

Using corn gluten feed in post-partum diets of young beef cows to optimize reproductive performance

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ABSTRACT: Forty-eight primiparous and diparous Angus-Simmental cows were fed 1 of 3 diets; 1) total mixed ration (TMR) based of corn silage and corn stalks (CON), 2) TMR with 3.3 kg/d DM of corn gluten feed (CGF; MID), or 3) TMR with 6.7 kg/d DM of CGF (HIGH). From 11 ± 5 days post-partum (DPP) to 105 ± 5 DPP, all diets were formulated to be isocaloric for a post-partum ADG targeted at 0.22 kg, but CP exceeded requirements in both CGF diets. Blood samples were collected from cows starting at trial initiation until estrous synchronization for determination of plasma progesterone concentration (7 d intervals), as an indicator of resumption of cyclicity, as well as for plasma urea nitrogen (PUN; 21 d intervals). Milk production was assessed at 62 ± 5 DPP via a weigh-suckle-weigh procedure, and milk samples were collected at 64 ± 5 DPP for composition analysis. A 5 d Co-Synch + Control Internal Drug Release (CIDR) protocol was used and cows were bred by timed artificial insemination (TAI). Trans-rectal ultrasonography was used for the evaluation of the dominant follicle at TAI, as well as pregnancy diagnosis. Nineteen days post-TAI, cow and calf pairs were managed as a single group until weaning (205 ± 5 DPP) and exposed to nat-

ural mating for a total of a 60 d breeding season. Dam ADG was not significantly different among treatments ($P = 0.849$), but, DMI decreased with increasing CGF in the diet ($P = 0.049$). There were no differences in final BW ($P = 0.779$), however, final BCS was lower in the HIGH treatment when compared to the MID ($P = 0.042$). Milk production ($P = 0.457$), as well as, milk components ($P \geq 0.188$) were not different, with the exception of milk fat, which tended to be greater in the HIGH treatment ($P = 0.059$) when compared to the MID. A treatment by week interaction ($P < 0.0001$) was found for PUN concentrations. Concentrations were greater in the HIGH treatment compared to the MID treatment at 63, 84, and 105 d, and greater than the CON treatment at all time points except d-42. There were no differences in resumption of cyclicity ($P = 0.419$), dominant follicle ($P = 0.648$), or TAI conception rates ($P = 0.761$). However, season long pregnancy rates were significantly greater in the CGF treatments when compared to the CON ($P = 0.009$). In summary, feeding high or intermediate amounts of CGF neither has a positive nor negative effect on TAI conception rates of beef cows, however, it positively affected season long pregnancy.

Key words: beef cattle, corn gluten feed, reproduction

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INTRODUCTION

Ethanol production in the United States has increased exponentially in the last 10 to 15 years, as well as, the conversion of land used for pasture and hay to row crop production. The utilization of alternative feed stuffs, such as corn co-products from ethanol production are being researched for the uti-

lization in sustainable feeding programs for beef cattle. Recent studies have shown that the utilization of dried distiller's grains plus soluble (DDGS) can improve conception rates to timed artificial insemination (TAI; Gunn et al., 2014b; Shee et al., 2016). Corn gluten feed (CGF) is another corn co-product that is more readily available in some areas compared to others, and its evaluation as a primary dietary energy source for early lactation cows is needed.

Dried distiller's grains plus solubles have both elevated protein and fat (Klopfenstein et al., 2008; National Academies of Sciences, Engineering, and

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Medicine, 2016), which makes it challenging to decipher which nutritional component is contributing to improved fertility. Corn gluten feed, delivers a similar amount of protein profile without the added fat. Similar to DDGS, CGF is also greater in RUP, which has been shown to have a positive effect on fertility (Wiley et al., 1991; Triplett et al., 1995).

