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Effect of energy balance profiles on metabolic and reproductive response in Holstein and Swedish Red cows

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ABSTRACT

This study examined the effect of two feeding levels during the antepartum and postpartum period on reproductive performance and blood metabolites (glucose, non-esterified fatty acids (NEFA), insulin) in primiparous Holstein and Swedish Red (SRB) cows, in order to identify possible differences in the way these breeds respond to negative energy balance after calving. A total of 44 cows (22 Holstein, 22 SRB) kept in a loose housing system were included in the study. The control group (HE, n = 23) was fed a diet for high-producing cows (target 35 kg/d energycorrected milk, ECM). A lower feeding intensity (LE, n = 21) was achieved by giving -50% concentrate to target 25 kg/d ECM. Diets were implemented 30 days before expected calving and the cows were monitored for 120 days postpartum. Milk yield and composition, dry matter intake (DMI), live body weight and body condition score (BCS) were assessed to calculate the weekly energy balance (residual feed intake). Blood sampling started before diet implementation and was repeated every 2 weeks until Day 60 postpartum and then once monthly until Day 120. Plasma was kept at −20 °C until analysis for glucose, insulin and NEFA concentrations. Mixed linear models were used to analyse data (SAS 9.3; PROC MIXED). Holstein cows had lower mean energy balance than SRB cows (−4.7 ± 1.4 and −0.9 ± 1.4 MJ, respectively; $p = 0.05$). SRB cows had higher ($p<0.001$) BCS (3.3 ± 0.1) than Holstein cows (2.7 ± 0.1) and also higher plasma glucose concentrations from Day -30 to Day 120 relative to parturition (4.1 ± 0.1 and 4.2 ± 0.1 log ; mg/100 ml, respectively; $p < 0.05$). Overall, breed or diet had no effect on NEFA blood plasma concentrations. However, plasma NEFA concentration levels tended to be higher ($p = 0.09$) in SRB cows than in Holsteins at Day -14 before calving, indicating higher mobilisation of lipid from adipose tissue already before calving. In contrast, Holstein cows had higher NEFA at Day 14 postpartum than SRB cows ($p < 0.05$). There were no significant effects of diet or breed on reproductive performance (% pregnant at first AI, days open). However, commencement of luteal activity within 21d postpartum was affected ($p < 0.05$) by the interaction of breed and diet. These results suggest that Holstein cows prioritise milk production to a larger extent than SRB cows, resulting in a less balanced metabolic profile.

1. Introduction

In high-producing dairy cows, metabolic and reproductive disorders are gaining importance with the intensification of milk production [1,2]. Genetic advances in combination with herd management strategies have succeeded in increasing milk production levels, but reproductive performance has been affected [3–5]. Fertility has been decreasing for more than 50 years, more so in Holstein cows than in the Swedish Red breed (SRB) [6,7]. For Holstein cows, the pregnancy rate per AI decreased from 41% in 1998 to 38% in 2005, but in recent years this sharp decline in fertility in Holsteins has levelled out [8]. For SRB cows the decrease

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has been lower, from 43% to 41% [9,10]. Holstein and SRB cows are the two major dairy breeds in Sweden [9].

For dairy cows, the beginning of lactation represents a stage of metabolic stress. During that time animals will have to adapt their high energy demands due to the rapid increase of milk production which will increase the energy requirements. A failure to meet those demands will lead to negative balance (NEB) [11]. The resulting NEB can have an effect on the reproductive potential of the affected cows [12–14].

Although many studies have examined the interaction between the somatotropic and the gonadotropic axis [15,16], few have taken into consideration the variation between breeds in terms of nutrient prioritisation and the consequences of this variation on metabolism and reproductive performance [16,17]. Plasma glucose and insulin concentrations are correlated [18], but are also associated with other hormones and metabolites, such as growth hormone and non-esterified fatty acids (NEFA) [19]. Correlations between the concentrations of blood metabolites and their association with physiology and diseases have been reported [20]. However, few studies have acknowledged that cows of different breeds may cope differently with negative energy balance [11].

The aim of this study was to investigate the effect of two feeding levels during the antepartum and postpartum period on reproductive performance. A set of blood metabolites (glucose, NEFA, insulin) was analysed in primiparous Holstein and SRB cows, in order to identify possible differences in the way these breeds adapt to negative energy balance after calving.

2. Material and methods

2.1. Experimental design

All experimental protocols were accepted by the Uppsala Animal Experiment Ethics Board (application C329/12, PROLIFIC) and were carried out in accordance with the terms of the Swedish Animal Welfare Act.

