Effect of Excess Dietary Crude Protein from Corn Gluten Meal or Soybean Meal on Reproductive Function of Beef Cows Consuming Low Quality Forage

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Summary and Implications

Coproducts of the ethanol industry are a concentrated package of crude protein (CP) which can be fed to beef cows in conjunction with low quality forage to make economical diets that meets nutrient requirements. With this pairing, having excess dietary CP is likely; however the effects of these excessive CP diets on beef cow reproduction have not been made clear. In addition, the effects of excess dietary CP from feedstuffs that differ in rumen degradability are not known. In the present study, we studied the effects of diets containing 150% of metabolizable protein (MP) requirements from a moderately high (corn gluten meal) or low (soybean meal) rumen undegradable protein (RUP) fraction on reproductive function around the time of ovulation. We observed that excess dietary RUP enhanced dominant follicle growth and ovulatory parameters, while excess dietary rumen degradable protein (RDP) improved circulating progesterone concentration post ovulation. Based on these data, source of CP when fed to excess may have differential impacts on reproductive function in mature beef cows. However, the mechanisms by which these physiological alterations occur are unknown at this time. Thus, more research is warranted to elucidate how source and amount of CP, when supplemented in low quality forage-based diets, may influence reproductive function in beef cows.

Introduction

It has been hypothesized that feeding diets with high concentrations of distillers grains may result in metabolic and reproductive inefficiency due to excess dietary protein. However, recent studies in our lab have shown that feeding distillers dried grains with solubles (DDGS) as a primary energy source to beef cows during early lactation improved pregnancy rates. This is likely due in part to increased dietary fat, as feeding diets high in unsaturated fatty acid content has been reported to improve conception rates. With the emergence of fractionated ethanol coproducts that are rich in protein but less concentrated in fat than traditional DDGS, determining how excess CP concentrations impact reproduction will become increasingly critical in the next few years.

Previous research in dairy cows has reported a link between excess dietary CP and suppressed fertility. However, these data were derived from cows consuming feedstuffs with elevated RDP fractions such as soybean meal. At present there has been little research conducted on the effects of excess dietary CP on reproductive function in beef cows. Recent findings in our lab have shown that excess dietary CP high in RUP fraction positively impacts ovulatory follicle growth. This raises the question as to whether type of protein, when fed to excess in the diet, differentially impacts reproductive function in beef cows. Therefore, research is needed to determine if excess dietary CP from a moderately abundant RUP source, such as corn gluten meal, affects reproductive parameters of beef cows in a similar or dissimilar manner to excess supplementation of a more abundant RDP source, such as soybean meal.

The objective of this study was to determine the effects of feeding excess crude protein, from feedstuffs differing in rumen degradability, on reproductive functions including ovulatory follicular dynamics, subsequent corpus luteum development and steroid hormone production. We hypothesized that excess MP from RUP would improve ovulatory follicle growth, as well as increase circulating progesterone and estradiol concentrations compared to excess MP from RDP.

Materials and Methods

The experimental design is located in Figure 1. To study the effects of excess dietary protein source on ovarian and hormone parameters, 18 non-pregnant, non-lactating Angus-Simmental beef cows were allocated by age, BCS, and BW, and assigned to 1 of 2 diets, differing in rumen degradability of protein. Cows were offered ad libitum access to corn stalks and individually supplemented once daily with isocaloric, isonitrogenous supplements, either 1) soybean meal (RDP) or 2) corn gluten (RUP), formulated to target an ADG of 1 lb/d and equal 150% of NRC MP requirements. Diet supplement formulation is located in Table 1.

Diets were fed for a total of 60 days. Twenty days after dietary treatment initiation, cows were synchronized with the 5-day CO-Synch + CIDR protocol. Ten days after ovulation, 100 µg GnRH was again administered to initiate a new follicular wave. From GnRH injection and daily thereafter until ovulation, transrectal ultrasonography was performed to diagram location and size of all antral follicles ≥ 3mm in diameter on both ovaries. Daily ultrasonography was terminated once estrus was detected and a successful ovulation was confirmed by disappearance of the dominant

follicle. Seven days after observed estrus, corpus lutea (CL) size was determined and diets were terminated. Blood samples were collected every other day for metabolite analysis for the duration of the trial. Daily blood samples were collected during the ultrasonography period through CL characterization for steroid hormone analysis.

Data were analyzed using PROC MIXED of SAS. Cow age, initial BW and BW change were used as covariates for follicle and hormone analysis.

Table 1. Supplement provided to cows consuming ad-libitum corn stalks.

	Treatment	
Item	RDP	RUP
Dry matter intake, lb/d		
Corn silage	0.57	1.02
Corn gluten meal (62%)	---	2.3
Soybean meal (36%)	2.92	----
Mineral	0.25	0.25
Calculated nutrient intake		
Total CP, lb/d	1.62	1.65
Total RUP, lb/d	0.58	0.99
NEg, Mcal/d	2.14	2.3

Results and Discussion

As designed, cow BW and BCS were not different ($P > 0.55$; Table 2) between treatments at the beginning or end of the experiment. Ovulatory ovarian follicle wavelength, size at dominance and duration of dominance were not different ($P > 0.10$; Table 3) between treatments. Cows supplemented with excess RUP had greater ($P = 0.01$; Table 3) post-dominance Graafian follicle growth and larger ($P = 0.03$; Table 3) Graafian follicles at luteolysis than RDP supplemented cows. The proestrus interval was shorter and ovulatory follicle size was greater ($P \leq 0.03$; Table 3) for RUP than RDP cows. Research has shown that cattle with larger ovulatory follicles have potentially healthier oocytes and greater probability of successful fertilization and subsequent pregnancy.

