Effects of Late Gestation Nutrient Restriction on Late Gestation Cows

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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 McNay Memorial Research and Demonstration Farm fall herd.

Swings in weather patterns, which have inconsistently altered feed availability to cow-calf producers, plus demand for increased calf performance, have unfolded 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 thus, impacts on offspring performance. Though beef cows are efficient in utilizing protein and energy, their nutrient requirements often are compromised in late gestation and lactation due to events that cause producers to have poorer quality feeds at their disposal. Such instances may have negative effects on colostrum quality as the cow allocates nutrients towards 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; thus, 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 artificial insemination (AI) opportunity before being exposed to cleanup bulls for 90 days. No fetal aging was utilized 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 1040 to over 1400 lbs. Treatments consisted of ground hay (HAY), ground hay and whole-shell corn (HC), ground hay and dry distillers grains (HD), or ground hay with dry distillers and whole-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 month-eight of gestation (day 0 of trial) until the time they calved. Nutrient analyses of feedstuffs along with manure samples were collected biweekly during the study. Analysis of these feedstuffs including total tract neutral detergent fiber (NDF) digestibility along with starch digestibility was performed to calculate the available caloric and metabolizable protein content of the feed. Upon calving, all pairs were returned to normal herd management which involved grazing tall fescue pastures at the McNay Memorial Research and Demonstration 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 ultrasonography at day 0 of the trial and again at day 49 (just prior to calving). 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: [Wt of cow x (.01828 x 2.7/\(.02 x dp-.00000143 x DP x DP)] (DP represents days pregnant).

At calving, a composite colostrum sample of 100mL was collected from the left front and rear quarters of the cow within 24 hours of parturition and frozen at the time of collection. Samples later were analyzed for IgG, milk urea nitrogen (MUN) and total protein (TP) concentrations at the Cornell University diagnostic laboratory.

Performance variables were analyzed using repeated measures for least square means. These procedures were carried out using the MIXED procedure in SAS 9.4 (SAS Inst. Inc.).

Results and Discussion

As expected, there were no significant differences observed at day 0 or day 49 for live and empty body weight, despite a decrease in body weight over all treatments. Table 3 displays cow performance values on and off test, and at calving. HCD cows had the greatest increase in final visual BCS ($P = 0.03$), but because all cows showed a decrease in body weight, calculated BCS was included to eliminate potential bias of visual BCS. All cows had less final calculated BCS, with no significance observed between treatments. For BF, all treatment groups exhibited a decrease from initial to final, but no significant differences were observed between groups. HAY, HD, and HCD cows had a decrease in REA from initial to final, with HC cows staying the same; however, no significant differences were observed between groups.

Table 1. Timeline of events for trial.

July 8: day 0	Cows–ultrasound Measure: rib fat depth, ribeye area, body weight, body weight score
August 26: day 49	Cows–repeat easures of Day 0
Sept. 1	Calving begins– collect 100cc of colostrum: udder/treat score, calving ease, calf birth weight, calf vigor
Dec. 5	Vaccinations– breeding
Mar. 16	Weaning
Apr. 2	Pregnancy exam

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	HAY	HC	HD	HCD
NE, % of requirement	54.5	104.5	85.25	80.5
MP, % of requirement	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 methodology and provided above in terms of percent of calculated requirement met.
[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	HAY	HC	HD	HCD	SE	P-value
Initial data, day 0 of test	Live BW, lbs.	1358	1344	1352	1350	16.3	0.96
	EBW, lbs.	1235	1223	1230	1228	15.1	0.96
	Visual BCS	6.2	6.3	6.3	6.3	0.15	0.97
	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, lbs.	1386	1389	1382	1398	16.0	0.91
	Empty BW, lbs.	1192	1194	1189	1202	13.7	0.91
	Visual BCS	6.5a	7.3a	7.2a	7.0ab	0.19	0.03
	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]Abbreviations: 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.
[a,b] Means with different superscripts differ ($P < 0.05$).

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

Item	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	12.36a	11.4a	16.13b	13.0a	1.1	0.02

[1]Abbreviations: 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.
a,bMeans with different superscripts differ ($P \le 0.05$).

Cow colostrum composition relative to treatment also was analyzed for this study. No significant differences were observed for IgG and total protein concentrations between all treatment groups (Table 4). For HD cows, MUN concentrations were significantly higher than the other treatment groups (P = 0.02). Correlations of cow colostrum 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 ≤ 0.10). MUN and initial backfat (IBF) tended to be negatively correlated (P ≤ 0.10), while significance for a negative correlation (P ≤ 0.05) was observed for MUN and final backfat (FBF). Significance was observed for a negative correlation (P ≤ 0.05) between TP and final ribeye area (FREA).

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

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; suggesting a potential negative energy balance in which 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. Thus, 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 counterproductive as the cow mobilizes more fat to meet the energy demands of excreting excess protein from the urea cycle. Another takeaway from this study is the importance of BCS. Accounting for fetal weight and fluid can be difficult when visually assigning BCS, as is evidenced by the data. Thus, measuring BF and REA can be an important tool in determining the actual BCS of a cow, while keeping BW in mind.

Looking forward, what third trimester nutrition means in terms of cow productivity is summarized in Table 7. This table provides information on the subsequent breed-back or the next year's productivity. Note the more energy deficient ration (HAY) resulted in the greatest weight loss, but not significantly poorer breed-back from the HCD and HD treatments.

Table 5. Simple correlations of cow colostrum content to growth performance.

	TP	MUN	IBW	IBF	IREA	FBW	FBF	FREA
IGG	0.811	-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]Abbrevations: 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 ≤ 0.05). Values in italics tend to be significant (P ≤ 0.10).

Table 6. Calf performance measurements relative to treatment.

		HAY	HC	HD	HCD	SE	P-value
At birth	Birth weight, lbs	78	78	81	82	2.65	0.68
	Calf vigor	1.0	1.7	1.3	1.0	0.32	0.45
18 weeks	BW, lbs	339	356	332	350	17.9	0.77
At weaning	BW, lbs	378	403	354	386	18.7	0.34

[1]Abbreviations: 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.
[a,b]Means with different superscripts differ (P < 0.05).

Table 7. Subsequent cow reproductive performance-averaged over treatment groups

Treatment	Lactation weight change	Days bred at pregnancy check	% Open
Hay	-139	61.5	27.3
Hay+Corn	-93	91.7	0
Hay+Distillers	-117	67.5	20
Hay+Corn+Distillers	-93	66.8	18.2

The HC ration, which based on cow measurements did not seem to differ much from the others in results, but appeared to have the best balance from feed analysis and calculated requirements, performed considerably better with no cows in this group coming back open, and the days already bred being a month ahead of the other treatment groups.

In summary, restricting cows of energy during late gestation can negatively affect cow performance, as evidenced by colostrum content, but it is both a function of the extent of the restriction and the type of diet being fed. Further research is needed as to how maternal nutrition during late gestation may affect passive immunity in calves, and hence, calf performance.

Acknowledgements

The McNay Memorial Research and Demonstration 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 Dan Loy for coordination and review of research.