The current study was conducted to investigate potential differences in the reproductive performance of cows when fed CGF as a primary source of dietary energy, formulated to meet nutrient requirements (NRC, 2000), but exceed protein requirements during early lactation. We hypothesized that cows fed a diet containing elevated protein content would experience increased follicular growth and conception rates to TAI compared with cows fed a traditional dietary protein amount, similar to results previously observed with DDGS (Gunn et al., 2014b). Specifically, we expect that cows fed a high and mid-level protein, would experience an increase in follicular growth with a subsequent increase in TAI conception rates in a manner similar to results previously observed with DDGS.

MATERIALS AND METHODS

This study was conducted at the Purdue Animal Sciences Research and Education Center near West Lafayette, IN. All animals were handled in compliance with approved procedures from the Purdue Animal Care and Use Committee. PACUC #1312001000.

Animals and Diets

Forty-eight primiparous and diparous, Angus-Simmental cows of similar genetic background were used in a complete randomized block design study to evaluate the effects of feeding CGF as a primary source of dietary energy during early lactation, which resulted in protein concentrations in excess of requirements, on cow BW, milk composition, and reproductive performance.

At 11 ± 5 days post-partum (DPP) cows were blocked by cow weight, BCS and age before random assignment ($n = 16$) to 1 of 3 treatments (Table 1); 1) a silage-based total mixed ration (TMR; CON), 2) a TMR with 3.3 kg/d DM of CGF (MID), or a 3) TMR with 6.7 kg/d DM of CGF (HIGH). Due to a range in calving dates, cows were balanced across treatments (in multiples of 3) and placed on study in 1 of 2 groups to ensure all cows were fed their respective diets within 11 ± 5 d of calving. Groups 1 and 2 each included 24 cows.

All diets were formulated to be isocaloric and either meet, or exceed all other nutrient requirements (NRC, 2000), for a post-partum ADG targeted at 0.22 kg. Ingredient compositions of feed stuffs used to formulate

Table 1. Dietary feed ingredients and formulated and nutrient composition of diets fed to beef cows during early lactation

Item	Treatment ¹		
	CON	MID	HIGH
Ingredient, formulated, % DM/d			
Corn gluten feed	–	26.4	52.8
Corn silage	28.4	7.0	5.2
Alfalfa-grass silage	45.1	10.5	–
Corn stover	4.9	34.9	38.2
Soybean meal	1.7	–	–
Soybean hulls	18.5	18.7	–
Limestone	–	1.1	2.3
Mineral supplement ²	1.4	1.4	1.5
Total, kg DM/d	13.0	12.7	12.5
Formulated nutrient intake			
CP, %	11.5	11.6	13.5
RUP, %	18.5	31.5	34.9
NE _m , Mcal/kg	0.3	0.3	0.3
Fat, %	2.8	2.3	2.4
Ca, %	0.5	0.8	1.1
P, %	0.3	0.4	0.7
Salt, %	0.3	0.3	0.3

¹CON = control; MID = 3.4 kg/d corn gluten feed (CGF); HIGH = 6.9 kg/d CGF.

²Mineral composition; Ca = 11%, P = 5%, Mg = 2%, K = 2%, Na = 19.5%, Vitamin A = 661 KIU/kg, Vitamin E = 66 IU/kg, Cu = 1,500 mg/kg, Mn = 3,000 mg/kg, Zn = 3,700 mg/kg, Se = 27 mg/kg, Co = 40 mg/kg.

diets were obtained by wet chemistry methods (AOAC, 1990) before trial initiation (Dairy One, Ithaca, NY). Two cow-calf pairs were housed in individual feeding pens. All dietary treatments were fed ad libitum as a TMR in concrete bunks once daily at 0800 h. Analysis of individual feed ingredients were taken weekly with DM being measured via a forced-air oven at 60°C for 72 h. These values were used to adjust intake for dietary moisture content. During the study, calves did have access to cow diets due to bunk design and may have contributed to dietary dry matter disappearance. However, it is assumed that DM consumption was minimal due to calves being less than 3 months of age during the study.

