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Pasture versus total mixed ration during the periparturient period

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ABSTRACT

The effect of diet and genotype on metabolic indicators of energy status in the periparturient cow were investigated. Fifty-six dairy cows of two different genotypes (Overseas Holstein-Friesian (OSHF) and New Zealand Holstein-Friesian (NZHF)) were randomly allocated to two dietary regimens. Half of each genotype group received a pasture/pasture silage diet pre-calving and a pasture diet post-calving, while the other half received a total mixed ration (TMR) pre- and post-calving. Compared with NZHF, OSHF had higher concentrations of plasma non-esterified fatty acids (NEFA; $P<0.05$) and glutamic acid dehydrogenase (GDH; $P=0.09$), an indicator of liver fat infiltration, 30 d post-calving. Genotype did not affect the concentration of either β -hydroxybutyrate (BHBA) or glucose in plasma. Cows grazing pasture pre-calving had greater ($P<0.05$) BHBA concentrations, but plasma NEFA concentration and liveweight loss during the first 30 days of lactation were not different. In summary, a pre-calving TMR did not appear to improve the metabolic energy status of the cow pre-calving. These results suggest that provided sufficient nutrients are supplied in the diet, the homeorhetic mechanisms within the cow allow adaption to very different diets. This implies that an all-forage diet pre-calving is sufficient for dairy cows fed forage post-calving.

Keywords: periparturient; transition cow; metabolic; NEFA; pasture.

INTRODUCTION

Dairy producers in many parts of the world have changed to more-controlled, intensively managed feeding during the dry period because they are convinced that the transition period, centred round calving, is one of the most important periods in the lactation cycle of a cow. Recommendations for feeding during this period are equivocal (Stockdale *et al.*, 2000) and much of what is recommended for grazing cows is based on research from non-pasture-based systems.

Nutrient requirements escalate significantly in the final month of pregnancy (Bell, 1995). As energy requirements increase, dry matter intake is reported to decline (Grummer, 1995). This decline is less likely to occur when cows are fed primarily forage (Vazquez-Anon *et al.*, 1994; Roche *et al.*, 2001a).

Most research regarding the nutrition of the transition cow has been undertaken in overseas countries where forages would be lower in quality (energy) than pasture. Several studies have suggested that reducing the forage-concentrate ratio of a diet will increase pre-partum dry matter (DM) and energy intakes and plasma glucose concentrations while reducing nonesterified fatty acid (NEFA) and β -OH butyrate (BHBA) concentrations (Minor *et al.*, 1998; Vandehaar *et al.*, 1999). Forbes (1977) showed that, although voluntary intake increased as digestibility of the diet increased, the decline in DM intake in the final weeks before parturition was greatest when digestibility was highest. Consequently, energy intake at calving may be no greater when feeding high concentrate diets. Similarly, Coppock *et al.* (1972) reported a significant depression in the pre-calving DM intake when the diet contained more than 25% concentrates. This suggests that having high levels of forage in the pre-calving diet is important.

The increased incidence of metabolic diseases reported by Emery *et al.* (1968) and Coppock *et al.* (1972) in cows fed concentrates pre-calving disputes the need

for concentrates pre-calving, as do the findings of Hernandez-Urdaneta *et al.* (1976), who reported that cows could be changed from pre-partum diets of nearly all forage to high concentrate diets (60% concentrates) post-partum without any adverse effects.

Much inconsistency exists in the literature on the effects of feed type in the periparturient period on the health and production of dairy cows and there is little or no evidence on the effect of genotype. The reported research investigated the effect of diet during the final two weeks pre-calving, on indicators of metabolic stress in Holstein cows of differing genotypes.

MATERIALS AND METHODS

Experimental design and treatments

This experiment was conducted at No 1 Dairy, Dexcel, Hamilton, New Zealand ($37^{\circ}46'S$ $175^{\circ}18'E$). The effects of genotype, diet, and genotype x diet interactions on indicators of energy status in periparturient cows were investigated. Fifty-six cows (16 primiparous and 40 multiparous) were used that were already involved in a multiyear comparison trial comparing Holstein-Friesian (HF) cows of either New Zealand (NZ) or Overseas (OS) origin. Both genotypes (OSHF and NZHF) either grazed pasture (GRASS) or were fed a TMR according to a 2×2 factorial design, as described by Roche *et al.*, (2001b).

