The Professional Animal Scientist 26 (2010):356–364


# Comparison of Corn Coproducts and Corn Residue Bales with Alfalfa Mixed Hay on Beef Cow-Calf Performance, Lactation, and Feed Costs

**T. J. Braungardt,* D. W. Shike,*[1] D. B. Faulkner,* PAS, K. Karges,† M. Gibson,† and N. M. Post***

*Department of Animal Sciences, University of Illinois, Urbana, IL 61801; and †Dakota Gold Research Association, Sioux Falls, SD 57059

## ABSTRACT

*Two experiments were conducted to evaluate the effects of a winter feeding strategy on the performance, lactation, reproduction, and feed costs of spring-calving, lactating beef cows. In Exp. 1, Angus (n = 66) and Simmental (n = 70) cows were allotted to 1 of 4 treatments: 1) distillers dried grains with solubles (DDGS) and free-choice corn residue bales; 2) corn bran and DDGS and free-choice corn residue bales; 3) corn bran and high-protein distillers dried grains and free-choice corn residue bales; or 4) free-choice alfalfa mixed hay. In Exp. 2, Angus (n = 72) and Simmental (n = 92) cows were allotted to 1 of 4 treatments: 1) free-choice corn residue bale and 6.5 kg DDGS; 2) 6.4 kg ground corn residue bale and 6.5 kg DDGS; 3) 4.5 kg ground corn residue bale and 7.5 kg DDGS; and 4) free-choice alfalfa mixed hay. In both experiments, cows with free-choice hay intake lost more BW than cows fed coproduct and corn residue bales, but there were no differences in milk production or calf ADG. Three-year average price data were used to calculate feed costs (corn residue, \$55/ton; DDGS, \$124.71/ton; and hay, \$131.67/ton). In Exp. 2, the hay diet was more expensive than the 3 DDGS and corn residue diets (\$2.50 vs. \$1.44/cow·per day, respectively). Machinery costs were also considered for each diet with herd sizes from 50 to 300 cows. Herd size dictated which winter feeding strategy was the least expensive. Feeding corn coproducts with corn residue bales can result in acceptable performance and reduced feed costs compared with traditional hay diets.*

**Key words:** coproduct, corn residue, cow-calf, lactating, winter feeding

## INTRODUCTION

One of the greatest expenses in beef cow-calf production is feed costs. Feed costs constitute more than 60% of the total costs in a beef cow-calf operation (Miller et al., 2001). With recent increases in hay and grain prices, this expense could be even higher. For a cow-calf producer, the most expensive time to feed the cow is during the winter months, when pasture is limited or when the cows must be maintained on dry lots. It is important for producers to feed a nutritionally balanced diet, especially during early lactation (Hess et al., 2005), because nutritional balance affects both cow and calf performance.

Traditionally, cows are fed hay in the winter because of its ease of feeding. As feed costs continue to rise, hay feeding can become costly. Recently, hay prices have reached record high prices, with the average price for alfalfa hay in 2008 reaching \$172/ton (National Agricultural Statistics Service, 2009). Costs associated with feeding hay represent 33% of the total feed cost per cow (Strohbehn, 2001). Hay waste potentially magnifies the cost. Miller et al. (2007) reported 40% hay waste when cows were offered free-choice access to round bales in a fence-line feeder. Lower quality replacement roughage, such as baled

[1] Corresponding author: dshike@illinois.edu

corn residue, with supplementation may be an economical alternative.

As the demand for ethanol continues to increase, more distillers grains are becoming available for feeding. These corn coproduct feeds are very popular because they are an excellent source of energy and protein while being less expensive than alternative supplements. Distillers grains are a high-energy and high-protein source, with fat and protein concentrations of approximately 11 and 30%, as well as being a source of high P (NRC, 1996). With recent advancements in the ethanol industry, new biorefining technologies result in different coproducts. Further research is needed comparing the new and different types of coproducts in beef cow-calf diets to determine the least-cost approach.

In addition, if it is determined that feeding corn coproducts and corn residue bales can reduce feed costs, then evaluation of the feeding method (free-choice corn residue bales vs. ground corn residue bales) is necessary as well. The objectives of this study were to evaluate the use of coproducts and baled corn residue to reduce feed costs for spring-calving lactating beef cows in a dry-lot system as well as to compare free-choice access of corn residue bales with TMR containing ground corn residue bales.

## MATERIALS AND METHODS

### *Exp. 1*

***Experimental Animals.*** Angus (n = 66) and Simmental (n = 70) spring-calving (January to March) cows nursing calves at the Orr Research Center (Baylis, IL) were used to evaluate the effects of the winter feeding strategy on performance, lactation, and feed costs of beef cow-calf production. Animals used in this trial were managed according to the guidelines recommended in the Guide for the Care and Use of Agriculture Animals in Agriculture Research and Teaching (Consortium, 1988). All experimental procedures followed those approved by the University of Illinois Laboratory Animal Care Advisory Committee.

