicity due to its relatively high N content and rapid ruminal degradability (Mathis and Sawyer, 2003).

Farmer et al. (2004) studied the effects of supplementation frequency and urea level on ruminal fermentation parameters and performance of pregnant cows grazing dormant winter range. Cows were fed 1 of 4 supplements (30% CP) daily or 3 d/wk that contained increasing proportions of RDP from urea (0, 15, 30, or 45%). A frequency × urea level interaction was observed for prepartum BW changes. As the proportions of urea increased, prepartum BW loss increased quadratically for cows supplemented 3 d/wk. In addition, cows supplemented 3 d/wk with 45% of RDP coming from urea lost significantly more weight than cows supplemented daily at that level (101.9 vs. 62.9 kg). These authors concluded that this effect was likely related to reduced supplement intake. Cows, in their final trimester of pregnancy, supplemented daily refused an average of 4% of the supplement offered to them, whereas cows supplemented 3 d/wk refused an average of 44% of their supplement. Refusals increased during the month before calving. Cows supplemented daily with 45% of RDP in the form of urea increased refusals from 4 to 23%. In contrast, cows fed the same supplement 3 d/wk increased refusals from 44 to 62%. For infrequent supplementation, these researchers recommended not exceeding 15% of supplemented RDP being in the form of urea.

Köster et al. (2002) conducted 4 experiments to evaluate the effects of increasing the proportion of supplemental N from urea by steers and prepartum cows consuming low-protein forage. These experiments were intended to have four levels of supplemented with increasing levels of RDP in the form urea: 0, 20, 40, and 60%. However, refusals to consume the 60%

supplement by cows grazing tallgrass prairie resulted in the elimination of this treatment in Experiments 1 and 2. In Experiment 1, steers were fed supplements that contained 0, 20, or 40% of the RDP from urea; OMI, OMD, and NDFD in that study were not affected by urea level. In Experiment 2, prepartum cows were fed the same supplements as in the first experiment; the proportion of RDP from urea had no effect on cow BW or BCS. In Experiment 3, cows were fed forage sorghum and supplemented protein that contained 0, 20, 40, or 60% of the RDP fraction as urea. Authors did not observe any relationship between urea levels and calf ADG, weaning weight, and cow pregnancy rate; however, the differences in forage quality may have affected supplement intake. The forage sorghum in Experiment 3 contained 69% more CP than the tallgrass prairie available in Experiment 2 and therefore had higher inherent intake and digestion potential without supplemental protein. In the final experiment, cows were fed isonitrogenous supplements with 0, 15, 30 or 45% of the RDP fraction coming from urea. Treatment did not affect pregnancy rate, calf birth weight, or calf ADG. Köster et al. (2002) concluded that urea could replace between 20 and 40% of the RDP in a high-protein (30%) supplement fed on a daily basis without significantly altering supplement palatability or animal performance. After compiling previous research examining NPN supplementation to gestating cows grazing low-quality forages, Mathis and Sawyer (2003) suggested a more conservative approach of no more than 25% of RDP coming from urea when supplements are fed daily.

Frequency of Supplementation

Reducing supplementation frequency reduces input costs (i.e., labor and fuel) associated with protein supplementation without negatively impacting animal performance, thus it has become a common supplementation strategy in the beef industry. Infrequently supplemented animals consume a large amount of N on the days in which they are supplemented. Ruminant N

concentrations likely exceed the immediate demands of the ruminal microbial population (Van Soest, 1994). On non-supplementation days, the N requirement of the ruminal microbial population is satisfied by N recycled to the rumen as endogenously produced urea via the saliva or the ruminal capillary bed (Krehbiel et al., 1998).

Wickersham and others (2008b) evaluated the effect of supplementation frequency on urea recycling in steers consuming low-protein forage (4.7% CP). Ruminally-fistulated steers were infused with casein daily or every 3 d. The steers supplemented every 3 d tended to have greater apparently-absorbed N, retained N, NDF digestibility, and recycled urea-N than steers that were supplemented daily. In contrast, steers supplemented every 3 d had less microbial N flow to the duodenum when compared to steers supplemented daily.

Bohnert et al. (2002a) reported that wethers consuming low-protein meadow hay (5.2% CP) and supplemented with soybean meal (52.8 % CP) as infrequently as once every 6 d while had N retention levels similar to wethers supplemented daily. These researchers reported a linear decrease in daily N balance as supplementation frequency decreased, likely caused by lower average daily N intake as well as increased N fecal loss. This was supported by Atkinson et al. (2010b) who supplemented protein to wethers consuming low-protein crested wheatgrass hay (4.2% CP) either daily or every other d and reported no difference in N retention or N digestibility.

Farmer et al. (2001) reported that frequently protein supplemented animals had greater OMI and OM digestibility than infrequently supplemented animals which supported the claim that infrequently supplemented animals had less favorable daily N balance. These researchers allowed 16 ruminally-fistulated steers (BW = 257 kg) *ad libitum* access to tallgrass prairie hay (73.5% NDF, 4.8% CP) and supplemented them 7, 5, 3, or 2 d/wk with a sunflower meal-based

pellet (43% CP). They reported a linear increase in total OMI, forage OMI, digestible OMI, OM digestibility, and NDF digestibility as supplementation frequency increased. In contrast, Atkinson and others (2010a; 2010b) did not observe a decrease in OMD as supplementation frequency decreased; however, supplementation events were more frequent in their experiments than those previously discussed. Atkinson et al. (2010a) supplemented wethers consuming low-protein crested wheatgrass hay (4.2% CP) either daily or every other day and examined these effects on extent of digestion. They reported daily supplementation increased duodenal OM flow, decreased total-tract OM digestion, and decreased microbial efficiency. Conversely, alternate day supplementation increased apparent and true ruminal OM digestibility as a percent of intake. In a complementary study, however, Atkinson et al. (2010b) reported no differences in OM intake, OM digestion, NDF intake, and NDF digestion between frequently and infrequently supplemented animals.

Beatty et al. (1994) fed 8 ruminally-fistulated steers (456 kg) wheat straw (3.1% CP) *ad libitum* while supplementing increasing levels of SBM either daily or 3 d/wk. Steers that were supplemented 3 d/wk had a decreased DMI but had increased total-tract DMD and NDF digestibility when compared to steers supplemented daily. Authors proposed that daily supplementation increased the fermentable contents of the rumen, thus increasing passage rate. On non-supplementation days infrequently supplemented animals only consumed low-quality forage, which may have decreased passage rate and allowed for more complete digestion.

Farmer et al. (2001) evaluated performance of spring-calving cows grazing dormant tallgrass prairie range (3.8% CP) that were supplemented 7, 5, 3, or 2 d/wk with a sunflower meal based pellet (43% CP). They reported a linear decrease in BW loss through calving as supplementation frequency increased; however, the differences in performance between cows

supplemented 2 d/wk and 7 d/wk was marginal (14.8 kg). These findings are similar to those of Beaty et al. (1994) who also reported that there were small increases in performance by grazing, pregnant cows supplemented daily compared to cows supplemented 3 d/wk.

Huston et al. (1999) supplemented cottonseed meal to cows consuming low-protein native range 7, 3, or 1 d/wk and did not observe any performance differences due to supplementation frequency. Bohnert et al. (2002b) also reported supplementation frequency had no effect on BW or BCS of cows supplemented daily, once every 3 d, or once every 6 d while consuming low-protein hay (5% CP). Similarly, Bennett et al. (2013) did not report any difference in BW or BCS among cattle supplemented dried distiller grains with solubles daily, once every 3 d, or once every 6 d.

