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Nutritional restriction of ewes during late gestation compromises foetal and post natal metabolite provision*

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ABSTRACT

Metabolic adaptation to nutritional restriction during late gestation, in twenty twin-bearing adult Shropshire ewes, was studied. During the last 6 weeks pre-partum, ewes were fed either a low (L) or high (H) energy diet, and all received the H diet post-partum. Nutritional restriction during late gestation resulted in a more catabolic and ketogenic state of the ewe, with birth weights of the lambs being substantially reduced. Moreover milk yield was also reduced as a consequence of the period of nutritional restriction indicating that mammary development was affected.

KEY WORDS: milk production, birth weight, metabolic adaption, glucose, acetate

INTRODUCTION

The pregnant twin-bearing adult ewe is a good model for studying the task of balancing feed intake and the mobilization of body reserves so as to sustain the nutritional requirements needed for healthy foetal growth. Results of a study are presented in which the aim has been to evaluate the consequences of nutritional restriction during late gestation on foetal growth, and more specifically the efficiency of any metabolic adaptions in the ewe leading to sustained growth of her off-spring.

Mammary development is largely complete at the time of parturition (Capuco et al., 2001), and level of nutrition may impact essential regulatory endocrine

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systems. We therefore tested the hypotheses that; 1. nutritional restriction during late gestation negatively affects milk production, and 2. nutritional restriction pre-partum does not only have negative consequences for the nutrition of off-spring *in utero*, but also during post-natal development.

MATERIAL AND METHODS

Animals

All experimental procedures were approved by and complied with guidelines laid down by The National Committee on Animal Experimentation, Denmark. Two groups of ten Shropshire ewes, all pregnant with twins were used. During the last 6 weeks of gestation, group H were fed a high energy diet (silage ad libitum +200 g barley +200 g commercial concentrate) and group L a low energy diet (silage, adminstered to approximately 60% of total energy intake in group H). Post-partum, all ewes were fed the H diet.

Sampling, measurements and analyses

Blood samples were taken by veni puncture on days -70, -42, -14, -7, -2, -1, 0, 1, 2, 3, 10 and 20 post-partum. Glucose and acetate concentrations were determined using quantitative spectrophotometric kits scaled to be performed in microplates (Sigma Diagnostics KIT 510-DA, Denmark, and Diffchamb, SCIL 1002811, Sweden, respectively) and insulin determined by an ELISA sheep insulin assay (DRG Instruments KIT EIA-2339, Germany).

Milk production in week 3 of lactation was determined by the D_2O-dilution technique (Theil et al., 2002).

Statistical analyses

Data were analysed as repeated measurements by the Proc MIXED procedure in SAS version V8 (SAS Institute Inc., Cary, NC 27513-2414, USA) with random effect of ewe. All data are presented as LSMEANS ± SEM.

RESULTS

Ewe performance

Lambs born to H ewes (3.95±0.82 kg) weighed significantly more than lambs born to L ewes (3.15±0.87 kg).

Preliminary results for milk production in week 3 of lactation show that ewes fed the H diet produced appr. 43% more milk per day than L ewes (3407±107 vs 2390±119 g/day, respectively; $P<0.05$).

Plasma metabolites in ewes

Low fed ewes had significantly higher plasma acetate levels the last two weeks pre- partum and the first day post-partum despite lower feed intakes, when compared to H ewes. Thereafter no significant differences were recorded (Figure 1).