Initial (11 ± 5 DPP) and final (104 ± 5 DPP) cow BW was determined by taking the average of 2 consecutive preprandial weights. Initial and final BCS (Wagner et al., 1988) was defined one day before trial initiation, with final BCS being taken at trial end. An experienced single investigator was responsible for BCS throughout the study. Body weight was taken on 21 d intervals throughout the study. Dietary treatments was terminated 104 ± 5 DPP, at which time all cow-calf pairs were commingled, placed on pasture, and exposed to natural mating for a total of a 60 d breeding season. Calf body weight was determined at birth and again at trial end (105 ± 5 DPP). Calf performance was not measured past trial end.

Milk Composition

Milk production was measured on $d-62 \pm 5$ DPP via a 24 h weigh-suckle-weigh (WSW) procedure. Cows and calves were separated from each other at 0600 h, with calves being placed in pens of 4, allowed to nurse the cows dry at 1200 h, and again separated to serve as the empty baseline. At 1800 h calves were weighed before nursing, allowed to nurse their dam, and once nursing was completed within a pen, immediately separated and reweighed. The difference between post and preprandial calf BW was used to calculate milk production for a 6 h interval. This method was repeated for 3 more consecutive 6 h intervals, to obtain a total 24 h milk production period. Cows were allowed access to water and diets in their pens during this period. Calves were penned separately and did not have access to feed or water.

Milk composition was assessed from samples collected from one quarter at 64 ± 5 DPP using a milking machine. Cows were separated from calves at 0300 h with access to water only. Cows were milked randomly starting at 0900 h. Each cow received 2 cc oxytocin Intramuscular (IM) and each quarter was cleaned with a betadine solution. Samples were collected from the quarter milked and immediately sent to Dairy One Laboratories for composition analysis [total fat, total protein, milk urea nitrogen (MUN), Lactose and Total solids]. Cows were immediately returned to their calves before milking.

Sample Collection and Analysis

Blood samples were collected via coccygeal venipuncture in 6 mL tubes containing EDTA (BD Vacutainer; Becton-Dickinson, Franklin Lakes, NJ) and placed on ice until further processing could occur. Samples were centrifuged at $1,750 \times g$ for 25 min at 4°C. Plasma was then transferred to polypropylene tubes and frozen at -20°C for subsequent analysis of progesterone and plasma urea nitrogen (PUN) concentration.

Starting at 7 ± 5 DPP, blood samples were collected at 7 d intervals until estrous synchronization for determination of plasma progesterone concentration as an indicator for resumption of cyclicity and has been previously described (Gunn et al., 2015). Plasma progesterone concentration was determined using a radioimmunoassay (RIA) kit (Coat-A-Count, Siemens Medical Solutions Diagnostics, Los Angeles, CA). Cows that had progesterone concentrations of ≥ 1 ng/ml were determined to have ovulated 7 d before that blood sampling date. Confirmation of 1st ovulation was considered as resumption of cyclicity. Across 2 assays, the inter-assay CV for pooled plasma samples containing 0.67 ng/mL and 7.4 ng/mL of progesterone, were 0.81 and 3.04% respectively.

Blood samples were also collected at 21 d intervals from initiation of diets through termination of di-

ets for PUN. Samples were analyzed using a commercial ELISA kit (Urea Nitrogen Procedure No. 0580 Stanbio Laboratory, Boerne, TX). Samples were read in 96-well polystyrene plates (Becton-Dickinson) on an Opsys MR microplate reader (Dynex Technologies Inc., Chantilly, VA) at 530 nm. Across 6 assays, the average intra-assay CV was 3.14% and the inter-assay CV for a pooled plasma sample containing 3.35 mg/dL of urea nitrogen was 3.51%.