Schauer et al. (2005) compared unsupplemented cattle with cattle supplemented daily or once every 6 d. They reported protein supplementation frequency had little effect on grazing distribution, DMI, and forage harvest efficiency; moreover, supplementation increased BW gain, BCS gains, and decreased grazing time compared to no supplementation.

Supplement Source

Choosing a protein supplement is partially dependent on forage availability. When forage is abundant but forage protein level is low, the objective should be to stimulate forage intake by supplementing a protein source high in RDP (Mathis, 2003). When forage is in limited supply, energy should be supplemented along with protein if necessary. Supplementing energy generally has negative or substitutionary effects on forage intake. The former condition can be avoided when supplements are formulated to minimize negative effects on cellulolytic fermentation. Grains contain energy in the form of starch. Supplying a large amount of starch increased ruminal populations of amylolytic bacteria and reduced ruminal ammonia availability for

fibrolytic bacteria. This resulted in reduced forage digestibility (Heldt, 1998). Olson et al. (1999) also reported a linear decrease in forage OM, NDF, and DOM intakes in response to starch supplementation. Mathis and Sawyer (2003) suggested using energy supplements in the form of digestible fiber (e.g., wheat middlings, soybean hulls, or wheat bran) to maintain a ruminal environment conducive to cellulose fermentation.

Forage quality and anti-quality factors must be considered when devising a supplementation strategy. Bohnert and others (2002a) fed low-protein hay (5.2% CP) to lambs. Treatments included an unsupplemented control, an RDP-supplemented group (soybean meal; 52.8% CP), and an RUP-supplemented group (expeller-processed soybean meal, blood meal, and molasses; 59.8% CP). The RDP treatment was formulated to provide 100% of RDP requirements and the RUP treatment was formulated to be isonitrogenous to the RDP treatment. They noted no difference in total OM intake, hay intake, or total DMI between treatment groups and proposed that protein content was not the only factor limiting intake under the conditions of their study. They noted that NDF intakes were relatively large (13g/kg BW) across treatments. Mertens (1985) proposed that NDF could be used to indicate ruminal fill and that the capacity of beef cows to consume NDF was limited to approximately 1.2% of BW. Ferrell et al. (1999) supplemented RDP and energy (soybean meal, dried molasses, and cornstarch) or RUP and energy (blood and feather meal, cornstarch, and dried molasses) to sheep consuming low-protein forage (4.3% CP). They noted supplemental protein type did not influence forage DMI. Similar to Bohnert et al. (2002a), these authors attributed the lack of an intake response to supplementation to relatively high NDF intakes (1.3% of BW) across treatments.

Dried Distiller's Grains with Solubles

The use of DDGS in livestock diets has dramatically increased due to the recent expansion of the ethanol industry. Dried distiller's grains with solubles are a corn- or sorghum-based byproduct of ethanol production and have become an economically-attractive replacement to the typically more expensive, traditional oilseed protein meals. Unlike their cereal grain sources, DDGS are nearly free of starch and the associated negative effects on forage digestion (Morris et al., 2005). Conversely, they are inherently lower in protein than oilseed meals. Dried distillers grains may also undergo a Maillard reaction during the drying process which denatures proteins and renders them ruminally undegradable. The results of this non-enzymatic browning is a greater proportion of RUP (% of total CP) than oilseeds (Shurson and Noll, 2005; NRC, 2000).

Stalker et al. (2009) compared daily supplementation with DDGS to supplementation every 2 d or every 3 d. As supplementation frequency decreased, DMI, DMD, OMD, and NDF digestibility declined. These researchers concluded the reduction in fiber digestion and its impact on intake was likely a result of the elevated crude fat content of DDGS (10.2%).

Morris et al. (2005) examined the effects of DDGS supplementation on growing heifers fed either medium- or high-quality forages by providing increasing levels of DDGS (0 to 2.72 kg/d). Supplement efficiency was greater for heifers fed the low-quality forage than for heifers fed the high-quality forage.

Winterholler et al. (2012) supplemented DDGS or a wheat middlings / cottonseed meal mixture to spring calving beef cows consuming low-protein hay (5.6%). They reported both groups had similar changes in BW and BCS before calving.

Summary

Winter supplementation practices for beef cattle are a function of forage quality and quantity and the physiological state of the animal. After addressing those variables, it is possible to develop a suitable supplementation strategy by supplementing DDGS on an infrequent basis.

Literature Cited

- Atkinson, R. L., C. D. Toone, and P. A. Ludden. 2010a. Effects of ruminal protein degradability and frequency of supplementation on site and extent of digestion and ruminal fermentation characteristics in lambs fed low-quality forage. *J. Anim. Sci.* 88:718-726.
- Atkinson, R. L., C. D. Toone, T. J. Robinson, D. L. Harmon, and P. A. Ludden. 2010b. Effects of ruminal protein degradability and frequency of supplementation on nitrogen retention, apparent digestibility, and nutrient flux across visceral tissues in lambs fed low-quality forage. *J. Anim. Sci.* 88:727-736.
- Bailey, E. A., E. C. Titgemeyer, R. C. Cochran, T. J. Jones, and K. C. Olson. 2011. Influence of ruminally-undegradable protein supplementation and advancing gestation on forage use and performance by beef cows consuming low-quality warm-season forage. *Proc. Western Sec. Amer. Soc. Anim. Sci.* 62:217-221.
- Bandyk, C. A., R. C. Cochran, T. A. Wickersham, E. C. Titgemeyer, C. G. Farmer, and J. J. Higgins. 2001. Effect of ruminal vs postruminal administration of degradable protein on utilization of low-quality forage by beef steers. *J. Anim. Sci.* 79:225-231.
- Beaty, J. L., R. C. Cochran, B. A. Lintzenich, E. S. Vanzant, J. L. Morrill, R. T. Brandt Jr., and D. E. Johnson. 1994. Effect of frequency of supplementation and protein concentration in supplements on performance and digestion characteristics of beef cattle consuming low-quality forages. *J. Anim. Sci.* 72:2475-2486.
- Bennett, B. W., J. W. Waggoner, J. R. Jaeger, A. K. Sexten, and K. C. Olson. 2013. Effect of supplementation frequency on performance of spring-calving cows supplemented with dried distillers grain. *Proc. West. Sec. Amer. Soc. Anim. Sci.* 64:97-102.
- Bohnert, D. W., C. S. Schauer, and T. DelCurto. 2002a. Influence of rumen protein degradability and supplementation frequency on performance and nitrogen use in ruminants consuming low-quality forage: Cow performance and efficiency of nitrogen use in wethers. *J. Anim. Sci.* 80:1629-1637.
- Bohnert, D. W., C. S. Schauer, S. J. Falck, and T. DelCurto. 2002b. Influence of rumen protein degradability and supplementation frequency on steers consuming low-quality forage: II. Ruminal fermentation characteristics. *J. Anim. Sci.* 80:2978-2988.
- DelCurto, T., R. C. Cochran, L. R. Corah, A. A. Beharka, E. S. Vanzant, and D. E. Johnson. 1990. Supplementation of dormant tallgrass-prairie forage: II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentrations. *J. Anim. Sci.* 68:532-542.
- Dhuyvetter, K. C. 2012. Differences between high, medium, and low profit producers: an analysis of 2007-2011 Kansas farm management association cow-calf enterprise. Kansas State Univ. Department of Agricultural Economics. AM-KCD-2012.03.