The experiment was conducted in a 2 × 2 (diet x breed) factorial design, i.e. with two groups of Holstein and SRB cows, respectively. The animals were enrolled during two consecutive years. The first group (sampling period 1) started in 2013 and in total 26 animals were enrolled, while the second group (sampling period 2) started a year later and an 18 additional animals were enrolled. The numbers of animals used in the experimental groups are shown in Table 1. The experiment ran during September 2013–May 2014 and September 2014–May 2015.

2.2. Animals and housing

The animals used in the experiments (44 in total) were heifers that became pregnant after a maximum of two artificial inseminations (AI), recruited at the Swedish Livestock Research Centre in Uppsala/Lövsta. Mean annual milk production per cow was 10 328 kg energy-corrected milk (ECM) during 2013–2014 and 10 233 kg ECM during 2014–2015. Only healthy heifers not treated for any clinical signs of disease were included. At the start of the experiment, the average age of the 44 animals was 20.8 ± 1.8 months (mean ± SD), while the average body weight was 587 ± 40.8 kg for the Holsteins and 571 ± 40.9 kg for the SRB cows (mean ± SD). Visual inspections for oestrus detection were carried out three times daily and heifers were artificially inseminated about 12 h after onset of standing oestrus was detected. Animals were re-inseminated until they became pregnant. All heifers were examined for pregnancy by the same investigator, using transrectal palpation and ultrasonography with a 7.5 MHz linear probe (DRAMINSKI iScan, Olsztyn, Poland), at 35 and 60–90 days after AI.

Pregnant heifers were moved 30 days before expected calving (Day -30) to a straw-bedded calving pen. The treatment groups were separated by a gate. After calving, the animals were relocated to a loose housing barn with a voluntary milking system (VMS, DeLaval, Tumba, Sweden), where they stayed for 120 days. During the whole study period, the animals were kept indoors and had free access to water.

2.3. Diet regime and groups

Animals were randomly divided into two diet groups, a control group (HE; Holstein n = 12, SRB n = 11) and a low feeding intensity group (LE; Holstein n = 10, SRB n = 11). The HE group (n = 23) was fed according to Nordic standards [21] for high-producing cows (expected production per day of 35 kg ECM). The low feeding intensity (n = 21) targeted expected milk production of 25 kg ECM per day, which was achieved by giving 50% less concentrate than in the control group. Cows were identified by a neck collar transponder at the entrance to the milking parlour and in the feeding area of the housing barn. The amount of the concentrate offered in the VMS and in concentrate stations in the feeding area was individually adjusted. Silage was fed in forage mangers placed on weighing cells (CRFI, BioControl, Rakkestad, Norway). Silage and concentrate were fed separately to all cows through the experimental period. The chemical and nutrient composition of the feed is shown in Tables 2 and 3.

2.4. Milk composition and analysis

At the entrance to the milking parlour, cows were identified by a neck collar transponder. Milk yield was automatically recorded in the VMS after each milking and milk composition was analysed once weekly. Milk samples (20 ml) pooled from two consecutive milkings (afternoon milking and the following morning milking) were collected from Day 7 after calving until approximately Day 120. These samples were analysed for fat, protein and lactose content at the laboratory of the Department of Animal Nutrition

Table 1
Number of pregnant heifers included in the experiment.

	Sampling period 1		Sampling period 2		Total
	Control[a] (HE)	Low diet[b] (LE)	Control (HE)	Low diet (LE)	
Holstein	6	6	6	4	22
SRB[c]	7	7	4	4	22
Total	13	13	10	8	44

[a] Control diet (HE) aimed 35kg energy-corrected milk per day (ECM).
[b] Low intensity diet (LE) aimed 25 kg ECM per day.
[c] SRB = Swedish Red breed.

Table 2
Chemical composition and nutritive value of grass offered and concentrates used.

Feed stuff	Silage[a]	Concentrate[a,b]
Dry matter (g/kg DM)	388 (100.4)	880 (5.8)
Crude protein (g/kg DM)	131 (30.1)	235 (75.7)
Soluble protein (g/kg CP)	565 (34.8)	202 (27.3)
Ash (g/kg DM)	79.6 (9.9)	70.8 (11.9)
Crude fat (g/kg DM)	35	76 (19.6)
Starch (g/kg DM)	N/A	196 (143)
NDF[c] (g/kg DM)	439.4 (68.7)	255 (19.8)
iNDF (d/kg NDF)	196 (47.3)	241 (47.9)

DM = dry matter and CP = crude protein.
[a] Standard deviation values within brackets.
[b] Trade names (Lantmännen, Malmö, Sweden), Unik 82, Solid 120, Solid 620.
[c] Neutral Detergent fibers.