Estrous Synchronization and Breeding

A 5 d Co-Synch + Control Internal Drug Release (CIDR) protocol was initiated at 77 ± 5 DPP to synchronize ovulation. At protocol initiation, all cows received a CIDR (CIDR Zoetis, Florham Park, NJ) paralleled with the administration of 100 μg of GnRH (Cystorelin, Merial Animal Health, Duluth, GA). Five days after protocol initiation, the CIDR was removed and 2 separate 25-mg injections of PGF_{2 α} (Lutalyse, Zoetis) were simultaneously administered. At 72 h post PGF_{2 α} injection, all cows were time-bred using artificial insemination (TAI), paralleled with the administration of 100 μg of GnRH (Cystorelin, Merial Animal Health). Cows were bred by 1 of 2 technicians. Trans-rectal ultrasonography was used to measure any ovarian follicle with diameters ≥ 7 mm at TAI and again at 48 h post-TAI to confirm which follicle underwent ovulation. All cows were exposed to natural mating for a total of a 60 d breeding season. Pregnancy diagnosis was performed at 39 d after TAI to determine TAI pregnancy rates. Final pregnancy diagnosis was conducted 35 d after termination of the breeding season.

Statistical Analysis

All data were analyzed with pen used as the experimental unit. The MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was used for analysis of BW, BCS, DMI, ADG, milk production, milk composition, and follicle diameter. Binary data (cyclicity, TAI, season long pregnancy) was analyzed using the GLIMMIX procedure of SAS. The models included the fixed main effect of treatment. Sire and AI technician were initially included in the models as covariates, but were removed due to insignificance. The MIXED procedure of SAS for repeated measures was used for PUN data and the model included the fixed main effects of treatment and week, as well as, the treatment \times wk interaction with animal nested within treatment as a random variable. A multiple comparison of means was performed using Tukey-Kramer method.

In addition, orthogonal contrasts were used for all variables to test treatment effects among the CON diet vs. the average of the MID diet and the HIGH diet, as

well as, the MID diet vs. the HIGH diet for the remaining parameters. For all variables analyzed, a P -value ≤ 0.05 was identified as significant and a P -value ≤ 0.10 was identified as a trend.

RESULTS

Dam Performance

Cow performance is illustrated in Table 2 and data were summarized with pen used as the experimental unit. As designed initial cow BW and cow BCS were not different among treatments (BW, CON vs. MID, and HIGH $P = 0.953$; MID vs. HIGH $P = 0.8457$; $P = 0.979$; BCS, CON vs. MID and HIGH $P = 0.883$; MID vs. HIGH $P = 0.718$; $P = 0.925$). Additionally, there were no significant differences, among treatments for final cow BW (CON vs. MID and HIGH $P = 0.606$; MID vs. HIGH $P = 0.637$; $P = 0.779$) or ADG (CON vs. MID and HIGH $P = 0.733$; MID vs. HIGH $P = 0.651$; $P = 0.849$), however, final BCS (MID vs.

HIGH $P = 0.042$; $P = 0.109$) was significantly lower in the HIGH treatment when compared to the MID. Dry matter intake decreased (CON vs. MID and HIGH $P = 0.025$; MID vs. HIGH $P = 0.288$; $P = 0.049$), as the amount of CGF increased in the diet. Specifically, the CON treatment had a greater DMI when compared to the MID and HIGH treatments ($P = 0.025$).

Total milk production (Table 3), determined by WSW at 62 ± 5 DPP did not differ among treatments (CON vs. MID and HIGH $P = 0.219$; MID vs. HIGH $P = 0.885$; $P \geq 0.457$). Similarly, milk protein (CON vs. MID and HIGH $P = 0.441$; MID vs. HIGH $P = 0.901$; $P = 0.732$), lactose (CON vs. MID and HIGH $P = 0.252$; MID vs. HIGH $P = 0.819$; $P = 0.498$), total solids (CON vs. MID and HIGH $P = 0.610$; MID vs. HIGH $P = 0.188$; $P = 0.365$) and MUN (CON vs. MID and HIGH $P = 0.645$; MID vs. HIGH $P = 0.718$; $P = 0.840$) concentrations were not different. However, milk fat (CON vs. MID and HIGH $P = 0.937$; MID vs. HIGH $P = 0.059$; $P = 0.161$) tended to be greater in the HIGH treatment when compared to the MID treatment.