- Farmer, C. G., R. C. Cochran, D. D. Simms, E. A. Klevesahl, T. A. Wickersham, and D. E. Johnson. 2001. The effects of several supplementation frequencies on forage use and performance of beef cattle consuming dormant tallgrass-prairie forage. *J. Anim. Sci.* 79:2276-2285.
- Farmer, C. G., B. C. Woods, R. C. Cochran, J. S. Heldt, C. P. Mathis, K. C. Olson, E. C. Titgemeyer, and T. A. Wickersham. 2004. Effect of supplementation frequency and supplemental urea level on dormant tallgrass-prairie hay intake and digestion by beef steers and prepartum performance of beef cows grazing dormant tallgrass-prairie. *J. Anim. Sci.* 82:884-894.
- Ferrell, C. L., K. K. Kreikemeier, and H. C. Freetly. 1999. The effect of supplemental energy, nitrogen, and protein on feed intake, digestibility, and nitrogen flux across the gut and liver in sheep fed low-quality forage. *J. Anim. Sci.* 77:3353-3364.
- Hannah, S. M., R. C. Cochran, E. S. Vanzant, and D. L. Harmon. 1991. Influence of protein supplementation on site and extent of digestion, forage intake, and nutrient flow characteristics in steers consuming dormant bluestem-range forage. *J. Anim. Sci.* 69:2624-2633.
- Heldt, J. S. 1998. Effect of various supplemental carbohydrate sources on the utilization of low-quality tallgrass-prairie forage. PhD Diss. Kansas State University, Manhattan.
- Huston, J. E., H. Lippke, T. D. Forbes, J. W. Holloway, and R. V. Machem. 1999. Effects of supplemental feeding interval on adult cows in western Texas. *J. Anim. Sci.* 77:3057-3067.
- Köster, H. H., R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant, I. Abdelgadir, and G. St-Jean. 1996. Effect of increasing degradable intake protein on intake and digestion of low-quality tallgrass prairie forage by beef cows. *J. Anim. Sci.* 74:2473-2481.
- Köster, H. H., B. C. Woods, R. C. Cochran, E. S. Vanzant, E. C. Titgemeyer, D. M. Grieger, K. C. Olson, and G. Stokka. 2002. Effect of increasing proportion of supplemental N from urea in prepartum supplements on range beef cow performance and on forage intake and digestibility by steers fed low-quality forage. *J. Anim. Sci.* 80:1652-1662.
- Krehbiel, C. R., C. L. Ferrell, and H. C. Freetly. 1998. Effects of frequency of supplementation on dry matter intake and net portal and hepatic flux of nutrients in mature ewes that consume low-quality forage. *J. Anim. Sci.* 76:2464-2473.
- Mathis, C. P. 2003. Protein and energy supplementation to beef cows grazing New Mexico rangelands. Tech. Bull. No. 564. rev. ed. New Mexico State University Cooperative Extension, Las Cruces, NM.
- Mathis, C. P., R. C. Cochran, G. L. Stokka, J. S. Heldt, B. C. Woods, and K. C. Olson. 1999. Impacts of increasing amounts of soybean meal on intake and digestion by beef steers and performance by beef cows consuming low-quality tallgrass-prairie forage. *J. Anim. Sci.* 77:3156-3162.

- Mathis, C. P., and J. E. Sawyer. 2003. Urea in range cattle supplements. Tech. Bull. No. 583. rev. ed. New Mexico State University Cooperative Extension, Las Cruces, NM.
- Mathis, C. P., and J. E. Sawyer. 2007. Nutritional management of grazing beef cows. *Vet. Clin. North Amer. Food Anim. Pract.* 23:1-19.
- Mertens, D. R. 1985. Factors affecting feed intake in lactating dairy cows: From theory to application using neutral detergent fiber. *Proc. Georgia Nutr. Conf.* pp 1–18.
- Morris, S. E., T. J. Klopfenstein, D. C. Adams, G. E. Erickson, and K. J. Vander Pol. 2005. The effects of dried distillers grains on heifers consuming low or high-quality forage. *Nebraska Beef Cattle Report.* MP 83-A:18–20.
- NRC. 1985. Ruminant Nitrogen Usage. National Academy Press, Washington, DC.
- NRC. 2000. Nutrient Requirements of Beef Cattle. National Academy Press, Washington, DC.
- Olson, K.C., R. C. Cochran, T. J. Jones, E. S. Vanzant, E. C. Titgemeyer, and D. E. Johnson. 1999. Effects of ruminal administration of supplemental degradable intake protein and starch on utilization of low-quality warm-season grass hay by beef steers. *J. Anim. Sci.* 77:1016-1025.
- Russell, J. B., and R. B. Hespell. 1981. Microbial rumen fermentation. *J. Dairy Sci.* 64:1153-1169.
- Schauer, C. S., D. W. Bohnert, D. C. Ganskopp, C. J. Richards, and S. J. Falok. 2005. Influence of protein supplementation frequency on cows consuming low-quality forage: Performance, grazing behavior, and variation in supplementation intake. *J. Anim. Sci.* 83:1715-1725.
- Shurson, J., and Noll, S. 2005. Feed and alternative uses for DDGS. In: *Energy from Agriculture: New Technologies, Innovative Programs & Successes Conference*, Dec. 14–15, 2005. Farm Foundation, NRCS, and USDA Office of Energy Policy and New Uses, St. Louis, MO. pp. 1.
- Sletmoen-Olson, K. E., J. S. Caton, K. C. Olson, and L. P. Reynolds. 2000. Undegraded intake protein supplementation: I. Effects on forage utilization and performance of preparturient beef cows fed low-quality hay. *J. Anim. Sci.* 78:449-455.
- Stalker, L. A., D. C. Adams, and T. J. Klopfenstein. 2009. Influence of dried distillers grain supplementation frequency on forage digestibility and growth performance of beef cattle. *Prof. Anim. Sci.* 25:289-295.
- Van Soest, P. J. 1994. *Nutritional Ecology of the Ruminant*, 2nd ed. Cornell Univ. Press, Ithaca, NY.
- Wickersham, T. A., R. C. Cochran, E. C. Titgemeyer, C. G. Farmer, E. A. Klevesahl, J. I. Arroquy, D. E. Johnson, and D. P. Gnad. 2004. Effect of postruminal protein supply on

- the response to ruminal protein supplementation in beef steers fed low-quality grass hay. *Anim. Feed Sci. Technol.* 115:19-36.
- Wickersham, T. A., E. C. Titgemeyer, R. C. Cochran, and E. E. Wickersham. 2009. Effect of undegradable intake protein supplementation on urea kinetics and microbial use of recycled urea in steers consuming low-quality forage. *British J. of Nutr.* 101:225-232.
- Wickersham, T. A., E. C. Titgemeyer, R. C. Cochran, E. E. Wickersham, and D. P. Gnad. 2008a. Effect of rumen-degradable intake protein supplementation on urea kinetics and microbial use of recycled urea in steers consuming low-quality forage. *J. Anim. Sci.* 86:3079-3088.
- Wickersham, T. A., E. C. Titgemeyer, R. C. Cochran, E. E. Wickersham, and E. S. Moore. 2008b. Effect of frequency and amount of rumen-degradable intake protein supplementation on urea kinetics and microbial use of recycled urea in steers consuming low-quality forage. *J. Anim. Sci.* 86:3089-3099.
- Winterholler, S. J., C. P. McMurphy, G. L. Mourer, C. R. Krehbiel, G. W. Horn, and D. L. Lalman. 2012. Supplementation of dried distillers grains with solubles to beef cows consuming low-quality forage during late gestation and early lactation. *J. Anim. Sci.* 90:2014-2025.