Feeds and feeding

Pre-calving. All cows were fed to achieve a DM intake of 2% of pre-calving live weight (LWT) of a 50:50 pasture and pasture-silage diet until three weeks prior to calving. One group remained on this pasture/pasture-silage diet until calving (GRASS). The other group (TMR) was gradually introduced to a pre-calving TMR over a ten day period. Once adjusted to the TMR, the TMR comprised the whole diet for the 10 d prior to calving. Both NZHF and OSHF cows were offered the same TMR.

Post-calving. After calving, the grazing cows

TABLE 1: Mean chemical composition (% of DM¹) of the formulated diet (Total Mixed Ration) fed during the late dry period and during early lactation, pasture and pasture silage offered during the late dry period and pasture offered during early lactation.

Item	Late dry	Early TMR	Pasture	Pasture Silage	GRASS
	TMR	TMR		Silage	Total Diet
DM (g/kg)	45.2	50.3	125	320	220
Crude Protein	15.1	17.8	28.4	15.4	21.9
Acid Detergent Fiber	25.2	21.3	22.9	34.4	28.7
Neutral Detergent Fiber	42.4	35.2	40.8	51.4	46.1
Lignin	6.3	6.1	4.4	4.8	4.6
NFC ²	34	36.2	22.1	23.6	22.9
Crude Fat	5.0	7.0	4.6	4.4	4.5
Ash	7.8	7.5	10.5	8.9	9.7
ME ³ (MJ/kg)	10.6	12.1	12.1	11.4	11.8
Calcium	0.46	0.73	0.54	0.53	0.54
Phosphorus	0.39	0.525	0.38	0.30	0.34
Magnesium	0.20	0.23	0.16	0.16	0.16
Potassium	1.64	1.53	3.30	2.46	2.88
Sodium	0.22	0.32	0.28	0.27	0.27
Sulfur	0.18	0.20	0.33	0.20	0.27
Chloride Ion	0.63	0.60	0.55	1.08	0.78
DCAD ⁴	224	23	604	338	471

¹ Unless otherwise stated² Non fibre carbohydrate (NFC) = 100-%NDF-%CP-%Fat-%Ash³ Metabolisable energy⁴ Dietary Cation-Anion Difference

(GRASS) were offered *ad libitum* pasture and the comparative treatment were offered a TMR formulated for early lactation. NZHF and OSHF cows received the same TMR mix and were fed to achieve a 10% refusal rate.

Grazing treatment. Grazing cows were offered a fresh break of pasture twice daily at 0700 and 1500 h. The aim was to feed the lactating cows in the grazing treatment generously on pasture, i.e., an allowance of >45kg DM/cow/d. The grazing protocol was described by Roche *et al.* (2001b). The nutrient characteristics of the pasture and pasture silage offered are shown in Table 1.

TMR treatment. The TMR cows were confined to one of three sheltered loafing paddocks (0.25 ha/paddock), before calving, and a free-draining feed pad (11.5m² per cow), which was sheltered from the wind, after calving. The TMR was fed between 0800 and 0900 h and between 1500 and 1630 h in 5-m long mobile fibreglass troughs. The feeds were mixed in a Jaylor vertical mixing wagon.

The nutrient profiles of the pre- and post-calving TMR diets are shown in Table 1. The criteria used to formulate the TMR were described by Roche *et al.*, (2001b). Cows were fed according to NRC (1989) dairy cow feed requirements for high production. Rations were formulated using the Spartan ration formulation program (Vandehaar *et al.*, 1992) and the Cornell Net Carbohydrate and Protein System model (Fox *et al.*, 1992). The TMR diets were based on maize silage (40 and 25%), grass silage (13 and 19.5%), hay (11 and 7.5%), whole cottonseed (6 and 10%) and a compounded concentrate (24 and 38%) for late-dry and early-lactation cows, respectively. The pelleted concentrate (10 mm in length) was formulated to balance nutrients supplied by the forages.