***Management and Diets.*** The feedstuffs used were distillers dried grains with solubles (**DDGS**), high-protein, low-fat distillers dried grains (**HP**), corn bran (hereafter, "bran"), alfalfa mixed hay (large square bales stored inside), and corn residue (large square bales stored inside). Feed analyses are shown in Table 1. Cows were randomly allotted to 1 of 4 dietary treatments at calving: 1) 6.5 kg/d DDGS and free-choice corn residue bales (**DDGS** treatment); 2) 4.4 kg/d bran and 2.2 kg/d DDGS and free-choice corn residue bales (**bran/DDGS** treatment); 3) 5.1 kg/d bran and 1.5 kg/d HP and free-choice corn residue bales (**bran/HP** treatment); or 4) free-choice alfalfa mixed hay (hereafter, "hay" treatment). Coproduct supplements (1, 2, and 3) were formulated to be isocaloric and to meet the average of Simmental and Angus cow maintenance and lactation energy requirements. The bran/DDGS and bran/HP diets were also isonitrogenous and were formulated to meet protein requirements (NRC, 1996). The DDGS and hay treatments were not isonitrogenous but exceeded protein requirements (NRC, 1996). Cows were maintained in 11.0 × 10.7 m concrete lots with a 7 × 7 m open-front shed. Coproduct supplements (1, 2, and 3) were pen-fed once daily in 7.3-m fence-line bunks, and corn residue and alfalfa mixed hay bales were fed in 3.7-m fence-line bale feeders. Corn residue bale and alfalfa mixed hay bale disappearances were calculated by weighing back refusals and subtracting that weight from initial bale weights. Cows were blocked by calving date and randomly assigned to 16 pens (12 pens had 9 cows and 4 pens had 7 cows) after calving, resulting in 4 pens per treatment. Two cows were removed from the study (1 cow on the bran/HP treatment and 1 cow on the bran/DDGS treatment) for reasons unrelated to treatments.

***Performance, Lactation, and Reproduction Analysis.*** Within 24 h of calving, cows and calves were weighed and allotted. Calf birth weights were used as initial calf BW. Cow BW and BCS, taken after calving and before feeding, were used as initial cow BW and BCS. Milk production was estimated using the weigh-suckle-weigh technique at an average of 57 ± 13.6 d postpartum. Twenty-four-hour milk production estimates were determined using a 12-h weigh-suckle-weigh technique (Beal et al., 1990). Six hours after the weigh-suckle-weigh measurement, a subsample of 6 cows per treatment were milked using a commercial portable milk machine (Porta Milker, The Coburn Company Inc., Whitewater, WI). Cows were administered 20 USP units of oxytocin (Phoenix Scientific, St. Joseph, MO) intravenously within 2 min of milking to initiate milk letdown. Milk was sampled and sent to Dairy Lab Services Inc. (Dubuque, IA) for compositional analysis. At an average of 64 ± 13.6 d postpartum, the dietary treatments ended, and final cow shrunk BW and calf BW were taken. After the conclusion of the dietary treatments, all cows were fed 6.5 kg DDGS and free-choice corn residue bales until the completion of synchronized AI. Cows were synchronized using the CoSynch+CIDR procedure (Bremer et al., 2004) and were artificially inseminated at an average of 68 ± 13.6 d postpartum. After AI, all cows went to pasture as a group. First-service conception rates were determined via transrectal ultrasonography at 41 d after AI.

***Feed Cost Calculations.*** Three-year (2006 to 2008) average price data for feedstuffs (alfalfa mixed hay, \$131.67/ton; DDGS, \$137.08/ton; HP, \$182.28/ton; and bran, \$96.02/ton) were used for feed cost calculations. Price data for mixed alfalfa hay was attained from annual commodity reports (2006 to 2008; National Agricultural Statistics Service, 2009). Price data for DDGS, HP, and bran were attained from Dakota Gold Research Association (Sioux Falls, SD; K. Karges, personal communication). Three-year price data for corn residue bales could not be found; thus, the authors estimated a value of \$55/ton.

**Table 1. Feed analyses (DM basis)**

| Ingredient | CP, % | ADF, % | NDF, % | TDN, % | Fat, % | S, % | K, % | Ca, % | P, % |
|---|---|---|---|---|---|---|---|---|---|
| Exp. 1 | | | | | | | | | |
| DDGS[1] | 30.68 | 17.82 | 33.04 | 90 | 9.67 | 0.88 | 1.12 | 0.07 | 0.78 |
| HP[2] | 40.04 | 13.35 | 30.29 | 89 | 5.5 | 0.68 | 0.47 | 0.13 | 0.41 |
| Bran[3] | 13.34 | 5.34 | 22.01 | 89 | 9.89 | 0.69 | 1.06 | 0.11 | 0.65 |
| Corn residue bale[4] | 3.37 | 46.11 | 71.63 | 54.52 | — | 0.05 | 1.03 | 0.61 | 0.05 |
| Alfalfa mixed hay[5] | 17.31 | 37.98 | 52.05 | 61.42 | — | 0.17 | 1.67 | 0.94 | 0.29 |
| Exp. 2 | | | | | | | | | |
| DDGS[1] | 27.38 | 14.17 | 29.82 | 88 | 7.87 | 0.62 | 1.33 | 0.11 | 0.89 |
| Corn residue bale[4] | 3.05 | 48.69 | 77.07 | 52.71 | — | 0.07 | 1.34 | 0.63 | 0.08 |
| Alfalfa mixed hay[5] | 20.1 | 37.57 | 48.62 | 61.7 | — | 0.2 | 1.66 | 1.13 | 0.34 |

[1]DDGS = distillers dried grains with solubles (Dakota Gold BPX, Dakota Gold Research Association, Sioux Falls, SD).

[2]Dakota Gold HP (Dakota Gold Research Association).

[3]Dakota Bran (Dakota Gold Research Association).

[4]Large square bales of corn residue stored inside.

[5]Large square bales of alfalfa mixed hay stored inside.