Table 2. Effect of beef cow diet fed during early lactation on dam growth performance

Item	Treatment ¹			SEM ³	Contrast P -value ²		Overall P -value ²
	CON	MID	HIGH		1 vs 2,3	2 vs 3	
BW,kg							
Initial	546.24	547.09	543.51	13.04	0.953	0.845	0.979
Final	579.19	565.40	574.93	19.86	0.606	0.637	0.779
BCS ⁴							
Initial	4.99	5.05	4.98	0.14	0.883	0.718	0.925
Final	5.23	5.38	5.16	0.08	0.651	0.042	0.109
DMI, kg/d	16.61	15.55	14.83	0.98	0.025	0.288	0.049
ADG, kg/d	0.37	0.25	0.36	0.23	0.733	0.651	0.849

¹CON = control; MID = 3.3 kg/d corn gluten feed (CGF); HIGH = 6.7 kg/d CGF.

² P -value ≤ 0.05 was identified as significant and between 0.05 and 0.10 was considered a tendency.

³Greater SEM presented ($n = 8$ for CON; $n = 8$ for MID; $n = 8$ for HIGH).

⁴BCS scale of 1 to 9 (1 = emaciated, 9 = obese; Wagner et al., 1988).

Table 3. Effect of dam diet fed during lactation on milk composition¹

Item	Treatment ²			SEM ⁴	Contrast P -value ³		Overall P -value ³
	CON	MID	HIGH		1 vs 2, 3	2 vs 3	
Milk production, kg/d ⁵	7.87	8.67	8.78	0.75	0.219	0.885	0.457
Milk protein, %	2.43	2.37	2.36	0.11	0.441	0.901	0.732
Milk fat, %	2.26	1.92	2.66	0.33	0.937	0.059	0.161
Milk lactose, %	4.58	4.32	4.37	0.23	0.252	0.819	0.498
Milk total solids, %	10.17	9.53	10.31	0.56	0.610	0.188	0.365
Milk urea N, mg/dL	7.48	6.99	7.29	0.81	0.645	0.718	0.840

¹Samples collected at 62 and 64 ± 5 DPP.

²CON = control; MID = 3.3 kg/d corn gluten feed (CGF); HIGH = 6.7 kg/d CGF.

³ P -value ≤ 0.05 was identified as significant and between 0.05 and 0.10 was considered a tendency.

⁴Greater SEM presented ($n = 16$ for CON; $n = 16$ for MID; $n = 16$ for HIGH).

⁵Measured via 24 h weigh-suckle-weigh procedure with 4, 6-h sampling times.

There was a significant difference in treatment ($P = 0.001$), wk ($P = 0.014$), and a treatment \times wk ($P < 0.0001$) interaction for PUN concentrations (Fig. 1). As expected the initial sampling date did not differ among treatments ($P \geq 0.873$), as well as, at d-21 ($P \geq 0.970$). However, numerically the differences are quite large at d-21, and the lack of significance may be due to the low number of animals on study at this time point. Similarly, at d-42 ($P \geq 0.579$) and 84 ($P \geq 0.524$) there were no differences among treatments. The general trend over the course of the study was for PUN concentration to increase as CP and undegradable protein increased in the diet.

Prior to estrous synchronization, no difference in resumption of cyclicity, as determined by plasma progesterone concentrations, was observed (CON vs MID and HIGH $P = 0.802$; MID vs. HIGH $P = 0.200$; $P = 0.419$;

Table 4). In addition, no differences were detected in the diameter of the dominant follicle before ovulation (CON vs. MID and HIGH $P = 0.384$; MID vs. HIGH $P = 0.759$; $P = 0.648$), or the proportion of cows pregnant to TAI (CON vs. MID and HIGH $P = 0.465$; MID vs. HIGH $P = 1.00$; $P = 0.719$). Season long pregnancy however, was significantly greater in the CGF treatments when compared to the CON treatment (CON vs. MID and HIGH $P = 0.009$; MID vs. HIGH $P = 1.00$; $P = 0.020$).