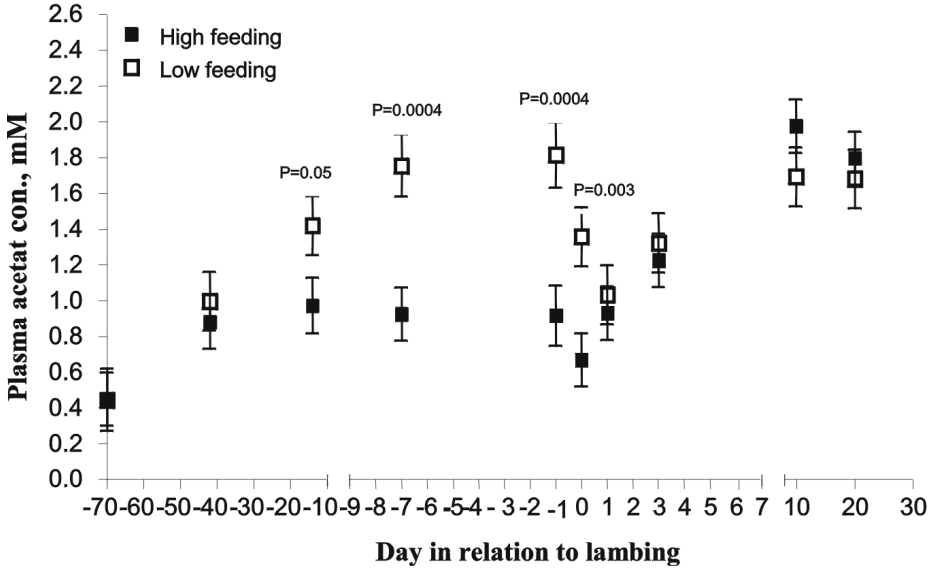

Figure 1. Ewe plasma acetate concentrations before and after parturition (n=20)

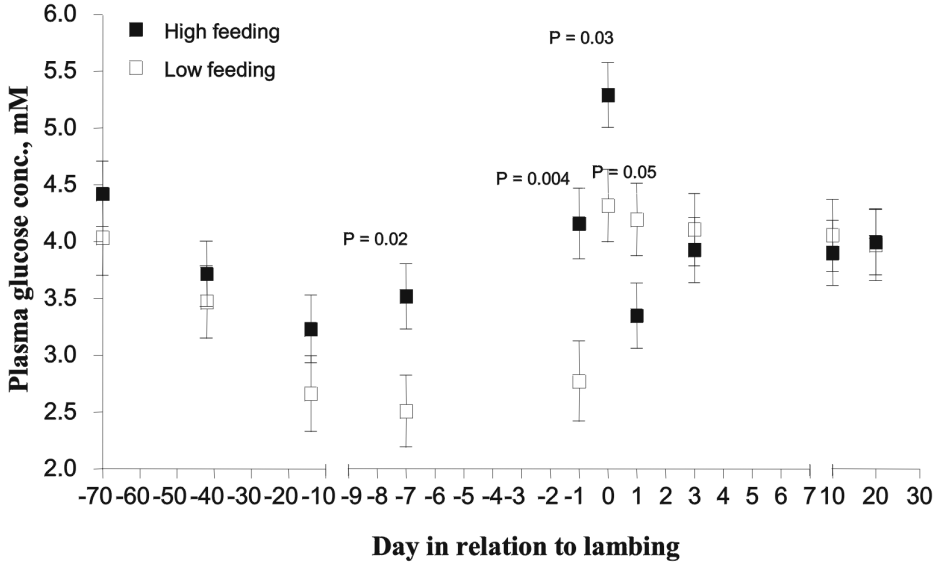

Figure 2. Ewe plasma glucose concentrations before and after parturition (n=20)

The reverse was true for glucose, where L fed ewes had considerably lower plasma glucose levels during the last week pre-partum compared to H ewes.

Glucose concentrations increased post-partum in the L fed ewes, who also had higher plasma levels at day 1 post-partum compared to H ewes. No subsequent significant differences in plasma levels were recorded (Figure 2).

DISCUSSION

Plasma acetate concentrations have been shown to increase dramatically in ketogenic cows (Waterman et al., 1972) as a result of hepatic endogenous formation linked to incomplete fatty acid oxidation. The lower glucose and higher plasma acetate concentrations in L ewes pre-partum thus reflect animals in a more catabolic/ketogenic state, where maternal nutritional oxidation has shifted away from glucose towards the use of ketone bodies and acetate oxidation. Combined with a lower maternal concentration of insulin (results not shown) these changes will ensure preferential repartitioning of glucose for the foetus.

In the post-partum period, animals were fed identically, yet glucose concentrations were found to increase more rapidly in L ewes, which must primarily reflect their lower milk production compared with H ewes. IGF-1 is a major stimulatory factor for mammary development, with nutritional restriction reducing circulating levels (Purup et al., 1996). Thus one might infer that a period of induced pre-partum nutritional restriction will most likely interfer with mammary development in ewes *via* altered IGF-1 secretion, giving rise to relatively more long-term effects on any viable off-spring.

CONCLUSIONS

Our results indicate that: 1. altered partitioning of glucose in favour of the foetus is not sufficient to ensure normal foetal development in L fed ewes, and 2. pre-partum nutritional restriction of ewes compromises the nutrition of off-spring postnatally, despite the provision of adequate feeding, since mammary development and therefore lactation performance is affected.

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