***Feed Samples.*** Core samples were obtained from the alfalfa mixed hay and corn residue bales. Samples of corn coproducts were collected from each load of product. The alfalfa mixed hay, corn residue bales, and coproducts for Exp. 1 and 2 were analyzed by Rock River Laboratory Inc. (Watertown, WI). The TDN values for DDGS, HP, and bran in Exp. 1 were values determined by Dakota Gold Research Association. For Exp. 2, the book value of TDN was used for DDGS (NRC, 1996). In both experiments, TDN values for alfalfa mixed hay and corn residue bales were determined by Rock River Laboratory Inc.

## *Statistical Analysis*

Treatment effects were considered significant at an $\alpha$ level of 0.05. Initial BW, final BW, BW change, initial BCS, final BCS, BCS change, milk production, first-service AI percentage, bale disappearance, DM disappearance, feed costs, and calf ADG were analyzed using the GLM procedure of SAS (SAS Institute Inc., Cary, NC). Pen served as the experimental unit, and comparisons were made using single degree of freedom orthogonal contrasts (DDGS vs. bran/DDGS and bran/HP; bran/DDGS vs. bran/HP; and hay vs. DDGS, bran/DDGS, and bran/HP). Milk components were also analyzed using the GLM procedure of SAS; however, the individual animal (n = 6 per treatment) was the experimental unit.

## *Exp. 2*

***Experimental Animals.*** Angus (n = 72) and Simmental (n = 92) spring-calving (January to March) cows nursing calves at the Orr Research Center were used to determine the effects of winter feeding strategy on performance, lactation, and feed costs of beef cow-calf production. Animals used in this trial were managed according to the guidelines recommended in the Guide for the Care and Use of Agriculture Animals in Agriculture Research and Teaching (Consortium, 1988). All experimental procedures followed those approved by the University of Illinois Laboratory Animal Care Advisory Committee

***Management and Diets.*** The feedstuffs used were DDGS, alfalfa mixed hay (large square bales stored inside), and corn residue (large square bales stored inside). The feed analyses are shown in Table 1. Cows were randomly allotted to 1 of 4 dietary treatments at calving: 1) free-choice corn residue bale and 6.5 kg DDGS (**AdLibRes** treatment); 2) 6.4 kg ground corn residue bale and 6.5 kg DDGS (**TMR** treatment); 3) 4.5 kg ground corn residue bale and 7.5 kg DDGS (**LowResTMR** treatment); and 4) free-choice alfalfa mixed hay (**AdLibHay** treatment). Coproduct diets 2 and 3 were formulated to be isocaloric and to meet the average of Simmental and Angus cow maintenance and lactation energy requirements. The diets were not isonitrogenous, but all diets did exceed protein requirements (NRC, 1996). Cows were maintained in 11.0 × 10.7 m concrete lots with a 7 × 7 m open-front shed. The DDGS for the AdLibRes as well as the entire ration for TMR and LowResTMR were pen-fed once daily in 7.3-m fence-line bunks. Corn residue bales (treatment 1) and alfalfa mixed hay bales (treatment 4) were fed in 3.7-m fence-line bale feeders. Corn residue bale and alfalfa mixed hay bale disappearances were calculated by weighing back refusals and subtracting that weight from initial bale weights. Cows were blocked by calving date and randomly assigned to 16 pens (12 pens had 10 cows, and 4 pens had 11 cows) after calving, resulting in 4 pens per treatment.

***Performance, Lactation, and Reproduction Analysis.*** Within 24 h of calving, cows and calves were weighed and allotted. Calf birth weights were used as initial calf BW. Cow BW and BCS, taken after calving and before feeding, were used as initial cow BW and BCS. Milk production was estimated using the weigh-suckle-weigh technique at an average of 53 ± 14.9 d postpartum. Twenty-four-hour milk production estimates were determined using a 12-h weigh-suckle-weigh technique (Beal et al., 1990). Six hours after the weigh-suckle-weigh measurement, a subsample of 6 cows per treatment were milked using a commercial portable milk machine (Porta Milker, The Coburn Company Inc.). Cows were administered 20 USP units of oxytocin (Phoenix Scientific) intravenously within 2 min of milking to initiate milk letdown. Milk was sampled and sent to Dairy Lab Services Inc. for compositional analysis. At an average of 78 ± 14.9 d postpartum, dietary treatments ended, and final cow shrunk BW and calf BW were taken. After the conclusion of the dietary treatments, all cows were fed 6.5 kg DDGS and free-choice corn residue bales until completion of synchronized AI. Cows were synchronized using the CoSynch+CIDR procedure (Bremer et al., 2004) and were artificially inseminated at an average of 81 ± 14.9 d postpartum. After AI, all cows went to pasture as a group. First-service conception rates were determined via transrectal ultrasonography at 67 d after AI.