Progeny Performance

Calf performance is reported in Table 5. Though there was a tendency for differences in initial birth weight (CON vs. MID and HIGH $P = 0.070$; MID vs. HIGH $P = 0.400$; $P = 0.137$) between the CON and MID and

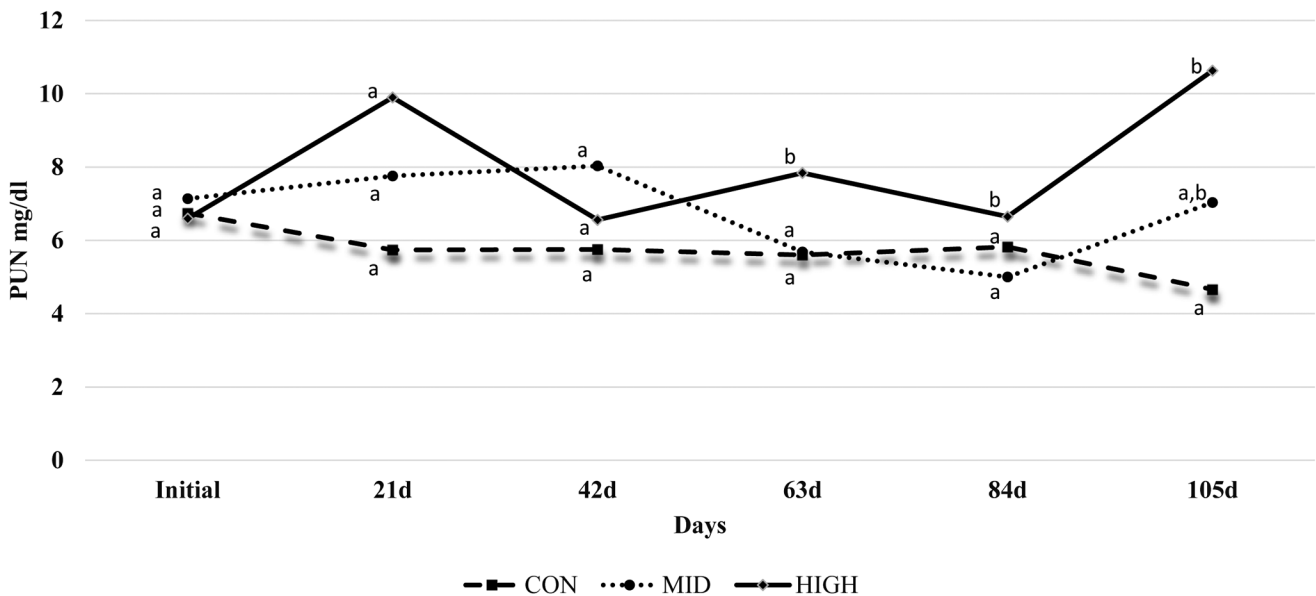


Figure 1. Effect of cow diet fed during early lactation on plasma urea nitrogen concentration (PUN). All treatments (CON = control; MID = 3.3 kg/d corn gluten feed (CGF); HIGH = 6.7 kg/d CGF) were significantly different at trial end, d-105, however, there were no discernable trends throughout the sampling dates. Means with the same letter designation, within sample date, are not statistically different ($P \geq 0.05$)

Table 4. Effect of beef cow diet during early lactation on dam reproductive performance

Item	Treatment ¹			SEM ³	Contrast P -value ²		Overall P -value ²
	CON	MID	HIGH		1 vs 2, 3	2 vs 3	
Resumption of Cyclicity, %	18.8	6.3	25.0		0.802	0.200	0.419
Dominant follicle diameter, mm	13.1	12.7	12.5	0.67	0.384	0.759	0.648
Pregnancy rates, %							
TAI ⁴	43.8	56.3	56.3		0.465	1.000	0.761
Season long pregnancy, %	81.3	100	100		0.009	1.000	0.020

¹CON = control; MID = 3.3 kg/d corn gluten feed (CGF); HIGH = 6.7 kg/d CGF.

