Effects of Late Gestation Nutrient Restriction on Cow Performance, Colostrum Quality, and Subsequent Calf Performance

RFR-A19105

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Introduction

The objective of this study was to evaluate the effects of metabolizable protein and energy restriction during late gestation on the body condition score, body weight, and colostrum quality of fall calving cows, as well as their subsequent calf performance. For this study, 48 multiparous Angus cows were used from the Iowa State University McNay Research Farm, Chariton, Iowa, fall herd.

Swings in weather patterns have inconsistently altered feed availability to cow-calf producers, and a demand for increased calf performance have shown a need to further investigate the negative impacts of inefficient beef cow nutrition. Extensive research in the dairy industry and in other species, such as sheep, has shown correlations between maternal performance and colostrum quality and impacts on offspring performance. Although beef cows are efficient in utilizing protein and energy, their nutrient requirements often are compromised in late gestation and lactation due to events in which producers have poorer quality feeds at their disposal. Such instances may have negative effects on colostrum quality as the cow allocates nutrients toward fetal development and eventually lactation. This plays a crucial role in the initial development and passive immunity of the calf, because there is no fetal placental transfer of antibodies in utero, therefore the calf must acquire those antibodies through colostrum.

In addition to immunoglobulins, colostrum also delivers essential vitamins, proteins, and fat to the calf. There is little known permeability of fat-soluble vitamins across the placenta, meaning the calf must acquire important vitamins like A and E through colostrum as well. The calf is able to absorb intact proteins for approximately 24 hours after birth before intestinal closure; thus, quality and quantity of colostrum is key to survival and growth of the neonatal calf.

Materials and Methods

To investigate the effects of nutrient restriction on cow and subsequent calf performance, multiparous Angus cows (n=48) were blocked by body weight and randomly assigned to one of four treatments. All fall cows were given one A.I. opportunity before being exposed to cleanup bulls for 90 days. No fetal aging was used for this study. Cows were grouped into four groups within each treatment, for a total of 16 groups. Average empty cow weights per pen ranged from 1,040 to over 1,400 lb. Treatments consisted of ground hay (HAY), ground hay and shell corn (HC), ground hay and dry distillers grains (HD), or ground hay with dry distillers and shell corn (HCD). Table 2 includes percentages of metabolizable protein and net energy for each treatment. Cows were fed at constant levels throughout the trial with the expectation their caloric intake may not be adequately met from approximately eight months gestation (d 0) until the time they calved. Nutrient analyses of feedstuffs were collected biweekly during the study. When calving, all pairs were returned to normal herd management at the McNay Research Farm.

Table 1 outlines the timeline of measurements taken for both the cows and their calves. Twelfth rib backfat (BF) and ribeye area (REA) were measured via carcass ultrasonography. Body condition score (BCS) was calculated as: [(BF/REA*100) + 2.5]. Empty body weight (EBW) was calculated using the following equation: (EBW = shrunk weight x 0.96). The weight of the fetal calf plus fluids also was accounted for using the following equation: [Weight of cow x (.01828 x 2.7)/(.02 x dp-.00000143 x dp x dp)] where dp represents days pregnant. A composite colostrum sample of 100mL was collected from the left front and rear quarters of the cow within 24 hr of parturition and frozen at the time of collection. Samples were later analyzed for immunoglobulins (IgG), milk urea nitrogen (MUN,) and total protein (TP) concentrations.

Performance variables were analyzed as a randomized complete block design with cow as the experimental unit and pen as the random effect. These procedures were carried out using the MIXED procedure in SAS 9.4 (SAS Inst. Inc., NC, USA).

Results and Discussion

As expected, no significant differences were observed at day zero or 49 for live weight and EBW despite a decrease in empty body weight over all treatments. Table 3 displays cow performance values on and off test, and at calving. All cows had lower final calculated BCS, with no significance observed. For BF, all treatment groups exhibited a decrease from initial to final, but no significant differences between treatments were observed. HAY, HD, and BAL cows had a decrease in REA from initial to final, with HC cows staying the same. However, no significant differences were observed. This demonstrates cows were drawing on muscle tissue reserves to support the growing fetus.

Cow colostrum composition relative to treatment also was analyzed for this study. No significant differences were observed for IgG and total protein concentrations for all treatment groups (Table 4). For HD cows, MUN concentrations were significantly higher than the other treatment groups ($P = 0.02$), which is representative of the higher dietary protein content. Correlations of cow colostral content to growth performance are displayed in Table 5. IgG and TP tended to be positively correlated, while IgG and MUN tended to be negatively correlated ($P \leq 0.10$). MUN and initial backfat (IBF) tended to be negatively correlated ($P \leq 0.10$), and significance for a negative correlation ($P \leq 0.05$) was observed for MUN and final backfat (FBF). Significance was observed for a negative correlation ($P \leq 0.05$) between TP and final ribeye area (FREA).

Overall, it was observed that restricting cows of energy during late gestation could potentially lead to a decrease in cow performance. HC was the only treatment that met energy requirements and had the least decline in BW, BF, REA, and BCS. All other treatment groups exhibited moderate decreases in BW, BCS, BF, and REA. This suggests a potential negative energy balance where cows were mobilizing more fatty acids from adipose tissue to compensate for an energy deficit. A high value of MUN in the HD treatment group was expected because of a large oversupply of metabolizable protein (MP) in that diet. Therefore, the negative correlations between MUN and IBF and FBF could point toward a higher energy demand by the cows that were oversupplied protein to excrete that extra protein via the milk and urine. Consequently, at a certain point, oversupplying protein can be counter-productive as the cow mobilizes more fat to meet the energy demands of excreting excess protein from the urea cycle.