***Feed Cost Calculations.*** Three-year (2006 to 2008) average price data for feedstuffs (alfalfa mixed hay, \$131.67/ton; DDGS, \$124.7/ton) were used for feed cost calculations. Price data for mixed alfalfa hay was attained from annual commodity reports (2006 to 2008; National Agricultural Statistics Service, 2009). Price data for DDGS was obtained from University of Nebraska's Department of Agricultural Economics "Mark's Marketing" Web site (Mark, 2010). Three-year price data for corn residue bales could not be found; thus, the authors estimated a value of \$55/ton. Machinery costs were also considered in each diet, along with herd sizes ranging from 50 to 300 cows. Formulas developed by the American Society of Agricultural Engineers were used to calculate machinery costs. Yearly ownership costs for a feed wagon with a list price of \$20,000 were determined to be \$4,009. This was composed of interest (7%), \$1,400; depreciation (10 yr − 35% salvage), \$1,300; insurance and housing (1%), \$200; and repairs and maintenance (0.05546× list), \$1,109. Yearly ownership costs for a grinder-TMR mixer with a list price of \$30,000 were calculated to be \$6,014. This was composed of interest (7%), \$2,100; depreciation (10 yr − 35% salvage), \$1,950; insurance and housing (1%), \$300; and repairs and maintenance (0.05546× list), \$1,664. Feed wagon and grinder-TMR mixer costs per day were calculated with the assumption of 150-d use of machinery each year. Costs associated with a feed wagon were used for the AdLibRes treatment, and costs associated with a combination grinder-TMR mixer were used for the TMR and LowResTMR treatments. Tractor costs were calculated using a 110 hp power take-off tractor at \$58.95/h (overhead, \$23.10; fuel, \$19.90; labor, \$15.95). Tractor usage costs were calculated for use on the feed wagon and grinder-TMR mixer as well as for feeding residue and hay bales. Bale feeding was estimated to take 10 min/454-kg bale, and actual bale disappearance for each treatment was used to calculate feeding cost. Costs of hand feeding cattle were also calculated for the AdLibRes diet for 50- and 100-cow herd sizes. It was estimated to take 1 h to hand feed 50 cows, at \$15.95/h.

### *Statistical Analysis*

Treatment effects were considered significant at an α level of 0.05. Initial BW, final BW, BW change, initial BCS, final BCS, BCS change, milk production, first-service AI percentage, and calf ADG were analyzed using the GLM procedure of SAS. Pen served as the experimental unit, and comparisons were made using single degree of freedom orthogonal contrasts (AdLibRes vs. TMR and LowResTMR; TMR vs. LowResTMR; and AdLibHay vs. AdLibRes, TMR, and LowResTMR). Milk components were also analyzed using the GLM procedure of SAS; however, the individual animal (n = 6 per treatment) was the experimental unit. No statistical analysis could be performed on feed costs for Exp. 2. Feed costs are based on feed intakes, and intake was controlled for treatments 2 (TMR) and 3 (LowResTMR); thus, there was not any pen-to-pen variation in DM disappearance or feed costs for those treatments.

## RESULTS AND DISCUSSION

### *Exp. 1*

Feed disappearance, initial BW, final BW, BW change, initial BCS, final BCS, milk production, calf ADG, and first-service AI conception are shown in Table 2. There were no differences in corn residue disappearance among the coproduct treatments. In addition, there were no differences in any of the contrasts in total DM disappearance. Cows fed hay lost more BW ($P \leq 0.05$) than cows fed the coproduct diets, but there were no differences in milk production or calf ADG in any of the contrasts. The increased BW loss for hay could be due to energy repartitioning or added fat. The DDGS contains high concentrations of RUP, and some studies indicate that increasing RUP can partition energy to body reserves. Wiley et al. (1991) showed an increase in postpartum BW change in heifers supplemented with additional RUP. Distillers grains also tend to have a higher fat content. Some research has found that cows tend to lose less body condition during lactation when fed polyunsaturated fat sources (Bottger et al., 2002). Although the alfalfa mixed hay used in this study was more than 61% TDN, it should be noted that the hay had a NDF concentration of approximately 52%. The high NDF concentration could have limited intake of the hay and could

**Table 2. Effect of winter feeding strategy on spring-calving beef cows (Exp. 1)**

| | Treatment[1] | | | | | Contrast | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1) DDGS | 2) Bran/DDGS | 3) Bran/HP | 4) Hay | SEM | 1 vs. 2 and 3 | 2 vs. 3 | 1, 2, 3 vs. 4 |
| Bale disappearance,[2] kg/d | 9.4 | 9.2 | 9.5 | 16.1 | 0.44 | 0.95 | 0.75 | — |
| DM disappearance,[3] kg/d | 15.9 | 15.8 | 16.1 | 16.1 | 0.44 | 0.98 | 0.76 | 0.81 |
| Initial BW, kg | 662 | 637 | 672 | 655 | 13.7 | 0.66 | 0.10 | 0.89 |
| Final BW, kg | 652 | 632 | 669 | 625 | 12.0 | 0.92 | 0.05 | 0.09 |
| BW change, kg | −10 | −5 | −3 | −30 | 7.13 | 0.50 | 0.87 | 0.02 |
| Initial BCS | 5.6 | 5.4 | 5.6 | 5.7 | 0.13 | 0.67 | 0.29 | 0.42 |
| Final BCS | 5.4 | 5.2 | 5.5 | 5.3 | 0.13 | 0.97 | 0.26 | 0.97 |
| BCS change | −0.2 | −0.2 | −0.2 | −0.3 | 0.15 | 0.69 | 0.93 | 0.47 |
| Milk production,[4] kg/d | 9.1 | 9.3 | 9.2 | 8.6 | 0.33 | 0.77 | 0.84 | 0.17 |
| Calf ADG, kg/d | 1.22 | 1.15 | 1.20 | 1.22 | 0.034 | 0.30 | 0.32 | 0.43 |
| First-service AI, % | 60 | 41 | 60 | 51 | 10.5 | 0.47 | 0.23 | 0.81 |
| Feed cost,[5] $/cow per day | 1.94 | 1.72 | 1.77 | 2.80 | 0.036 | <0.01 | 0.32 | <0.01 |

[1]Treatments: 1) DDGS = 6.5 kg distillers dried grains with solubles (Dakota Gold BPX, Dakota Gold Research Association, Sioux Falls, SD), free-choice corn residue bale; 2) bran/DDGS = 4.4 kg Dakota Bran (Dakota Gold Research Association), 2.2 kg Dakota Gold BPX, free-choice corn residue bale; 3) bran/HP = 5.1 kg Dakota Bran, 1.5 kg Dakota Gold HP (Dakota Gold Research Association), free-choice corn residue bale; 4) hay = free-choice alfalfa mixed hay.