Measurements

Feed offered and refused for each treatment group was recorded daily. Pasture allocations were visually

assessed and assessors were calibrated weekly through cutting a range of pasture yields, representative of pre- and post-grazing yields (O'Donovan, 2000).

Representative samples of TMR (offered and refused), pasture and pasture silage were taken weekly and analysed for crude protein, neutral detergent fibre, acid detergent fibre, soluble sugars, fat, ash and metabolisable energy by Near Infra-Red (NIR) Spectroscopy. Weekly feed samples were bulked monthly for mineral analysis by inductively coupled plasma emission spectroscopy.

Liveweight (LWT) and body condition score (BCS) were assessed fortnightly by one assessor (ten-point scale where 1 = thin to 10 = fat). BCS measured in the week pre-calving was used as calving BCS while LWT measured in the week post-calving was used as calving LWT. The GRASS and TMR cows were managed to calve at a BCS of 5.5 and 6.5, respectively.

Blood samples were collected from all cows two weeks and one week prior to expected calving date, and on each day between 4 d pre- and 4 d post-calving. Cows were also sampled on d 14 and d 30 post-calving. All cows were sampled at approximately 0700 h. Calving date was determined from mating records and pregnancy diagnosis. Blood was collected by coccygeal venipuncture into heparinised vacutainers and analysed for NEFA (colorimetric method), BHBA (BHBA dehydrogenase assay), glucose (hexokinase method), aspartate aminotransferase (AST - IFCC UV test) and glutamate dehydrogenase (GDH - using an "optimised standard method" conforming to the recommendations of the Deutsche Gesellschaft fur Klinische Chemie). All assays were performed on the Hitachi 717 analyser (Roche) at 30°C by Alpha Scientific Ltd (Hamilton, New Zealand). The inter-assay and intra-assay coefficient of variation was <2% for all assays.

Statistical analysis

All data were analysed using analysis of variance for

a factorial design using the statistical procedures of Genstat V (1997) with cows as the experimental unit. Main effects (genotype and feed) and interactions were examined.

RESULTS

LWT (483 ± 46 , 524 ± 84 , 579 ± 83 and 602 ± 87 kg for NZGRASS, NZTMR, OSGRASS and OSTMR, respectively) and BCS (5.5 ± 0.5 , 6.6 ± 1.3 , 5.7 ± 1.4 and 6.2 ± 1.1 for NZGRASS, NZTMR, OSGRASS and OSTMR, respectively) at calving were different across treatments ($P < 0.001$ and 0.05 , respectively). OSHF were significantly heavier (590 vs. 503 kg; $P < 0.001$) post-calving than their NZHF counterparts, but there was no difference in BCS (6.1 vs. 6.0). BCS was higher ($P < 0.01$) in TMR cows compared with the GRASS comparison (6.5 vs. 5.6). Loss of BCS during the first four weeks of lactation was greater in OSHF (1.7 vs. 1.2 ; $P < 0.1$) and TMR fed cows (1.8 vs. 1.2 ; $P < 0.05$).

Group dry matter intakes were similar for both genotypes on their respective diets before calving (1.7 ± 0.27 and 2.0 ± 0.3 % of pre-calving LWT for GRASS and TMR, respectively). Indicators of the energy status (plasma NEFA, BHBA and glucose concentrations) are shown in Figure 1. The concentration of NEFA and BHBA rose sharply four days before calving and increased steadily until four days after calving. Blood NEFA concentrations appeared to have reached a nadir 14 days

FIGURE 1. Effect of genotype (G: OSHF and NZHF) and diet (D: GRASS and Total Mixed Ration - TMR) on plasma concentration of non-esterified fatty acids (NEFA), -OH Butyrate (BHBA) and glucose in periparturient cows (NZ GRASS - ▲; NZ TMR - □; OS GRASS - ▨; OS TMR - ▩).

