BRIEF COMMUNICATION: Effect of maternal diet in late gestation on development of dairy calves

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Abstract

To investigate whether feeding strategies to reduce urinary N excretion would have negative effects on calf development, two feeding systems were compared. A total of 190 pregnant, Friesian × Jersey dairy cows were randomly allocated to one of two groups and offered either a low crude protein diet of maize silage and fodder beet (LCP) or a moderate CP diet of lucerne silage and fodder beet (MCP) for eight weeks prior to calving. Apparent metabolisable energy (ME) intake of dams was similar (110 MJME/cow/day) but CP concentration was greater for MCP than LCP (13.4 vs 7.5% of the DM). There was no effect of maternal diet on calf birth weight (33.0±0.5 kgLW) or morphometric measurements; heart girth (72.8±0.5) spine length (54.4±0.4) or hip height (73.1±0.4 cm). These results suggest that dietary protein restriction in late gestation does not have any immediate negative effects on *in utero* calf development.

Keywords: late-gestation; fodder beet; supplementation; birth weight; morphometric development

Introduction

The long-term productivity of the national herd relies on successful rearing of replacement stock and the factors influencing this success begin *in utero*. In this regard, nutritional management of pregnant cows has implications on replacement heifer production as it impacts reproductive system development of the utero-fetus, and can alter the postnatal growth pathway, metabolism, and body composition of the offspring (Rhind 2004). Currently, the feeding of high-energy, low-protein crops, such as fodder beet (FB) and a high fiber supplement to support rumen function, to late-gestation cows has become commonplace as the advantages of FB include its low cost, high yield and low risk of N leaching (Edwards et al. 2014).

Preliminary studies comparing skeletal development of calves born from cows fed kale or FB in late-gestation showed lower skeletal weight in cows fed FB diets (Bryant & Pirat 2014). One conclusion was that the higher protein in the kale diet better met fetal amino acid requirements through improved protein supply compared with the FB. However, those results were confounded, because both crops and supplements differed. The aim of this study was to compare calf development from cows fed the same FB crop with either a low or moderate protein supplement.

Materials and methods

Experimental design and management

The experiment was conducted at the Ashley Dene Research and Development Station (ADRDS), Lincoln University (-43.65°N 172.33°E), between 1 June and 25 August 2017, with the approval of the Lincoln University Animal Ethics Committee (AEC 2017-08).

A total of 190 pregnant, non-lactating spring-calving Friesian × Jersey dairy cows were allocated to one of two groups using stratified randomisation. Average BCS, live weight (LW) and expected calving date (± standard error of mean) at the start of the experiment were respectively: 4.45±0.03 BCS, 496.4±5.13 kg LW and 12/08/2017±8 days. Diet treatments consisted of FB offered at 5 kg DM/cow/day to both groups and 5 kg DM/cow/day as maize silage (MS) and straw for LCP or 5 kg DM/cow/day as lucerne silage (LS) (MCP). Energy allocation for both groups was targeted for maintenance (in cold weather) and gestation, offering approximately 110 MJ ME/cow/day including a 5% safety factor (AFRC 1993)

Between 1 and 14 June cows transitioned onto crop and supplement, the latter of which was fed in the paddock at about 0800 h daily followed by new allocation of crop at approximately 0900 h. Prior to calving (approximately seven days) dams were transferred from crop to ryegrass pasture and continued with their treatment supplement.

Measurements

Allocation and refusals of the crop and supplements were determined weekly from quadrat cuts which were used to determine pre and post graze yield. Subsamples of crop and supplement were collected for DM analysis (oven drying) and chemical composition (freeze drying) by NIRS. Metabolisable energy content was calculated using the modified ADF equation: 14.55 - 0.0155 MADF (CSIRO 2007).

All dams were body-condition scored (BCS) by a trained observer at the beginning and after eight weeks, using the 'hands-on' NZ scoring system (1-10) (Roche et al. 2009) and LW was measured concurrently using portable scales.