[2]Bale disappearance represents corn residue for treatments 1, 2, and 3 and alfalfa mixed hay for treatment 4.

[3]DM disappearance of coproduct and corn residue or alfalfa mixed hay, depending on treatment.

[4]24-h milk production determined via the weigh-suckle-weigh technique (Beal et al., 1990) at 57 ± 13.6 d postpartum.

[5]Feed costs calculated using the following prices: Dakota Gold BPX (DDGS), $137.08/ton; Dakota Gold HP, $182.28/ton; Dakota Bran, $96.02/ton; alfalfa mixed hay, $131.67/ton; corn residue, $55/ton.

thus potentially explain the greater BW loss.

There were no differences in any of the contrasts for first-service AI conception rate. However, with the low numbers used in the study, it would be difficult to detect a meaningful difference in reproduction.

Milk composition and component production data are shown in Table 3. Milk from cows consuming the DDGS diet had a higher percentage of milk protein ($P \leq 0.05$) and 0.03 kg/d greater production of protein than the cows fed the bran supplements, but this was most likely caused by the diet containing a higher concentration of CP. One concern of feeding distillers grains is the potential milk fat depression that can occur from feeding high-fat diets. In dairy cows, feeding vegetable oils often results in poorer fiber digestion and, frequently, lower milk fat tests (Coppock and Wilks, 1991). Leonardi et al. (2005) reported a linear decrease in milk fat percentage as the level of DDGS increased. Kleinschmit (2006) reported no difference in milk fat percentage from DDGS supplementation. In this study, however, there was a trend for the cows on the DDGS treatment to have a higher percentage of fat ($P = 0.08$) in the milk and 0.16 kg/d greater production of fat ($P \leq 0.05$) when compared with cows fed the bran diets, which contradicts the previously mentioned studies. There were no differences between any of the contrasts in lactose or other solids. The cows fed DDGS had a higher milk urea nitrogen (**MUN**) value than those fed the bran/DDGS and bran/HP diets ($P \leq 0.05$). This was likely caused by the higher protein content of the DDGS supplement. In addition, the cows on the hay treatment had a higher MUN value than those on the coproduct/corn residue treatments ($P \leq 0.05$). This was also likely due to the higher protein concentration and RDP of the hay.

The diet costs are also shown in Table 2. The bran diets were less expensive than the DDGS diets ($1.75 vs. $1.94/cow per day, respectively; $P \leq 0.05$), and the hay diet was more expensive than the coproduct diets ($2.80 vs. $1.81/cow per day, respectively; $P \leq 0.05$). The break-even price for hay would be approximately $85/ton when corn residue is priced at $55/ton, DDGS at $137.08/ton, HP at $182.28/ton, and bran at $96.02/ton. This means if alfalfa mixed hay cannot be produced or purchased for less than $85/ton, feed costs could be reduced by feeding corn coproducts and corn residue bales. Not only was the hay diet more expensive, but the cows on the hay diet also lost more BW.

### *Exp. 2*

Initial BW, final BW, BW change, initial BCS, final BCS, BCS change, milk production, calf ADG, and first-service AI conception data are shown in Table 4. Similar to the results in Exp. 1, the cows fed the AdLibHay treatment lost more BW ($P \leq 0.05$) than those fed the coproduct/corn residue bale treatments, but there

**Table 3. Effect of winter feeding strategy on milk composition and milk component production of spring-calving beef cows (Exp. 1)**

| | Treatment[1] | | | | | Contrast | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1) DDGS | 2) Bran/DDGS | 3) Bran/HP | 4) Hay | SEM | 1 vs. 2 and 3 | 2 vs. 3 | 1, 2, 3 vs. 4 |
| Protein, % | 3.40 | 2.97 | 3.01 | 2.91 | 0.144 | 0.03 | 0.85 | 0.18 |
| Protein, kg/d | 0.31 | 0.28 | 0.28 | 0.25 | 0.010 | 0.02 | 0.96 | <0.01 |
| Fat, % | 5.30 | 3.32 | 3.58 | 4.86 | 0.825 | 0.08 | 0.82 | 0.42 |
| Fat, kg/d | 0.48 | 0.31 | 0.33 | 0.42 | 0.014 | <0.01 | 0.33 | 0.02 |
| Lactose, % | 4.92 | 4.48 | 4.72 | 4.84 | 0.259 | 0.32 | 0.52 | 0.67 |
| Lactose, kg/d | 0.45 | 0.42 | 0.43 | 0.42 | 0.016 | 0.25 | 0.45 | 0.43 |
| Other solids, % | 5.86 | 5.39 | 5.63 | 5.74 | 0.265 | 0.30 | 0.53 | 0.71 |
| Other solids, kg/d | 0.53 | 0.50 | 0.52 | 0.49 | 0.019 | 0.31 | 0.54 | 0.35 |
| MUN,[2] mg/dL | 9.68 | 3.16 | 3.79 | 13.39 | 0.827 | <0.01 | 0.59 | <0.01 |

[1]Treatments: 1) DDGS = 6.5 kg distillers dried grains with solubles (Dakota Gold BPX, Dakota Gold Research Association, Sioux Falls, SD), free-choice corn residue bale; 2) bran/DDGS = 4.4 kg Dakota Bran (Dakota Gold Research Association), 2.2 kg Dakota Gold BPX, free-choice corn residue bale; 3) bran/HP = 5.1 kg Dakota Bran, 1.5 kg Dakota Gold HP (Dakota Gold Research Association), free-choice corn residue bale; 4) hay = free-choice alfalfa mixed hay.