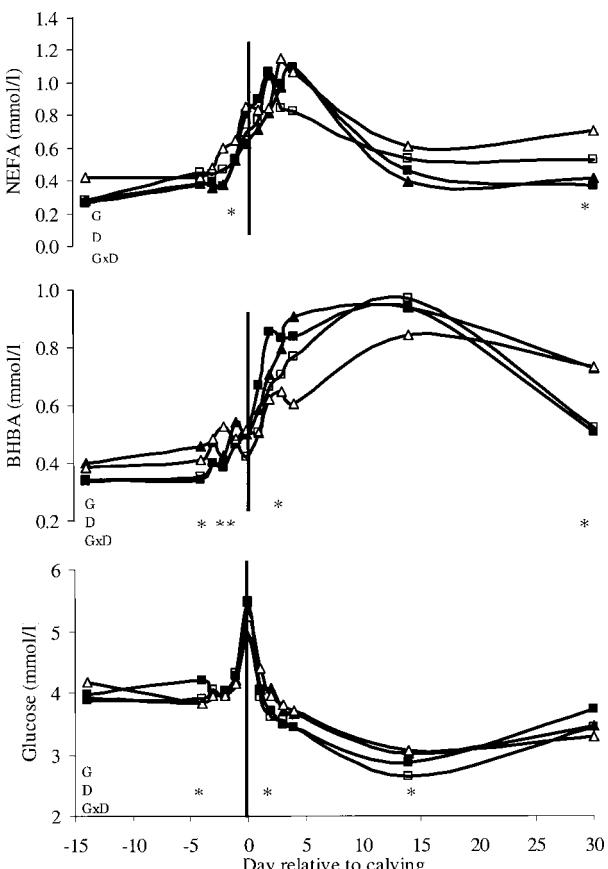
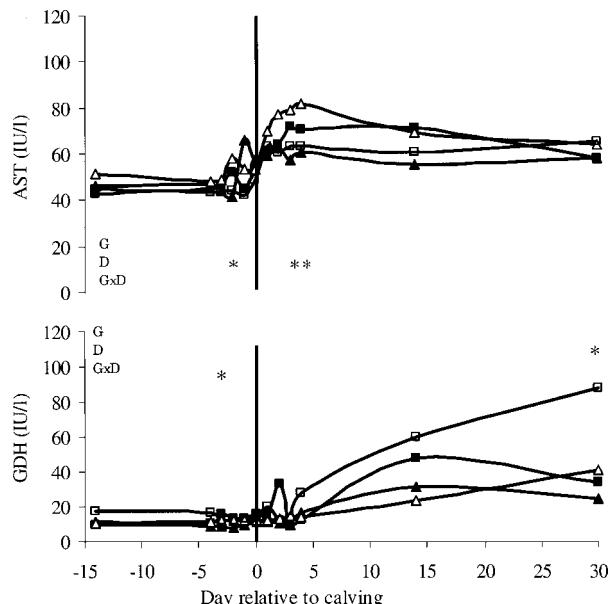


FIGURE 2. Effect of genotype (G: OSHF and NZHF) and diet (D: GRASS and TMR) on plasma concentration of aspartate aminotransferase (AST) and glutamate dehydrogenase (GDH) in periparturient cows (NZ GRASS - ▲; NZ TMR - □; OS GRASS - ▨; OS TMR - ▩).



post-calving and were similar on d 30 while BHBA remained high at d 14 post-calving before declining.

The concentration of NEFA in plasma before or after calving was unaffected by either genotype or pre-calving diet (Figure 1), except for 30 days post-calving, when OSHF cows had higher ($P < 0.05$) plasma NEFA concentrations. This genotypic divergence in blood NEFA concentration appeared to be starting at day 14 post-calving ($P = 0.09$). Grazing cows had higher BHBA 2, 3 and 4 d pre-calving and 30 d post-calving ($P < 0.05$, 0.05 , 0.05 and 0.1 , respectively). Genotype did not influence the concentration of BHBA in plasma.