² P -value ≤ 0.05 was identified as significant, and between 0.05 and 0.10 was considered a tendency.

³Greater SEM presented ($n = 16$ for CON; $n = 15$ for MID; $n = 16$ for HIGH).

⁴Timed artificial insemination rate.

Table 5: Effect of beef cow diet on calf growth performance

Item	Treatment ¹			SEM ³	Contrast <i>P</i> -value ²		Overall <i>P</i> -value ²
	CON	MID	HIGH		1 vs 2,3	1,2 vs 3	
Calf, kg							
Birth weight	37.05	39.15	40.63	1.15	0.070	0.400	0.137
End weight	158.74	155.71	156.62	4.89	0.692	0.903	0.916
ADG, kg/d ⁴	1.16	1.13	1.13	0.04	0.469	0.984	0.764

¹CON = control; MID = 3.3 kg/d corn gluten feed (CGF); HIGH = 6.7 kg/d CGF.

²*P*-value ≤ 0.05 was identified as significant, and between 0.05 and 0.10 was considered a tendency.

³Greater SEM presented (n = 16 for CON; n = 16 for MID; n = 16 for HIGH).

⁴Overall ADG was calculated between 0 ± 5 DPP and 105 ± 5 DPP.

HIGH treatment, calves were similar in BW among treatments for final end weights (CON vs. MID and HIGH *P* = 0.692; MID vs. HIGH *P* = 0.903; *P* = 0.916). Average daily gain from birth to 105 ± 5 DPP were not significantly different among treatments (CON vs. MID and HIGH *P* = 0.469; MID vs. HIGH *P* = 0.984; *P* = 0.764).

DISCUSSION

The current study was conducted to evaluate feeding beef cows varied amounts of CGF as a primary source of dietary energy, which resulted in feeding protein in excess of requirements during early lactation, on calf growth and cow reproductive performance. It was hypothesized that feeding CGF to dams, would increase reproductive performance of the dam, as well as, increase growth rate of offspring. It has been reported that providing greater amounts of RUP could cause a reduction in weight loss due to free fatty acids release inhibition (Serrato-Corona et al., 1996; Hawkins et al., 2000). This is supported by the current research, as BW was similar between treatments and increased throughout the study. In contrast, Kane et al. (2002) reported BW loss when feeding varying amounts of RUP, however, their high RUP was 335 g/d, while the current diets consisted of 475 and 614 g/d for the MID and HIGH diets respectively.

In the current study, diets were formulated to be similar in energy content and cows were of similar age and genetic background, therefore, similar total milk production among treatments (8.33 ± 0.46 kg/d) was expected. Comparable results have been reported when feeding excess RUP (400 to 680 g/d) during lactation (Rusche et al., 1993), however, in the current study, while not statistically significant, milk production increased numerically with greater amounts of RUP which is similar to results reported by Kane et al. (2002). In contrast to results from the current study, a numeric increase in milk components with increasing RUP has been reported (Kane et al., 2002). Milk fat was observed to be significantly greater in the HIGH treatment when compared to the MID in the current study, however, these results are not

related to total fat consumed in the diet, and the numeric differences are small and likely do not have biological significance. We have no explanation as to why the MID treatment would have reduced milk fat, and to our knowledge there is only 1 study that has evaluated CGF and milk composition (Shike et al., 2009). The current study's significant reduction in milk fat, when compared to that reported by the National Academies of Sciences, Engineering, and Medicine (2016), as well as, Shike et al. (2009) could be due to the lack of a complete milk removal from all 4 quarters. Although, milk fat varied among treatments, calf performance did not differ. This is similar to the Shike et al. (2009) study, which reported no differences in ADG of calves from dams fed 7.7 kg/d of CGF vs. 7.2 kg/d of DDGS.