[2]Milk urea nitrogen.

were no differences in BCS change. Although the alfalfa mixed hay used in this study was almost 62% TDN, it should be noted that the hay had a NDF concentration of approximately 49%. The high NDF concentration could have limited intake of the hay and could thus potentially explain the greater BW loss. The cows fed the AdLibRes treatment had lower ($P \leq 0.05$) final BCS and had greater ($P \leq 0.05$) BCS loss than cows fed either of the TMR treatments, but there was not any difference in BW change between AdLibRes and the 2 TMR treatments. The cows on the AdLibRes treatment did have less corn residue bale disappearance than we expected, and this may have contributed to greater BCS loss. In addition, the cows fed the AdLibRes diet tended ($P = 0.10$) to have greater milk production, although it did not translate into a difference in calf ADG. The greater milk production may also explain the difference in BCS change. There appeared to be differences in nutrient partitioning. The composition of the AdLibRes diet was very similar to that of the TMR diet. However, the LowResTMR diet had greater inclusions of DDGS. The percentage of CP as RUP in DDGS is 52% (NRC, 1996). Hunter and Magner (1988) reported that feeding a diet high in RUP resulted in repartitioning of nutrients to maternal body growth rather than milk production. This may explain some of the differences seen in BCS loss and trends in milk production differences. There were no differences in calf ADG between any of the contrasts.

Cows fed the AdLibHay diet tended to have poorer first-service conception rates than cows on the corn coproduct/corn residue treatments (36 vs. 51%; $P = 0.09$). Feed sources containing high levels of unsaturated fatty acids have resulted in improved reproductive performance (Lammoglia et al., 1997; Bellows et al., 2001; Graham et al., 2001). Martin et al. (2007) reported improved AI conception for heifers fed DDGS compared with corn gluten feed; however, those diets were formulated to have the same levels of fat. The authors hypothesized that the improved conception could be due to high RUP levels. The improved first-service conception rate for cows fed corn coproducts could be attributed to the higher fat and RUP levels. However, the greater BW loss by the cows fed the AdLibHay diet may have contributed as well.

Milk composition and component production data are presented in Table 5. Cows fed the AdLibRes diet produced more ($P \leq 0.05$) fat, lactose, and other solids per day than cows fed the TMR or LowResTMR diet, but there were no differences in concentrations for any of these components. The greater production of fat, lactose, and other solids by cows consuming the AdLibRes diet is most likely associated with the trend for higher milk production compared with the other treatments. Milk from cows fed the TMR diet contained higher concentrations of lactose and other solids than cows fed the LowResTMR diet ($P \leq 0.05$). The cows receiving the AdLibHay diet had a higher MUN value than those fed the DDGS/corn residue diets ($P \leq 0.05$). This was likely caused by the high protein concentration and high RDP of the hay.

The feed cost analyses are presented in Table 6. With the feed cost alone, the hay diet was more than $1.00/cow per day more expensive than the 3 DDGS/corn residue diets ($2.50 vs. $1.44/cow per day). The break-even price for hay would be approximately $76/ton when corn residue is priced at $55/ton and DDGS is $124.71/ton. This means if alfalfa mixed hay cannot be produced or purchased for less than $76/ton, feed costs could be

Table 4. Effect of winter feeding strategy on spring-calving beef cows (Exp. 2)

| | Treatment[1] | | | | | Contrast | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1) AdLibRes | 2) TMR | 3) LowResTMR | 4) AdLibHay | SEM | 1 vs. 2 and 3 | 2 vs. 3 | 1, 2, 3 vs. 4 |
| Bale disappearance,[2] kg/d | 5.9 | — | — | 14.7 | — | — | — | — |
| DM disappearance,[3] kg/d | 12.4 | 12.9 | 12 | 14.7 | — | — | — | — |
| Initial BW, kg | 640 | 650 | 668 | 649 | 25.5 | 0.17 | 0.27 | 0.77 |
| Final BW, kg | 623 | 629 | 657 | 619 | 24.9 | 0.14 | 0.08 | 0.18 |
| BW change, kg | −17 | −21 | −11 | −30 | 12.8 | 0.89 | 0.23 | 0.04 |
| Initial BCS | 5.8 | 5.7 | 5.7 | 5.6 | 0.09 | 0.37 | 0.66 | 0.21 |
| Final BCS | 5.1 | 5.5 | 5.5 | 5.4 | 0.13 | 0.02 | 0.77 | 0.63 |
| BCS Change | −0.7 | −0.2 | −0.2 | −0.2 | 0.09 | <0.01 | 0.90 | 0.08 |
| Milk production,[4] kg/d | 12.1 | 11.2 | 10.3 | 10.1 | 0.69 | 0.10 | 0.35 | 0.12 |
| Calf ADG, kg/d | 1.19 | 1.14 | 1.17 | 1.18 | 0.058 | 0.37 | 0.33 | 0.62 |
| First-service AI, % | 55 | 50 | 47 | 36 | 6.7 | 0.48 | 0.81 | 0.09 |

[1]Treatments: 1) AdLibRes = 6.5 kg DDGS (ADM, Peoria, IL), free-choice corn residue bale; 2) TMR = 6.5 kg DDGS, 6.4 kg corn residue; 3) LowResTMR = 7.5 kg DDGS, 4.5 kg corn residue; 4) AdLibHay = free-choice alfalfa mixed hay.

[2]Bale disappearance represents corn residue bale for treatment 1 and alfalfa mixed hay for treatment 4.