Plasma glucose concentrations increased during the 4 d before calving to a peak on the day of calving and declined subsequently, but were not affected by genotype either before or after calving or by diet before calving (Figure 1). There was a trend ($P = 0.08$) towards a lower blood glucose concentration post-calving, in cows receiving TMR and the difference was significant on d 1, 2 and 14 post-calving ($P < 0.05$, 0.01 , and 0.05 , respectively).

Plasma concentrations of AST and GDH (Figure 2) are recognised indicators of the degree of liver fat infiltration (Bogin *et al.*, 1988; Cebra *et al.*, 1997). The concentration of AST in plasma began to rise four days pre-calving and reached a plateau three to four days after calving before declining. Neither diet nor genotype had a significant effect on the concentration of this metabolite. Plasma concentrations of GDH rose post-calving and appeared to be still rising in OSHF cows at the end of the experimental period. At this point (d 30 post-calving) the TMR-fed cows had greater ($P < 0.01$) concentrations of GDH in plasma than their grazing counterparts and the difference between genotypes (29.0 and 64.5 IU/l for NZHF and OSHF, respectively) approached significance ($P = 0.09$).

DISCUSSION

The 46% greater loss in BCS post-calving in cows fed a TMR compared with grazing cows was probably due to the higher BCS at calving (Stockdale *et al.*, 2000). It has been suggested that cows have a target level of energy reserves that they try to maintain through physiological feedback mechanisms (Oldham & Emmans, 1988). The lower BCS reported for OSHF cows 3, 5 and 7 weeks post-calving in this experiment suggests that this target level is different for cows of different genotypes and is supported by the findings of Veerkamp *et al.* (1994) and Buckley *et al.* (2000). It is possible that New Zealand dairy cows have been indirectly selected to limit the amount of BCS mobilised in early lactation or the rate at which they mobilise it.

The trends in glucose concentration in the experiment reported here are similar to those described by others (Athanasou & Phillips, 1978; Vazquez-Anon *et al.*, 1994). The sudden peak is probably due to a rise in the foetal adrenocortical production of cortisol around calving (Liggins, 1994). This peak in glucose concentration is short lived and levels return to normal quickly, as expected. Values discussed in this paper are very similar to those presented by Butler (1999), although greater than those reported by Athanasou & Phillips (1978) and Vazquez-Anon *et al.* (1994).

It is unclear why the feeding of TMR would decrease plasma glucose concentrations post-calving. The greater milk production in cows fed TMR (data not shown) and the consequential greater demand for lactose is the most plausible explanation.

An increased lipolysis initiated at parturition is demonstrated here in the rapid increase in plasma NEFA and BHBA concentration during the four days before calving (Figure 1) and is similar to values published by Vazquez-Anon *et al.* (1994) and Butler (1999) for cows fed forage-concentrate diets. The lack of a difference between grazing cows and cows on TMR in plasma concentrations of NEFA before calving suggests that it is the intake of energy that is important in the pre-calving period and not the feed eaten per se.

The reason for the higher concentration of BHBA in grazing cows in the experiment reported here is unknown. It is unlikely however that it is the result of increased lipolysis, as was postulated by Butler (1999). The lack of a difference in NEFA, as was also shown by Butler (1999), and the concomitant lack of a difference in the concentration of AST and GDH, suggest that the increase in BHBA post-calving in grazing cows was not due to increased bodyfat catabolism. The increased BHBA in the cows that were force fed by Bertics *et al.* (1992) even though liver triglyceride was lower at calving also suggests a source of BHBA other than lipolysis. This suggests that BHBA concentrations in blood are not an effective indicator of the energy status of the animal and should not be used in isolation for this purpose.

CONCLUSION

High levels of good quality forage alone pre-calving appears sufficient for cows that are to be fed a diet of pasture post-calving. A pre-calving TMR did not appear

to improve the net energy status of cows during the transition period. OSHF have a greater propensity to mobilise body fat in the early postpartum period. Further work is required to fully elucidate the benefits, if any, of feeding a pre-calving TMR compared with high quality forage alone.

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