It has been shown that increasing protein in the diet using DDGS, corn gluten meal, soybean meal or blood meal has resulted in the increase of PUN levels (McCormick et al., 1999; Gunn et al., 2014b). In the current study, PUN concentrations generally increased with CP and RUP concentration of the diet, but there was inconsistency on days 42, 63, and 84 of the study. Because the protein in CGF and DDGS are similar in profile, one could assume that PUN levels would increase, consistent with previous findings (Gunn et al., 2014b). However, in the current study, PUN levels were consistently lower when feeding CGF than DDGS (Gunn et al., 2014b). While the reasoning is unknown, one could speculate that differences in PUN levels might be affected by the oil content in the DDGS, which is absent in CGF, and may be causing alterations in nitrogen metabolism within the rumen. McCormick et al. (1999) also observed lower PUN concentrations when substituting corn gluten meal for soybean meal in dairy diets, though, total fat in the diet was not reported.

Previous research evaluating the post-partum interval and its relation to increasing amounts of CP have suggested that increasing CP in the diet will aid in the decrease of the PPI (Bolze et al., 1985; Gunn et al., 2014b). However, these studies have been conducted during both gestation and lactation, in contrast to the current study which was conducted only during

early lactation. The results from the current study suggest that the critical period for an impact on resumption of cyclicity may be during late gestation.

Recently reported by Gunn et al. (2014b) and Shee et al. (2016), enhancements in reproductive efficiency have been observed when feeding DDGS as a primary source of dietary energy, and therefore excess protein during early lactation. Enhancements in conception from feeding DDGS may have resulted from the increased intake of RUP, fat, or a combination of the 2 as part of the feed matrix. An increase in dominant follicle diameter when evaluating follicular wave dynamics has been reported by Gunn et al. (2014b). These results have been observed both when feeding greater amounts of DDGS (Gunn et al., 2014b) and CGF (Gunn et al., 2014a). However, dominant follicle diameter at TAI was reportedly not different (Gunn et al., 2014b), and one could speculate that the use of an estrous synchronization protocol negated the possible influence on follicular growth. Numeric increases in TAI conception rates have been consistently reported when DDGS was used as a primary energy source in isocaloric diets (Gunn et al., 2014b; Shee et al., 2016). Although we hypothesized an increase in reproductive efficiency, feeding CGF as a dietary energy source did not significantly improve conception rates over the control animals (56.3% vs 43.8%). Recent DDGS studies (Gunn et al., 2014b; Shee et al., 2016), suggest that elevated dietary concentrations of protein and RUP may increase TAI conception rates. These results are similar to those reported by McCormick et al. (1999), where conception rate, though not hindered, was not significantly improved by feeding greater dietary concentrations of protein, and RUP. Season long pregnancy rates were significantly greater in the CGF treatments when compared to the CON. Because there was a numeric increase in TAI conception rates, and the range in conception rates increased as the breeding season continued, one could speculate that the numeric differences at TAI are real. However, increased number of animals in the study is warranted for further investigation.

In summary, this data suggests no detrimental effects of feeding high or intermediate amounts of CGF during early lactation on reproductive efficiency. While we hypothesized that feeding either a lower amount (3.3 kg/d) or greater amount (6.7 kg/d) of CGF would increase cow reproductive efficiency and offspring performance, this study did not show a statistically significant benefit. The results from this study do not suggest that CGF at similar protein amounts as recent DDGS studies, improves TAI conception rates. However, a study feeding CGF to increased number of animals may be warranted. Further research is needed to decipher the potential benefits on cow performance, due to RUP, fat or a combination of the two.

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