To determine the effects of *in-utero* nutrition on calf development, all calves were measured within 24 hours of birth. Measurements were carried out in the calf rearing facilities of the farm between 8am and 10am each morning from circa 26 July until 25 August 2017. Heart girth, neck length (distance from the crown to shoulder), spine length (shoulder to tail head), withers height, hip height and waist circumference were measured using a tape measure. Calves were weighed using a manual weigh crate (Prattley Industries Ltd. Temuka).

Means were compared using ANOVA procedure in Genstat (v. 12, VSN International). For cow's liveweight and calf variables, diet treatment was used as a fixed term and animal as a random term. Median BCS for each group was compared using Mann-Whitney U test.

Results and discussion

Fodder beet crop yields were similar for both groups (23.1±0.4 vs 23.0±0.3 t DM/ha in LCP and MCP group, respectively). The composition of crops and supplements are presented in Table 1. Combined crop and supplement crude protein (CP) concentration was lower than targeted at 7.5% and 13.4% for LCP and MCP. The CP contents of maize and lucerne silage were typical of these feeds (Brito & Broderick 2006) but because the FB yields were higher than those previously reported for this site, the proportion of bulb was relatively large reducing the CP concentration (Edwards et al. 2014). As anticipated, apparent N intake of the MCP group was greater than the LCP group (192 ±2.4 vs 115±3.1 gN/cow/day), which was lower than the 260 gN/cow/d reported by Edwards et al. (2014). In this study the target was to dry off at BCS 5.0 and feed cows according to the maintenance and gestation requirements (110 MJ ME/cow/day). This required less DM allocation than previous years and low apparent N intake.

Although BCS was lower than the targeted 5.0 at the commencement of the study, the two groups remained similar with a median BCS of 4.5 after 8 weeks. Similarly the liveweight of the cows were not different (P>0.05) after eight weeks (518.7±7.5 vs 514.2±7.6, LCP and MCP respectively). As mentioned above, earlier studies by Edwards et al. (2014) had greater DM and ME allocation (160 MJ ME/cow/day) to meet the added requirements for BCS gain. However, in this study, BCS and liveweight of the LCP cows maintained throughout the study period, indicating no negative effect of diet treatments on dams. Indeed, at the low apparent N intakes reported here, the environmental impact of these feeding regimes suggest lower urinary N excretion compared with previous studies (Edwards et al. 2014).

There was no apparent effect of a low CP concentration in maternal diets on calf birth weight (BW) or morphometric parameters (Table 2). Birth weights were in the normal range of 32 to 34 kg LW for a Friesian × Jersey calf (Bryant & Pirat 2014). Carstens et al. (1987) also showed that feeding low CP diets of 7 or 11% to late gestation cows had no effect on calf BW. It was anticipated here that some amino acids would be restricted by coupling FB diets with a low N supplement and cause a check in calf development. For example, Pacheo et al. (2016) found a decrease in plasma concentration of arginine and citrulline, in lactating dairy cows offered 25% of their diet as FB. The role of arginine in fetal development was demonstrated by McCoard et al. (2013) who showed that arginine supplementation to lambs was associated with increased BW and fetal brown

Table 1 Feed quality of fodder beet and supplements offered to dairy cows in late gestation (Values are mean ± SEM)