Chapter 2 - Effects of Altering Supplementation Frequency during the Pre-partum Period of Beefs Cows Grazing Dormant Native Range

C. J. M^cMullen*, J. R. Jaeger*, J. W. Waggoner*, K. R. Harmony*, and K. C. Olson[†]

*Western Kansas Agricultural Research Center
Kansas State University, Hays 67601

[†]Department of Animal Sciences and Industry
Kansas State University, Manhattan 66506

Abstract

A 2-yr study was conducted at the Kansas State University Western Kansas Agricultural Research Center, Hays to evaluate the effect of altering supplementation frequency during late gestation on performance of spring-calving cows grazing low-quality dormant native range and supplemented with dried distillers grains with solubles (**DDG**). Angus cross cows ($n = 238$; mean age = 6 ± 2.5 yr; BW = 618 ± 56.2 kg; BCS = 5.7 ± 0.03) were stratified by age, BW, BCS, and assigned randomly to 1 of 4 treatments that were initiated 88 d prior to the expected onset of calving: 1) DDG daily (**D1**); 2) DDG once every 6 d (**D6**); 3) DDG daily from d 1 to d 60 and then every 6 d (**D1-D6**) until d 88; 4) DDG every 6 d from d 1 to d 60 and then daily (**D6-D1**) until d 88. Cow BW and BCS were measured every 28 d during the study. Cows were sorted daily before supplementation at 0830 h. Supplement delivery was calculated to meet dietary CP requirements. Increasing supplementation frequency immediately prepartum negatively affected final BW and BW change from d 61-88 for the D6-D1 supplementation group ($P < 0.05$) compared to other supplementation groups. Cow BW change for the study (d 1-88) was also less ($P < 0.01$) for the D6-D1 group compared to other groups and was also affected ($P < 0.01$) by year. Under the conditions of our study, increasing supplementation frequency 28 d prior to calving was not a viable means of maintaining or improving pre-partum cow performance.

Key words: cow performance, dried distillers grain, low-quality forage, supplementation frequency

Introduction

Spring-calving beef cattle grazing low-quality ($< 7\%$ CP) dormant forage are typically unable to meet their maintenance requirements for protein. Providing a protein supplement ($>$

30% CP) is recommended to reduce BW and BCS losses that may occur (DelCurto et al., 1990; Beaty et al., 1994; Mathis et al., 1999). Nutrient supplementation when forage quality is poor or forage availability is limited is generally among the greatest financial expenditures of forage-based beef cattle operations (Dhuyvetter, 2012). The expansion of the ethanol industry has afforded many producers in corn and sorghum-producing regions an alternative to traditional oilseed-based protein supplements. The availability and nutrient profile of dried distillers grains with solubles (**DDG**) has made it a popular protein supplement for beef producers maintaining cows on dormant low-quality forages.

Reducing supplementation frequency may reduce the costs (i.e., labor and fuel) associated with winter supplementation programs. Previously, Bennett et al. (2013) reported no difference in BW and BCS of cows supplemented with DDG daily, once every 3 d, or once every 6 d; however, the proportion of cows consuming hay 60 min post-supplementation was less on the day of supplementation for cows supplemented once every 6 d compared to cows supplemented daily. Reduction of forage intake immediately following supplementation events could potentially reduce OMI during late gestation. Conversely, more frequent supplementation may increase OMI and increase performance during the weeks before parturition (Farmer et al., 2001). Therefore, the objective of this study was to evaluate the effects of altering DDG supplementation frequency during the last 28 d of gestation on performance of spring-calving beef cows consuming low-quality dormant native range.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol no. 3175).

Animals and Experimental Design. Pregnant Angus cross cows ($n = 238$; age = 6 ± 2.5 yr; BW = 618 ± 56.2 kg; BCS = 5.7 ± 0.03) were maintained on dormant native range for 88 d before the expected onset of calving (Table 2.1). Pasture botanical composition included the following species: sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), Japanese brome (*Bromus arvensis*), and buffalograss (*Bouteloua dactyloides*).

Cows were stratified by age, BW, BCS, and assigned randomly to 1 of 4 treatments: 1) DDG daily (**D1**); 2) DDG once every 6 d (**D6**); 3) DDG daily from d 1 to d 60 and then every 6 d until d 88 (**D1-D6**); 4) DDG every 6 d from d 1 to d 60 and then daily until d 88 (**D6-D1**). Dried distillers grains with solubles were delivered and stored in bulk for use throughout the duration of the study (Table 2.1). Cows were sorted daily into treatment groups and supplement was delivered at 0830 h into a bunk for consumption. Only one set of bunks was available; therefore, on d when multiple supplement treatments were fed, each group was given enough time to consume the supplement in its entirety before being moved out of the feeding area. Cows were released from the feeding area after all groups were finished consuming their supplement. On days when infrequently supplemented animals were not supplemented they remained in holding pens adjacent the feeding pen until daily supplemented animals had finished consuming their supplement. No record was kept of how much time elapsed before all the DDG was consumed. Cows were allotted 71.1 cm of linear bunk space / hd. Supplement intake was prorated to supply $0.36 \text{ kg CP}\cdot\text{head}^{-1}\cdot\text{day}^{-1}$ ($1.17 \text{ kg DDG DM}\cdot\text{head}^{-1}\cdot\text{day}^{-1}$, year 1; $1.18 \text{ kg DDG DM}\cdot\text{head}^{-1}\cdot\text{day}^{-1}$, year 2). Mineral (Prairie Cow 4P; Suther Feeds, Inc., Frankfort, KS) and salt were available continuously during the experiment. At the onset of calving, treatments were discontinued and

cows were fed forage sorghum hay at 2% of BW and supplemented 0.65 kg DDG daily in a common pasture (DM basis).

Data Collection. Forage samples for nutrient analysis were obtained before the trial initiated. Samples ($n = 24$) were collected from multiple areas in each pasture using a randomly-placed 0.25-m² clipping frame. All forage within the frame was clipped 2 cm above the soil surface, dried at 55°C for 96 h, passed through a Wiley Mill (2-mm screen; Arthur H. Thomas, Philadelphia, PA), and stored at room temperature for subsequent nutrient analysis.

A representative sample of DDG was collected at delivery and frozen. Forage and DDG samples were submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) and analyzed for DM, CP, NDF, ADF, Ca, P, and S.

Cow BW and BCS were measured every 28 d at 0900 h, weather permitting. Reported dates are an average of the two years. Supplement was withheld until after all cows had been weighed and assigned BCS. Two independent, trained observers assigned BCS using a 9-point scale (1= extremely emaciated, 9=extremely obese; Wagner et al., 1988) at each date. Cows that calved before the final data collection date were excluded from the data set resulting in 232 observations.

Statistical Analysis. Performance data were analyzed as a completely randomized design using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Initial BW, BW change, initial BCS, and BCS change were dependent variables. The model included terms for treatment, year and their interaction. Animal within treatment was used as the random term. Cow was utilized as the experimental unit. When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of least significant difference. Means were considered significant at $P \leq 0.05$. Tendencies were discussed when $0.05 < P \leq 0.10$.

Results and Discussion

Cattle consuming low-quality dormant native range do not consume sufficient CP to optimize ruminal fermentation, which may limit dietary energy availability (Köster et al., 1996; Bohnert et al., 2002; Arroquy et al., 2004). Therefore, RDP is typically considered the first limiting nutrient for cattle grazing dormant native range (Mathis et al. 1999; Bandyk et al 2001; Bohnert et al., 2002). Thus the use of supplements relatively high in CP and proportion of RDP (oilseed meals) has become a common method of supplying additional CP and RDP to cattle consuming low-quality forage.