Despite the difference in ovulatory follicle size, peak estradiol concentrations were not different ($P = 0.44$; Table 3), nor was CL volume on d 7 after estrus different ($P = 0.88$; Table 3) between treatments. However, progesterone concentration on d 7 post estrus tended to be lesser ($P = 0.07$; Table 3) in RUP than RDP cows. This may be of concern, as enhanced progesterone concentrations after d 0 are necessary to aid in establishment and pregnancy success. The difference between treatment progesterone concentrations after ovulation could be due to the larger ovulatory follicles having inadequate vasculature of the subsequent CL, which may decrease blood flow and concurrent progesterone secretion. Based on these data, source of CP when fed to excess may have differential impacts on reproductive function in mature beef cows. However, the mechanisms by which these physiological alterations occur are unknown at this time. Thus, more research is warranted to elucidate how source and amount of CP, when supplemented in low quality forage-based diets, may influence reproductive function in beef cows.

Figure 1. Experimental design

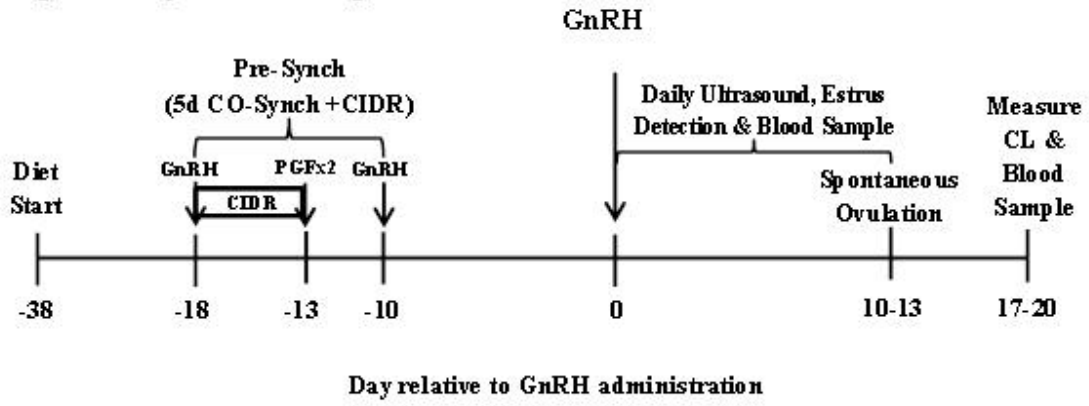

Table 2. Effects of excess CP supplementation on body weight and body condition score.

	Treatment[1]			
Item	RDP	RUP	SEM	*P*-Value
BW, lb				
Initial	1114	1098	59.25	0.85
Final	1201	1183	63.54	0.85
Change in BW	87	86	14.57	0.96
ADG	1.44	1.43	0.24	0.96
BCS				
Initial	4.43	4.54	0.13	0.55
Final	4.83	4.94	0.23	0.74
Change in BCS	0.41	0.41	0.12	1.00
Age	6.22	6.67	1.16	0.79

[1]Treatment: RDP = soybean meal supplement; RUP = corn gluten meal supplement

Table 3. Effects of excess CP supplementation on ovulatory follicle wave and subsequent corpus luteum characteristics.[1]

	Treatment[1]			
Item	RDP	RUP	SEM[2]	*P*-Value
Wavelength, d	9.04	9.59	0.74	0.61
Total ovarian antral follicle count (AFC)				
Day 1 of wave	19.85	17.44	3.18	0.63
Day 2 of wave	17.68	15.53	0.93	0.13
Day 3 of wave	19.14	16.50	1.97	0.37
Average AFC of entire wave	17.56	15.78	1.25	0.34
Size ovulatory follicle at dominance[3], mm	9.39	8.98	0.67	0.67
Duration of dominance[4], d	5.78	6.95	0.87	0.37
Growth of ovulatory follicle post-dominance[5], mm	4.22	6.46	0.41	< 0.01
Dominant follicle size at luteolysis[6], mm	10.41	13.27	0.80	0.03
Dominant follicle growth post-luteolysis, %	23.64	13.76	4.00	0.11
Proestrus[7], h	68.49	36.07	6.16	< 0.01
Ovulatory follicle diameter, mm	13.47	15.40	0.53	0.03
Peak estradiol, pg/mL	6.62	7.67	0.92	0.44
Estradiol: ovulatory follicle vol, pg · mL · mm $^{-1}$	0.49	0.49	0.06	0.99
Max secondary follicle diameter, mm	8.51	9.80	0.78	0.27
Corpus luteum volume 7 d post estrus, cm^3	4.64	4.81	0.74	0.88
Progesterone 7 d post estrus, ng/mL	5.70	4.66	0.35	0.07
Progesterone: corpus luteum vol, ng · mL $^{-1}$ · cm$^{3\ -1}$	1.35	1.07	0.16	0.24

[1]Treatment included ad libitum access to corn stalks, followed by daily supplementation of excess protein from primary RDP (SBM) or RUP (Gluten meal) source.

[2] Greater SEM presented (RDP n= 7; RUP n=8).

[3] Dominance obtained when largest growing follicle was at least 1mm larger than any other growing follicle and at least 8mm in diameter.

[4] Period between attainment of dominance until ovulation.

[5] Growth of ovulatory follicle between dominance and ovulation.

[6] Luteolysis defined as first day on which circulating progesterone concentrations were < 1 ng/mL.

[7] Period between luteolysis and expression of estrus.