Measurements of calf performance relative to maternal treatment also were recorded for this study (Table 6). Although there were slight variations in birth weight and calf vigor scores across all treatments, no significant differences were observed. Similarly, there were no significant differences observed across all treatments in BW at 18 weeks and at weaning.

In summary, restricting cows of energy during late gestation can negatively effect cow performance, as evidenced by colostrum content. Further research is needed on how maternal nutrition during late gestation may affect passive immunity in calves and calf performance.

Acknowledgements

The McNay Research Farm was used for this study. Thanks to Brad Evans, Logan Wallace, Chase Altenhofen, and Charley Philips for assisting with research. Also, thank you to Erika Lundy, Garland Dahlke, and Dan Loy for coordination and review of research.

Table 1. Timeline of cow and calf measurements.

Cows			Calves		
Feeding period					
Day 0 -Rib fat thickness, in. -Ribeye area, in.^{2} -Body wt, lb -BCS[1]	Day 49 -Rib fat thickness, in. -Ribeye area, in.^{2} -Body wt, lb -BCS	Calving -100cc colostrum -udder/teat score -Calving ease score	Calving -Birth wt, lb -Calf vigor score	Vaccinations -Body wt, lb	Weaning -Body wt, lb

[1]BCS = body condition score.

Table 2. Percentage of metabolizable protein and net energy requirements met for rations and percentage of crude protein, fat, neutral detergent fiber, and total digestible nutrients per ration.

Item[1]	HAY[2]	HC	HD	HCD
NE, %	54.5	104.5	85.25	80.5
MP, %	109.5	148.5	173.75	132.75
CP, %	11.2	10.4	14.9	11.5
Fat, %	1.8	2.1	3.2	2.2
peNDF, %	53.9	40.5	43.2	45.2
TDN, %	59.5	65.7	63.4	63.3

[1]NE and MP were determined using the NRC, 2016 method.
[2]HAY = hay diet; HC = hay and corn diet; HD = hay and dry distillers diet; HCD = hay, corn, and dry distillers diet.

Table 3. Cow performance measurements during test.

Item[1]	HAY[2]	HC	HD	HCD	SE	P-value
Initial data, day 0 of test						
Live BW, lb	1,358	1,344	1,352	1,350	16.3	0.96
EBW, lb	1,235	1,223	1,230	1,228	15.1	0.96
Calc. BCS	5.5	5.6	5.1	5.6	0.37	0.70
12th rib BF, in.	0.33	0.33	0.25	0.31	0.04	0.46
REA, sq in.	10.61	10.27	9.76	9.8	0.28	0.11
Final data, day 49 of test						
Live BW, lb	1,386	1,389	1,382	1,398	16.0	0.91
Empty BW, lb	1,192	1,194	1,189	1,202	13.7	0.91
Calc. BCS	4.9	5.2	4.9	4.9	0.35	0.92
12th rib BF, in.	0.24	0.29	0.24	0.23	0.04	0.79
REA, sq in.	9.46	10.27	9.93	9.21	0.35	0.17
Data at calving						
Visual BCS	5.0	5.7	5.8	5.9	0.25	0.06

[1]BW = body weight; EBW = empty body weight; BCS = body condition score; BF = backfat; REA = ribeye area.
[2]HAY = hay diet; HC = hay and corn diet; HD = hay and dry distillers diet; HCD = hay, corn, and dry distillers diet.

Table 4. Cow colostral IgG, total protein, and milk urea nitrogen relative to treatment.

Item[1]	HAY	HC	HD	HCD	SE	P-value
IgG, g/dL	7.29	7.61	7.39	7.77	7.68	0.91
TP, g/dL	15.92	16.05	16.62	16.06	2.0	0.99
MUN, mg/dL	12.36[a]	11.4[a]	16.13[b]	13.0[a]	1.1	0.02

[1]IgG = immunoglobulin g; TP = total protein; MUN = milk urea nitrogen.
[2]HAY = hay diet; HC = hay and corn diet; HD = hay and dry distillers diet; HCD = hay, corn, and dry distillers diet.

Table 5. Simple correlations of cow colostral content to growth performance.[1]

	TP	MUN	IBW	IBF	IREA	FBW	FBF	FREA
IGG	**0.811**[2]	**-0.353**	0.011	-0.050	-0.093	-0.043	0.005	-0.115
TP		-0.236	-0.020	-0.197	-0.217	-0.059	-0.144	*-0.324*
MUN			-0.113	**-0.381**	-0.107	-0.056	*-0.283*	-0.168

[1]IGG = immunoglobulin G; TP = total protein; MUN = milk urea nitrogen; IBW = initial body weight; IBF = initial 12th rib backfat; IREA = initial ribeye area; FBW = final body weight; FBF = final 12th rib backfat; FREA = final ribeye area.
[2]Values in bold indicate significance ($P \leq 0.05$). Values in italics tend to be significant ($P \leq 0.10$).

Table 6. Calf performance measurements relative to treatment.

Item[1]	HAY[2]	HC	HD	HCD	SE	P-value
At birth						
Birth wt, lb	78	78	81	82	2.65	0.68
Calf vigor	1.0	1.7	1.3	1.0	0.32	0.45
Subsequent performance						
BW at 18 weeks, lb	339	356	332	350	17.9	0.77
BW at weaning, lb	378	403	354	386	18.7	0.34

[1]BW = body weight.
[2]HAY = hay diet; HC = hay and corn diet; HD = hay and dry distillers diet; HCD = hay, corn, and dry distillers diet.
[3]Calf vigor assigned as: 1 = nursing/standing within 30 minutes of birth, 2 = nursing/standing within two hours of birth, 3 = nursing/standing within six hours of birth, 4 = tubed/assisted, 5 = dead.