[3]DM disappearance of coproduct and corn residue bale or alfalfa mixed hay, depending on treatment.

[4]24-h milk production determined using the weigh-suckle-weigh technique (Beal et al., 1990) at 53 ± 14.9 d postpartum.

reduced by feeding corn coproducts and corn residue bales. Not only was the hay diet more expensive, but the cows on the AdLibHay treatment also lost more BW.

Feed costs, including costs associated with feeding cows in herds ranging from 50 to 300 cows, are also reported in Table 6. For herd sizes of 50 or 100 cows, hand feeding the DDGS supplement in the AdLibRes treatment was approximately \$1.70/cow per day less expensive than feeding either the TMR or LowResTMR diet. When a tractor was used for feeding in a herd size of 50 cows, the AdLibHay diet was the least expensive. However, the DDGS/corn residue diets were less expensive than the AdLibHay diet in herd sizes of 100 cows or more when a tractor was used for feeding. The added costs associated with the grinder-TMR mixer used with the TMR and LowResTMR treatments did diminish as herd size increased; however, the AdLibRes treatment was less expensive than the TMR or LowResTMR treatment in herd sizes ranging from 50 to 300 cows.

## IMPLICATIONS

Using corn coproducts with corn residue bales is a viable alternative to feeding free-choice alfalfa mixed hay. Feeding corn coproducts and corn

Table 5. Effect of winter feeding strategy on milk composition and milk component production (Exp. 2)

| | Treatment[1] | | | | | Contrast | | |
|---|---|---|---|---|---|---|---|---|
| Item | 1) AdLibRes | 2) TMR | 3) LowResTMR | 4) AdLibHay | SEM | 1 vs. 2 and 3 | 2 vs. 3 | 1, 2, 3 vs. 4 |
| Protein, % | 2.70 | 2.69 | 2.82 | 2.65 | 0.112 | 0.68 | 0.41 | 0.51 |
| Protein, kg/d | 0.33 | 0.30 | 0.29 | 0.28 | 0.018 | 0.10 | 0.95 | 0.16 |
| Fat, % | 6.19 | 5.23 | 4.39 | 5.31 | 0.751 | 0.15 | 0.44 | 0.97 |
| Fat, kg/d | 0.77 | 0.58 | 0.47 | 0.55 | 0.105 | 0.04 | 0.52 | 0.66 |
| Lactose, % | 4.95 | 5.06 | 4.67 | 4.96 | 0.066 | 0.28 | <0.01 | 0.45 |
| Lactose, kg/d | 0.61 | 0.56 | 0.48 | 0.51 | 0.031 | 0.02 | 0.12 | 0.32 |
| Other solids, % | 5.84 | 5.94 | 5.56 | 5.84 | 0.066 | 0.29 | <0.01 | 0.49 |
| Other solids, kg/d | 0.72 | 0.66 | 0.57 | 0.60 | 0.035 | 0.02 | 0.16 | 0.32 |
| MUN,[2] mg/dL | 12.18 | 11.50 | 11.10 | 18.87 | 1.368 | 0.60 | 0.84 | <0.01 |

[1]Treatments: 1) AdLibRes = 6.5 kg DDGS (ADM, Peoria, IL), free-choice corn residue bale; 2) TMR = 6.5 kg DDGS, 6.4 kg corn residue; 3) LowResTMR = 7.5 kg DDGS, 4.5 kg corn residue; 4) AdLibHay = free-choice alfalfa mixed hay.

[2]Milk urea nitrogen.

**Table 6. Effect of winter feeding strategy on feed costs for varying herd sizes (Exp. 2)**

| | Treatment[1] | | | |
|---|---|---|---|---|
| Item | 1) AdLibRes | 2) TMR | 3) LowResTMR | 4) AdLibHay |
| Feed cost,[2] $/cow per day | 1.40 | 1.45 | 1.48 | 2.50 |
| Hand feeding,[2,3,4,5] $/ cow per day | | | | |
| 50 cows | 2.19 | — | — | — |
| 100 cows | 2.19 | — | — | — |
| Tractor feeding,[2,4,5,6] $/ cow per day | | | | |
| 50 cows | 3.58 | 3.90 | 3.93 | 3.21 |
| 100 cows | 2.73 | 2.91 | 2.94 | 3.21 |
| 150 cows | 2.44 | 2.58 | 2.61 | 3.21 |
| 200 cows | 2.30 | 2.42 | 2.45 | 3.21 |
| 250 cows | 2.21 | 2.32 | 2.35 | 3.21 |
| 300 cows | 2.15 | 2.25 | 2.28 | 3.21 |

[1]Treatments: 1) AdLibRes = 6.5 kg DDGS (ADM, Peoria, IL), free-choice corn residue; 2) TMR = 6.5 kg DDGS, 6.4 kg corn residue; 3) LowResTMR = 7.5 kg DDGS, 4.5 kg corn residue; 4) AdLibHay = free-choice alfalfa mixed hay.

[2]Feed prices: DDGS, $124.71/ton; alfalfa mixed hay, $131.67/ton; corn residue, $55/ton.

[3]Hand feeding calculated for treatment 1 only at 1 h/50 cows at $15.95/h.

[4]Tractor cost = $58.95/h (overhead, $23.10; fuel, $19.90; labor, $15.95).

[5]Bale feeding estimated at 10 min/bale fed (2.4 corn residue bales/d per 50 animals, 3.6 alfalfa mixed hay bales/d per 50 animals) using a tractor.