There were no performance differences ($P = 0.37$) between the D6 and D1 supplementation groups in the current study. Previous research also reported that reducing supplementation frequency from daily to as infrequently as once per week to have marginal to no effect on cow performance when supplemented with traditional oilseed-based protein (Beaty et al., 1994; Huston et al., 1999; Farmer et al., 2001). The CP content and RDP fraction of DDG is lower than oilseed meal supplements (NRC, 2000; Shurson and Noll, 2005) but has also been successful in maintaining cow BW and BCS when supplemented as infrequently as once every 6d (Bennett et al., 2013). Together these data demonstrate that for cows which don't experience a change in supplementation frequency while grazing low-quality range in the final trimester of gestation can be supplemented protein infrequently as once a week without a reduction in performance.

No interactions were observed 28 d after the experiment was initiated and therefore, data is not reported here. Initial cow BW and BCS were not different among treatments ($P \geq 0.37$; Table 2.2). A tendency for a Treatment \times Year interactions was observed for cow BW change from D 60-88 ($P = 0.07$; Table 2.2). Year interactions were observed for cow BW and BCS ($P < 0.01$; Table 2.2). These effects may be attributed to difference in total CP consumed among

years. Forage CP content was greater in year 1, than in year 2, this may be likely due to more late-spring and early-summer precipitation during the growing season in year 2 than year 1 (Table 2.1). The reduction in forage CP content experienced in year 2 reduced total CP consumed by cows compared to year 1. Thus cows in year 1 consumed 99.8% of their CP requirement while cows in year 2 consumed 89.5% of their CP requirement (NRC, 2000).

Beaty et al. (1994) fed 8 mature, ruminally-fistulated steers wheat straw (3.1% CP) *ad libitum* while supplementing increasing levels of SBM either daily or 3 × per wk. Steers that were supplemented 3 × per wk had lesser DMI when compared to steers that were supplemented daily. Additionally, Bennett et al., 2013 suggested that the amount of supplemented provided may affect eating behavior after observing a lower proportion of cows supplemented once every 6 d consumed hay 60 min post-feeding compared to daily-supplemented cows. We hypothesized that increasing supplementation frequency 28 d before the onset of calving would increase DMI for the D6-D1 supplemented cows, resulting in greater nutrient intake and improved performance when compared to the D1-D6 and D6 cows. In contrast, increasing supplementation frequency had the opposite of its intended effect.

Cow BW change prior to the change in supplementation frequency was not different between the two groups supplemented daily or between groups supplemented every 6 d; however, a tendency ($P = 0.08$) for cows in the D6-D1 to gain less BW compared to the D1 cows was observed. Body weight gain after the change in supplementation frequency was less for cows in the D6-D1 group when compared to the other groups ($P = 0.08$). At the end of the 88-d supplementation period cows in the D6-D1 group had lower ($P = 0.04$) BW and less BW gain compared to the D1, D6 and D1-D6 groups (Table 2.2). Likewise, BCS of D6-D1 cows tended ($P = 0.09$) to be lower than that of cows in the D1, D6 or D1-D6 supplementation groups.

Implications

Under the conditions of our study, increasing supplementation frequency 28 d before calving from once every 6 d to daily resulted in less BW gain and lower BCS in pregnant beef cows supplemented with DDG. Additionally, no adverse effects of reducing supplementation frequency from daily to once every 6 d were observed in pregnant beef cows fed DDG. Reducing supplementation frequency may be a viable means of reducing supplementation costs.

Literature Cited

- Arroquy, J. J., R. C. Cochran, M. Villarreal, T. A. Wickersham, D. A. Llewellyn, E. C. Titgemeyer, T. G. Nagaraja, D.E. Johnson, and D. Gnad. 2004. Effect of level of rumen degradable protein and type of supplemental non-fiber carbohydrate on intake and digestion of low-quality grass hay by beef cattle. *Anim. Feed Sci. Technol.* 115:83-99.
- Bandyk, C. A., R. C. Cochran, T. A. Wickersham, E. C. Titgemeyer, C. G. Farmer, and J. J. Higgins. 2001. Effect of ruminal vs postruminal administration of degradable protein on utilization of low-quality forage by beef steers. *J. Anim. Sci.* 79:225-231.
- Beaty, J. L., R. C. Cochran, B. A. Lintzenich, E. S. Vanzant, J. L. Morrill, R. T. Brandt Jr., and D. E. Johnson. 1994. Effect of frequency of supplementation and protein concentration in supplements on performance and digestion characteristics of beef cattle consuming low quality forages. *J. Anim. Sci.* 72:2475-2486.
- Bennett, B. W., J. W. Waggoner, J. R. Jaeger, A. K. Sexten, and K. C. Olson. 2013. Effect of supplementation frequency on performance of spring-calving cows supplemented with dried distillers grain. *Proc. Western Section, American society of Animal Science.* Vol. 64, 2013.
- Bohnert, D. W., C. S. Schauer, S. J. Falck, and T. DelCurto. 2002. Influence of rumen protein degradability and supplementation frequency on steers consuming low-quality forage: II. Ruminal fermentation characteristics. *J. Anim. Sci.* 80:2978-2988.
- DelCurto, T., R. C. Cochran, L. R. Corah, A. A. Beharka, E. S. Vanzant, and D. E. Johnson. 1990. Supplementation of dormant tallgrass-prairie forage. II. Performance and forage utilization characteristics in grazing beef cattle receiving supplements of different protein concentration. *J. Anim. Sci.* 68:532-542.
- Dhuyvetter, K. C. 2012. Differences between high, medium, and low profit producers: an analysis of 2007-2011 Kansas farm management association cow-calf enterprise. Kansas State Univ. Department of Agricultural Economics. AM-KCD-2012.03.
- Farmer, C. G., R. C. Cochran, D. D. Simms, E. A. Klevesahl, T. A. Wickersham, and D. E. Johnson. 2001. The effects of several supplementation frequencies on forage use and performance of beef cattle consuming dormant tallgrass-prairie forage. *J. Anim. Sci.* 79:2276-2285.
- Huston, J. E., H. Lippke, T. D. Forbes, J. W. Holloway, and R. V. Machem. 1999. Effects of supplemental feeding interval on adult cows in western Texas. *J. Anim. Sci.* 77:3057-3067.
- Köster, H. H., R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant, I. Abdelgadir, and G. St-Jean. 1996. Effect of increasing degradable intake protein on intake and digestion of low-quality tallgrass prairie forage by beef cows. *J. Anim. Sci.* 74:2473-2481.

- Mathis, C. P., R. C. Cochran, G. L. Stokka, J. S. Heldt, B. C. Woods, and K. C. Olson. 1999. Impacts of increasing amounts of soybean meal on intake and digestion by beef steers and performance by beef cows consuming low-quality tallgrass-prairie forage. *J. Anim. Sci.* 77:3156-3162.
- NRC. 2000. *Nutrient Requirements of Beef Cattle*. National Academy Press, Washington, DC.
- Shurson, J., and Noll, S. 2005. Feed and alternative uses for DDGS. In: *Energy from Agriculture: New Technologies, Innovative Programs & Successes Conference*, Dec. 14–15, 2005. Farm Foundation, NRCS, and USDA Office of Energy Policy and New Uses, St. Louis, MO. pp. 1.
- Wagner, J. J., K. S. Lusby, J. W. Oltjen, J. Rakestraw, R. P. Wettermann, and L. E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. *J. Anim. Sci.* 66:603-612

Table 2.1 Nutrient composition (DM basis) of native range and dried distillers grain with solubles (DDG)¹.