	Low crude protein		Moderate crude protein	
	Fodder beet	Maize silage	Fodder beet	Lucerne silage
Bulb (% DM)	91.5 ± 0.4	-	91.2 ± 0.5	-
Leaf (% DM)	8.5 ± 0.4	-	8.8 ± 0.5	-
Dry matter (% FW)	14.7 ± 0.4	94.9 ± 0.1	16.6 ± 0.2	90.4 ± 0.1
Pre grazing (t DM/ha)	23.08 ± 0.4	7.8 ± 0.9	23.04 ± 0.3	5.3 ± 0.4
DM utilisation (%)	95.4 ± 0.5	98.4 ± 0.4	97.6 ± 0.8	99.1 ± 0.2
Crude protein (% DM)	8.0 ± 0.3	7.0 ± 0.1	6.3 ± 0.1	20.5 ± 0.3
Organic matter (% DM)	93.0 ± 0.4	93.4 ± 0.3	91.9 ± 0.5	89.6 ± 0.3
Neutral detergent fibre (% DM)	16.2 ± 0.8	53.1 ± 0.7	15.8 ± 0.7	44.2 ± 0.5
Acid detergent fibre (% DM)	9.4 ± 0.4	34.1 ± 0.4	9.7 ± 0.5	31.2 ± 0.5
Metabolisable energy (MJ ME/kg DM)	13.09 ± 0.1	9.26 ± 0.1	13.04 ± 0.1	9.70 ± 0.1

Table 2 Effect of dam diet in late gestation on birth weight and morphometric measurements of day-old calves (Values are mean ± SEM)

	Maternal treatment		*P -value*
	Low protein	Moderate protein	
Calf measures			
Birthweight (kg)	32.9 ± 0.7	33.2 ± 0.7	0.73
Body skeletal (cm)			
heart girth	73.0 ± 0.7	72.7 ± 0.8	0.73
neck length	33.2 ± 0.9	34.4 ± 0.8	0.34
spine length	54.6 ± 0.7	54.3 ± 0.6	0.73
wither height	71.0 ± 0.6	70.5 ± 0.6	0.51
hip height	73.3 ± 0.6	72.8 ± 0.6	0.60
waist circumference	74.0 ± 0.8	72.7 ± 0.8	0.30

fat reserves. However, the lack of apparent differences in calf-growth parameters in this study suggests that a short-term protein restriction to dams in late gestation does not significantly impact calf development at birth.

References

AFRC 1993. Energy and protein requirements of ruminants. UK, CAB International. 159 p.

Brito AF, Broderick GA 2006. Effect of varying dietary ratios of alfalfa silage to corn silage on production and nitrogen utilization in lactating dairy cows1. Journal of Dairy Science 89(10): 3924-3938.

Bryant RH, Pirat M 2014. Effect of feeding kale or fodder beet diets to dairy cows in late gestation on calf birth weight and skeletal development Proceeding of the 5th Australasian Dairy Science Symposium, Hamilton, New Zealand 19-21 November, 2014. Pg 312-314.

Carstens GE, Johnson DE, Holland MD, Odde KG 1987. Effects of prepartum protein nutrition and birth weight on basal metabolism in bovine neonates1. Journal of Animal Science 65(3): 745-751.

CSIRO 2007. Nutrient requirements of domesticated ruminants. Australia, CSIRO Publishing. 270 p.

Edwards GR, Ruiter JM, Dalley DE, Pinxterhuis JB, Cameron KC, Bryant RH, DI HJ, Malcolm BJ, Chapman DF 2014. Urinary nitrogen concentration of cows grazing fodder beet, kale and kale-oat forage systems in winter. Proceeding of the 5th Australasian Dairy Science Symposium, Hamilton, New Zealand 19-21 November, 2014. Pg 144-147.

McCoard S, Sales F, Wards N, Sciascia Q, Oliver M, Koolaard J, van der Linden D 2013. Parenteral administration of twin-bearing ewes with L-arginine enhances the birth weight and brown fat stores in sheep. SpringerPlus 2: 1-12.

Pacheco D, Waghorn G, Dalley DE 2016. Plasma amino acid profiles of lactating dairy cows fed fodder beet and ryegrass diets. Proceedings of the New Zealand Society of Animal Production 76: 62-64.

Rhind SM 2004. Effects of maternal nutrition on fetal and neonatal reproductive development and function. Animal Reproduction Science 82–83: 169-181.

Roche JR, Friggens NC, Kay JK, Fisher MW, Stafford KJ, Berry DP 2009. Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. Journal of Dairy Science 92(12): 5769-5801.