[6]Annual ownership cost of the feed wagon was $4,009 and of the grinder-TMR mixer was $6,014. The feed wagon was used for treatment 1 and the grinder-TMR mixer was used for treatments 2 and 3.

residue bales to spring-calving cows from calving until breeding resulted in improved BW change with no negative effects on milk production, calf performance, or first-service conception rates compared with free-choice alfalfa mixed hay. Therefore, the winter feeding strategy can be selected based on feed costs. Feed costs are lower for corn coproducts and corn residue bales than for free-choice alfalfa mixed hay. When corn coproduct supplements are balanced for protein and energy, feed costs can be reduced even further. Herd size dictates which winter feeding strategy is the least expensive when the equipment necessary for feeding is factored into costs. In small herds, hand feeding the coproduct supplement with free-choice corn residue bales is the most economical. In large herds, feeding free-choice hay is the most expensive.

## LITERATURE CITED


Beal, W. E., D. R. Notter, and R. M. Akers. 1990. Techniques for estimation of milk yield in beef cows and relationships of milk yield to calf weight gain and postpartum reproduction. J. Anim. Sci. 68:937.

Bellows, R. A., E. E. Grings, D. D. Simms, T. W. Geary, and J. W. Bergman. 2001. Effects of feeding supplemental fat during gestation to first-calf beef heifers. Prof. Anim. Sci. 17:81.

Bottger, J. D., B. W. Hess, B. M. Alexander, D. L. Hixon, L. F. Woodard, R. N. Funston, D. M. Hallford, and G. E. Moss. 2002. Effects of supplementation with high linoleic or oleic cracked safflower seeds on postpartum reproduction and calf performance of primiparous beef heifers. J. Anim. Sci. 80:2023.

Bremer, V. R., S. M. Damiana, F. A. Ireland, D. B. Faulkner, and D. J. Kesler. 2004. Optimizing the interval from PGF to timed AI in the CoSynch+CIDR and 7–11 estrus synchronization protocols for postpartum beef cows. J. Anim. Sci. 82(Suppl. 2):106. (Abstr.)

Consortium. 1988. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. Consortium for Developing a Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching, Association Headquarters, Savoy, IL.

Coppock, C. E., and D. L. Wilks. 1991. Supplemental fat in high-energy rations for lactating cows: Effects on intake, digestion, milk yield, and composition. J. Anim. Sci. 69:3826.

Graham, K. K., J. F. Bader, D. J. Patterson, M. S. Kerley, and C. N. Zumbrunnen. 2001. Supplementing whole soybeans prepartum increases first service conception rate in postpartum suckled beef cows. J. Anim. Sci. 79(Suppl. 2):106. (Abstr.)

Hess, B. W., S. L. Lake, E. J. Scholljegerdes, T. R. Weston, V. Nayigihugu, J. D. C. Molle, and G. E. Moss. 2005. Nutritional controls of beef cow reproduction. J. Anim. Sci. 83(E-Suppl.):E90.

Hunter, R. A., and T. Magner. 1988. The effect of supplements of formaldehyde-treated casein on the partitioning of nutrients between cow and calf in lactating *Bos indicus* × *Bos taurus* heifers fed a roughage diet. Aust. J. Agric. Res. 39:1151.

Kleinschmit, D. H., D. J. Schingoethe, K. F. Kalscheur, and A. R. Hippen. 2006. Evaluation of various sources of corn dried distillers grains plus solubles for lactating dairy cattle. J. Dairy Sci. 89:4784.

Lammoglia, M. A., R. A. Bellows, E. E. Grings, J. W. Bergman, R. E. Short, and M. D. MacNeil. 1997. Effects of dietary fat composition and content, breed and calf sex on birth weight, dystocia, calf vigor and postpartum reproduction in first calf beef heifers. J. Anim. Sci. 75(Suppl. 1):117. (Abstr.)

Leonardi, C., S. Bertics, and L. E. Armentano. 2005. Effect of increasing oil from distillers grains or corn oil on lactation performance. J. Dairy Sci. 88:2820.

Mark, D. R. 2010. Mark's Marketing—Ethanol Co-Product Prices: Iowa, Kansas, Minnesota, and Missouri. http://agecon.unl.edu/mark/ethanol_byproducts.html Accessed Feb. 5, 2010.

Martin, J. L., A. S. Cupp, R. J. Rasby, Z. C. Hall, and R. N. Funston. 2007. Utilization of dried distillers grains for developing beef heifers. J. Anim. Sci. 85:2298.

Miller, A. J., D. B. Faulkner, T. C. Cunningham, and J. M. Dahlquist. 2007. Restricting time of access to large round bales of hay affects hay waste and cow performance. Prof. Anim. Sci. 23:366.

Miller, A. J., D. B. Faulkner, R. K. Knipe, D. R. Strohbehn, D. F. Parrett, and L. L. Berger. 2001. Critical control points for profitability in the cow-calf enterprise. Prof. Anim. Sci. 17:295.

National Agricultural Statistics Service. 2009. Crop Values—2008 Summary. http://usda.mannlib.cornell.edu/usda/nass/CropValuSu//2000s/2009/CropValuSu-02-13-2009.txt Accessed Feb. 5, 2010.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th rev. ed. Ed. Natl. Acad. Press, Washington, DC.

Strohbehn, D. R. 2001. 2000 Beef Cow Record Summary. File B1-47. Iowa State Univ. Ext., Ames.

Wiley, J. S., M. K. Petersen, R. P. Ansotegui, and R. A. Bellows. 1991. Production from first-calf beef heifers fed a maintenance or low level of prepartum nutrition and ruminally undegradable or degradable protein postpartum. J. Anim. Sci. 69:4279.