Item	Native Range		DDG	
	Year 1	Year 2	Year 1	Year 2
DM, %	85.5	87.4	88.4	88.2
CP, %	5.5	4.6	32.7	31.2
NDF, %	69.1	73.4	29.7	37.0
ADF, %	47.3	47.1	18.7	17.7
Calcium, %	0.36	0.28	0.09	0.07
Phosphorus, %	0.13	0.10	0.82	0.85
Sulfur, %	0.10	0.06	0.80	0.60
NE _m , Mcal/kg	0.95	0.56	1.98	1.93

¹Analysis conducted by SDK Laboratories, Hutchison, KS.

Table 2.2 Performance of spring-calving beef cows supplemented with dried distillers grain (DDG) during the last trimester of gestation.

Item	Supplement treatments ¹				SEM	P-value		
	D1	D6	D1-D6	D6-D1		Treatment	Year	Treatment × Year
Number of cows	57	65	57	59				
Cow BW, kg								
d 1	650.3	651.3	653.8	636.9	3.63	0.37	0.39	0.77
d 60	687.7	683.3	690.5	667.3	3.63	0.13	0.24	0.74
d 88	700.2 ^a	696.4 ^a	700.3 ^a	672.7 ^b	3.74	0.04	0.14	0.96
Cow BW change, kg								
d 1-60	38.6 ^c	33.3 ^{c,d}	38.4 ^c	31.8 ^{d,e}	1.28	0.08	< 0.01	0.65
d 60-88	11.9 ^a	12.4 ^a	8.7 ^a	4.7 ^b	0.94	0.03	0.53	0.07
d 1-88	50.8 ^a	46.0 ^a	47.7 ^a	36.9 ^b	1.47	< 0.01	< 0.01	0.39
Cow BCS ²								
d 1	5.9	5.8	6.0	5.9	0.03	0.45	0.53	0.59
d 60	5.6	5.5	5.6	5.5	0.03	0.39	< 0.01	0.89
d 88	5.8 ^c	5.8 ^c	5.8 ^c	5.6 ^d	0.03	0.09	< 0.01	0.75

¹Supplements provided during the last trimester of gestation. Treatments: D1= DDG fed daily from d 1 to d 88; D6 = DDG fed every 6 d from d 1 to d 88; D1-D6 = DDG fed daily from d 1 to d 60 and every 6 d from d 61 to d 88; D6-D1 = DDG fed every 6 d from d 1 to d 60 and daily from d 61 to d 88.

²Scale of 1 to 9; 1 = extremely emaciated, 9 = extremely obese (Wagner et al., 1988).

^{a,b}Means within rows with different superscripts denote significant difference between treatments ($P < 0.05$).

^{c,d,e}Means within rows with different superscripts denote a tendency for difference between treatments ($0.05 < P \leq 0.10$).

**Chapter 3 - Performance of beef replacement heifers supplemented
with dried distillers grains or a mixture of soybean meal and ground
sorghum grain**

C. J. McMullen*, J. R. Jaeger*, K. R. Harmony*, J. W. Waggoner*, and K. C. Olson[†]

*Western Kansas Agricultural Research Center
Kansas State University, Hays 67601

[†]Department of Animal Sciences and Industry
Kansas State University, Manhattan 66506

Abstract

The objective of this study was to determine if dried distillers grains with solubles (**DDG**) is a viable replacement for an oilseed meal-based protein supplement when developing heifers on low-quality, dormant native range. Angus × Hereford heifers (n = 88; BW = 264 ± 2.8 kg; BCS = 5.0 ± 0.03) were stratified by age, BW, BCS, and assigned randomly to 1 of 4 pastures (4.4 % CP) per supplement treatment. Treatments consisted of daily supplementation of either 1.65 kg DM **DDG** (**DDG**; 0.57 kg CP) or 1.37 kg DM of a 73.6% soybean meal and 26.4% rolled sorghum grain mixture (**SBM-S**; 0.56 kg CP). Treatments were administered from 1/15 until 4/8 (84 d). Initial BW and BCS were not different between treatments ($P \geq 0.29$). Final BW and BCS also did not differ ($P \geq 0.55$) between treatments; moreover, rates of BW and BCS change were not different ($P > 0.30$) between treatments. Proportion of heifers pubertal before ovulation synchronization, first service conception rates and final pregnancy rates were not affected ($P > 0.40$) by treatment. Under the conditions of our study, supplemental CP fed at a rate of 0.56 kg daily was sufficient to promote growth and BCS change adequate for optimal reproductive performance; moreover, ruminal degradability of supplemental CP did not influence heifer performance over an 84-d development period.

Key words: heifers, low-quality forage, RDP, RUP

Introduction

The feed, labor, and equipment costs associated with developing heifers in a confined feeding system are relatively high. High-Plains beef producers can reduce input costs by developing heifers on dormant native range; however, heifers are typically unable to consume

sufficient CP from the low-quality (< 7% CP) forage base (Mathis et al., 1999). Insufficient dietary protein reduces forage digestion and performance potential of growing heifers.

Supplementing protein when forage quality is poor can increase forage intake and forage digestibility, resulting in acceptable levels of performance (Beaty et al., 1994; Bandyk et al., 2001; Mathis and Sawyer, 2007).

An efficient means of supplying supplemental protein to heifers consuming low-quality forage is through the use of supplements with relatively high CP concentrations (> 30% CP; Heldt, 1998). Traditionally, producers have used oilseed meals in this capacity but, with the expansion of the ethanol industry, dried distillers grains with solubles (**DDG**) have become widely-available as an alternative protein source for producers near corn and sorghum-producing regions. Since DDG are derived from corn and sorghum, which are inherently lower in CP, DDG are lower in CP when compared to traditional oilseed meals, as well as lower in RDP due to the Maillard reaction during the heating process. Soybean meal is 44-49% CP and 65% RDP (NRC, 2000); whereas DDG is 28-32% CP and 45% RDP (Shurson and Noll, 2005; NRC, 2000).

Bandyk and others (2001) demonstrated the importance of RDP supplementation to cattle consuming low quality tallgrass-prairie hay by infusing casein either ruminally or post-ruminally. Cattle that were infused with casein post-ruminally had roughly half the DMI of ruminally-infused cattle. Adequate heifer BW and BCS at first breeding are essential to minimize age at first calving and to increase lifetime productivity (Lesmeister et al., 1973). The differences in CP concentration as well as proportion of RDP between soybean meal and DDG may affect animal performance and when developed on low-quality native range. Therefore, the objective of our study was to evaluate the effects of supplementation of DDG or an isonitrogenous mixture of

soybean meal and ground sorghum grain on growth and reproductive performance of replacement heifers grazing low-quality, dormant native range.

Materials and Methods

Animal care practices used in this study were approved by the Kansas State University Institutional Animal Care and Use Committee (Protocol no. 3175).

Animals and Experimental Design. Spring-born Angus × Hereford heifers (n = 88; initial BW = 264 kg ± 2.8 kg; initial BCS = 5.0 ± 0.03) were maintained on dormant, native range pastures for 84 d (Table 3.1). Botanical composition of pastures included: sideoats grama (*Bouteloua curtipendula*), western wheatgrass (*Pascopyrum smithii*), blue grama (*Bouteloua gracilis*), Japanese brome (*Bromus arvensis*), and buffalo grass (*Bouteloua dactyloides*). Free-choice mineral (Prairie Cow 4P; Suther's Feeds, Inc., Frankfort, KS) and salt were available throughout the study. Dried distiller's grains with solubles originated from a single location and were stored in bulk for use during the study (Table 3.1). Soybean meal and ground sorghum grain were also procured from single sources and were mixed on site before each feeding. The mixture was 73.6% soybean meal and 26.4% sorghum grain (Table 3.1).

Heifers were stratified by age, BW and BCS, and assigned randomly to one of 8 pastures (n = 4 pastures/treatment). Supplement feeding levels were designed to meet CP requirements of 300-kg growing calves with a targeted ADG of 0.91 kg (NRC, 2000). Supplements consisted of 1.65 kg DM DDG (DDG; calculated to supply 0.57 kg CP / d) or 1.37 kg DM soybean meal and ground sorghum grain (SBM-S; calculated to supply 0.56 kg CP / d). Due to limited bin space, multiple loads of DDG were required throughout the experiment; this also required soybean meal and ground sorghum grain to be mixed in a batch mixer before each feeding. Representative samples of each load of DDG were collected upon delivery, frozen, composited, and then a

representative sample was submitted to a commercial laboratory for analyses. Weekly, samples of the soybean meal and ground sorghum grain mixture and DDG were collected, frozen, composited, and then a representative sample was submitted to a commercial laboratory for analyses. Following the completion of the experiment, testing of the samples revealed that DDG supplied 0.54 kg CP / d and SBM-S supplied 0.58 kg CP / d. Supplement was delivered daily at 0930 h into a bunk for consumption. Heifers were allotted 110.6 cm of linear bunk space/hd.

Data Collection. Range forage samples for nutrient analysis were obtained prior to trial initiation. Samples (n = 48) were collected from 6 randomly-selected sites in each 15.5 ha pasture using a 0.25-m² clipping frame. Forage within the frame was clipped 2 cm above the soil surface. All samples were dried at 55°C for 96 h and passed through a Wiley Mill (2 mm screen; Arthur H. Thomas, Philadelphia, PA). Samples were composited by weight and stored at room temperature pending laboratory analysis for nutrient content. Forage and supplement samples were submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) and analyzed for DM, CP, NDF, ADF, Ca, P, and S. Energy values were calculated according to NRC (2000).

Treatments were administered from 1/15 to 4/8 for 84 d. Body condition scores were assigned by two independent, qualified observers using a 9-point scale (1= extremely emaciated, 9=extremely obese; Wagner et al., 1988) on d 0 and d 84; BW were also measured at those times.

Puberty Determination. Blood samples were collected via jugular venipuncture 10 d before (d 122) and on the day ovulation synchronization was initiated (d 133). Samples were collected into 10 mL serum vacutainer tubes (BD Vacutainer™, Becton, Dickinson, and Company, Franklin Lakes, NJ), immediately placed on ice, allowed to coagulate for 24 h at 4°C, and centrifuged (1,500 × g) for 10 min. Serum was decanted into 12 × 75 mm plastic tubes,

which were capped and immediately frozen (-20°C). Concentration of progesterone (P4) in serum was subsequently quantified using a solid-phase, no-extraction RIA (Coat-a-Count Progesterone; Diagnostic Products Corporation, Los Angeles, CA; Stevenson, 2011). Intra- and interassay CV were 3.4 and 7.6% respectively and sensitivity of the assay was 0.009 ng/mL. Blood collected on the 2 sampling dates was used to verify the presence of a functional corpus luteum (when concentrations of P4 exceeded 1 ng/mL). If either sample contained P4 >1 ng/mL (typical of heifers that have attained puberty and are in the luteal phase of the estrous cycle), heifers were assumed to be pubertal before the onset of ovulation synchronization treatment. If P4 concentrations in both samples were <1 ng/mL heifers were considered to be pre-pubertal.

Pregnancy Determination. Thirty-five d after AI (d 175), first service conception rate (**FSCR**) was determined by transrectal ultrasonography (Aloka 500V, 5MHz transrectal transducer, Wallingford, CT). A positive pregnancy outcome required the presence of uterine fluid and an embryo with a heartbeat. Final pregnancy rate (**PR**) was determined 35 d after the end of the breeding season (d 240) via transrectal ultrasonography.

Statistical Analysis. Performance data were analyzed as a completely randomized design using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC). Initial BW, BW change, initial BCS, and BCS change were the dependent variables; pasture was the experimental unit for performance data. The model included terms for treatment, pasture and their interaction. Puberty status, FSCR and PR were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC) with treatment as the fixed effect. Animal was the experimental unit. When protected by a significant F-test ($P < 0.05$), least squares treatment means were separated using the method of least significant difference. Least square means were considered different when $P \leq 0.05$.

Results and Discussion

Initial BW and BCS were not different ($P \geq 0.29$) between treatments (Table 3.2). Final BW and BCS also did not differ ($P \geq 0.55$) between treatments: moreover, rates of BW change and BCS change were not different ($P > 0.30$) between treatments. Proportions of heifers pubertal before ovulation synchronization, FSCR, and PR were not affected ($P > 0.40$) by treatment (Table 3.3). The relatively high P -values in comparison to the numerical differences reported were expected as responses to proportion of pubertal heifers, FSCR, and PR are binomial.

These observations agree with previous research where ruminants were supplemented high-RUP feedstuffs while consuming low-quality forage. Bohnert et al. (2002) supplemented wethers consuming low-quality hay with a protein source high in RUP (59.9%) and noted similar OMI and OMD when compared to wethers supplemented with a protein source low in RUP (17.6%). Atkinson and others (2010) found that lambs consuming low-quality wheatgrass hay and supplemented with a 50:50 mix of RDP and RUP exhibited improved OM digestibility compared to high-RDP supplementation. Similarly, Sawyer et al. (2012) also reported that steers consuming low-quality lovegrass hay and supplemented with 40 g/d of RUP had similar DM digestibility to steers fed 160 g/d of RDP.

Targeted ADG was not met in either treatment. Morris et al. (2005) examined the effects of five levels of DDGS supplementation on growing heifers fed brome hay (53% TDN). The authors created a formula using linear regression to predict heifer ADG when consuming low-quality forage and supplemented with DDG. Their equation suggested ADG for growing heifers in the current study consuming DDG would have been 0.52 kg / d, actual ADG was 0.54 kg / d. Failure to meet the targeted ADG also agrees with Jenkins et al., 2009. These authors

supplemented 225 kg steers four levels of DDG 3d/wk and reported steers supplemented 0.50% of their BW with DDG gained 0.64 kg / d.

When examining the RDP requirements of steers consuming low-quality (4.3% CP) sorghum hay, Mathis and others (2000) found that the requirement may be as low as 0.082% of BW, suggesting only a small amount of RDP may be required to sustain microbial populations for cattle grazing low-quality forage. Based on those findings, when DDG is fed at the proper level, the RDP fraction should provide adequate N to the rumen to sustain the microbial populations. Winterholler et al. (2012) supplemented DDG or a wheat middlings / cottonseed meal mixture to spring calving beef cows consuming low-protein hay (5.6%), and reported both groups had similar changes in BW and BCS before calving.

Jaeger and others (2012) reported that heifers developed with wet distillers grains with solubles in place of soybean meal as the primary dietary protein source gained less BW after 28 and 56 d of feeding; moreover, fewer wet distillers grain-supplemented heifers were pubertal than soybean meal-supplemented heifers. Conversely, proportion of pubertal heifers was not different prior to ovulation synchronization, nor was FSCR or PR in that study. Thus, heifers in both studies achieved sufficient growth and BCS to initiate puberty by consuming either distillers grains or soybean meal. Therefore, under the conditions of our study, developing replacement heifers on dormant rangeland with supplemental DDG was an acceptable management strategy.

Implications

Dried distillers grains with solubles may be utilized as an alternative to a mixture of soybean meal and ground sorghum grain without adversely affecting growth or reproductive performance of replacement heifers grazing low-quality dormant native range.

Literature Cited

- Atkinson, R. L., C. D. Toone, and P. A. Ludden. 2010. Effects of ruminal protein degradability and frequency of supplementation on site and extent of digestion and ruminal fermentation characteristics in lambs fed low-quality forage. *J. Anim. Sci.* 88:718-726.
- Bandyk, C. A., R. C. Cochran, T. A. Wickersham, E. C. Titgemeyer, C. G. Farmer, and J. J. Higgins. 2001. Effect of ruminal vs postruminal administration of degradable protein on utilization of low-quality forage by beef steers. *J. Anim. Sci.* 79:225-231.
- Beaty, J. L., R. C. Cochran, B. A. Lintzenich, E. S. Vanzant, J. L. Morrill, R. T. Brandt Jr., and D. E. Johnson. 1994. Effect of frequency of supplementation and protein concentration in supplements on performance and digestion characteristics of beef cattle consuming lowquality forages. *J. Anim. Sci.* 72:2475-2486.
- Bohnert, D. W., C. S. Schauer, S. J. Falck, and T. DelCurto. 2002. Influence of rumen protein degradability and supplementation frequency on steers consuming low-quality forage: II. Ruminal fermentation characteristics. *J. Anim. Sci.* 80:2978-2988.
- Heldt, J. S. 1998. Effect of various supplemental carbohydrate sources on the utilization of low-quality tallgrass-prairie forage. PhD Diss. Kansas State University, Manhattan.
- Jaeger, J. R., J. W. Waggoner, K. C. Olson, K. R. Harmony, and J. W. Bolte. 2012. Growth and reproductive performance of beef replacement heifers fed development diets containing soybean meal or wet distillers grains. *Prof. Anim. Sci.* 28:300-305.
- Jenkins, K. H., J. C. MacDonald, F. T. McCollum III, and S. H. Amosson. 2009. Effects of level of dried distillers grain supplementation on native pasture and subsequent effects on wheat pasture gains. *Prof. Anim. Sci.* 25:596-604.
- Lesmeister, J. L., P. J. Burfening, and R. L. Blackwell. 1973. Date of first calving in beef cows and subsequent calf production. *J. Anim. Sci.* 36:1-6.
- Mathis, C. P., R. C. Cochran, J. S. Heldt, B. C. Woods, I. E. O. Abdelgadir, K. C. Olson, E. C. Titgemeyer, and E. Z. Vanzant. 2000. Effects of supplemental degradable intake protein on utilization of medium- to low-quality forages. *J. Anim. Sci.* 78:224-232.
- Mathis, C. P., R. C. Cochran, G. L. Stokka, J. S. Heldt, B. C. Woods, and K. C. Olson. 1999. Impacts of increasing amounts of soybean meal on intake and digestion by beef steers and performance by beef cows consuming low-quality tallgrass-prairie forage. *J. Anim. Sci.* 77:3156-3162.
- Mathis, C. P., and J. E. Sawyer. 2007. Nutritional management of grazing beef cows. *Vet. Clin. North Amer. Food Anim. Pract.* 23:1-19.

- Morris, S. E., T. J. Klopfenstein, D. C. Adams, G. E. Erickson, and K. J. Vander Pol. 2005. The effects of dried distillers grains on heifers consuming low or high-quality forage. Nebraska Beef Cattle Report. MP 83-A:18–20.
- NRC. 2000. Nutrient Requirements of Beef Cattle. National Academy Press, Washington, DC.
- Sawyer, J. E., J. T. Mulliniks, R. C. Waterman, and M. K. Petersen. 2012. Influence of protein type and level on nitrogen and forage use in cows consuming low-quality forage. *J. Anim. Sci.* 90:2324-2330.
- Shurson, J., and Noll, S. 2005. Feed and alternative uses for DDG. In: Energy from Agriculture: New Technologies, Innovative Programs & Successes Conference, Dec. 14–15, 2005. Farm Foundation, NRCS, and USDA Office of Energy Policy and New Uses, St. Louis, MO. pp. 1.
- Stevenson, J. S. 2011. Alternative programs to presynchronize estrous cycles in dairy cattle before a timed artificial insemination program. *J. Dairy Sci.* 94:205-217.
- Wagner, J. J., K. S. Lusby, J. W. Oltjen, J. Rakestraw, R. P. Wettermann, and L. E. Walters. 1988. Carcass composition in mature Hereford cows: Estimation and effect on daily metabolizable energy requirement during winter. *J. Anim. Sci.* 66:603-612.
- Winterholler, S. J., C. P. McMurphy, G. L. Mourer, C. R. Krehbiel, G. W. Horn, and D. L. Lalman. 2012. Supplementation of dried distillers grains with solubles to beef cows consuming low-quality forage during late gestation and early lactation. *J. Anim. Sci.* 90:2014-2025.

Table 3.1 Nutrient composition¹ (DM basis) of native range, dried distiller's grains with solubles (DDG), and a mixture of soybean meal and ground sorghum grain (SBM-S)

Item	Native Range	DDG ²	SBM-S ³
DM, %	87.3	88.4	87.7
CP, %	4.4	32.7	42.1
NE _m ⁴ , Mcal/kg	0.99	1.98	1.98
NDF, %	71.3	29.7	8.6
ADF, %	46.8	18.7	7.0
Calcium, %	0.33	0.09	0.33
Phosphorus, %	0.09	0.82	0.59
Sulfur, %	0.08	0.80	0.35

¹Analysis conducted by SDK Laboratories, Hutchinson, KS.

²DDG: dried distillers grain plus solubles.

³SBM-S: 73.6 % soybean meal and 26.4% sorghum grain, DM basis.

⁴Calculated according to NRC (2000).

Table 3.2 Growth performance of beef replacement heifers supplemented with dried distillers grains with solubles (DDG) or a mixture of soybean meal and ground sorghum grain (SBM-S).

Item	Supplement		SEM	<i>P</i> -value
	DDG ¹	SBM-S ²		
Number of heifers	44	44		
Initial BW, kg	267.2	260.8	8.6	0.29
Final BW, kg	313.0	310.7	10.12	0.68
BW change, kg	45.8	49.9	3.58	0.17
ADG, kg	0.6	0.6	0.04	0.17
Initial body condition score ³	5.0	5.0	0.03	0.92
Final body condition score ³	5.8	5.8	0.06	0.55
Body condition score change	0.8	0.8	0.06	0.53

¹DDG: dried distillers grains with solubles.

²SBM-S: 73.6 % soybean meal and 26.4% ground sorghum grain, DM basis.

³Scale of 1 to 9; 1 = extremely emaciated, 9 = extremely obese.

Table 3.3 Reproductive performance of beef replacement heifers supplemented with dried distillers grains with solubles (DDG) or a mixture of soybean meal and ground sorghum grain (SBM-S).

Item	Supplement		<i>P</i> -value
	DDG ¹	SBM-S ²	
Estrual heifers, %	18.2	11.6	0.40
FSCR ³ , %	68.2	74.4	0.52
PR ⁴ , %	100.0	86.0	0.97

¹DDG: dried distillers grains with solubles.

²SBM-S: 73.6% soybean meal and 26.4% ground sorghum grain, DM basis.

³FSCR: First service conception rate determined 35 d after AI.

⁴PR: Final pregnancy rate determined 35 d after removal of bulls.