Effects of Different Transition Diets on Dry Matter Intake, Milk Production, and Milk Composition in Dairy Cows

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ABSTRACT

The primary objective of this study was to evaluate the effect on dry matter intake (DMI), milk yield, milk composition, body weight (BW), and body condition score (BCS) change of cows offered diets differing in energy density in the last 4 wk of gestation and in the first 8 wk of lactation. Three diets (grass silage:straw, 75:25 on a dry matter basis (SS), grass silage (S), and grass silage + 3 kg concentrate daily (C)) precalving, and two diets (4 kg [LC] or 8 kg [HC] concentrate daily + grass silage ad libitum) postcalving were combined in a 3 × 2 factorial design. Sixty Holstein-Friesian cows entering their second lactation were blocked according to expected calving date and BCS into groups of six and were then allocated at random to the treatments. Individual feeding started 4 wk prior to the expected calving date and measurements were made until the end of the 8th wk of lactation. Mean DMI differed between each of the precalving treatments (7.4, 8.1, and 9.9 kg/d for SS, S, and C, respectively) in the precalving period. The DMI also differed between SS and C for wk 1 to 8 (13.5 and 14.2 kg/d) postcalving. Postcalving, milk (24.2, 26.2, and 28.2 kg/d), fat (933, 1063, and 1171 g/d), and protein (736, 797, and 874 g/d) yields differed between SS, S, and C, respectively. The BCS changes differed between SS and C (−0.09 and 0.12 of a BCS) in the precalving period and between SS and S compared with C (0.02, 0.06, and −0.26 of a BCS) for wk 1 to 8 postcalving. The BW change differed between SS and S compared with C in both wk 1 to 4 (−0.23, −0.37, and −1.25 kg/d) and wk 1 to 8 (0.18, 0.10, and −0.58 kg/d) postcalving. The BW and BCS were lower at calving for cows on SS compared with C. The greater amount of concentrate supplement postcalving increased DMI, yields of milk, fat, and protein and decreased BW loss in the first 8 wk of lactation. In conclusion, these results indicate that a greater energy density diet in the final 4 wk of the dry period improves cow production in early lactation.

(**Key words:** dry cow, early lactation, intake, production)

Abbreviation key: C = grass silage/concentrate, HC = 8 kg concentrate + grass silage, IVDMD = in vitro dry matter digestibility, LC = 4 kg concentrate + grass silage, S = silage, SS = silage/straw.

INTRODUCTION

The transition period for dairy cows refers to the time from approximately 3 wk before calving to 3 wk after calving (Grummer, 1995; Drackley, 1998). Approximately 3 wk before parturition DMI starts to decline and reduces dramatically in the last 7 d before parturition. This decline has been as great as 30% before calving in data from the U.S. (Bertics et al., 1992; Grummer, 1995). A similar decline has been observed for dry cows on grass-silage based diets (Murphy, 1999). As DMI decline in late gestation is practically unavoidable, increasing the energy density of the close-up dry period diet should help to maintain energy intake, despite the decline in DMI. Ingvarstsen et al. (1999) suggested that there has been an overemphasis on the physical restriction theory on intake in late gestation and that DMI decline might be more related to body reserves and the adaptive changes that occur in the periparturient cow. They suggested that regulation of body reserves and intakes are controlled by nervous and hormonal factors. Concentrate supplementation is one strategy that has been employed to increase the energy density of the diet and this is also thought to beneficially acclimatize the rumen microflora to the postcalving diet in which greater levels of concentrates are normally included (Dirksen et al., 1985).

The dry pregnant cows' requirements are the sum of the maintenance, pregnancy, and reserve replenishment needs with additional needs for growth during the first two pregnancies. Precalving DMI has been positively correlated with the DMI at 21 DIM; therefore, maintaining high intakes in the precalving cow may help to achieve high intakes in early lactation (Grummer, 1995).

In seasonal grass production systems, grass silage is the typical diet fed to cows in late gestation. This is a

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feed that can have low intake characteristics because of a low DM content, poor fermentation, or low digestibility. Murphy (1999) showed that grass silage DMI declined from 10.4 kg/cow per d in wk 4 precalving to 8.8 kg/cow per d on d 4 precalving and to 6.4 kg/cow per d on d 1 precalving. The objective of this study was to investigate the effect of grass silage based transition diets for dairy cows differing in energy density, on DMI, milk production, and composition, BCS, and BW change from 4 wk prepartum until 8 wk postpartum.

MATERIALS AND METHODS

Animals and Experimental Design

Sixty spring-calving Holstein-Friesian dairy cows going into their second lactation were assembled in early December and trained to use Calan door controlled feeding boxes. All the cows were calving for the second time with a mean calving date of February 5, 1999 (range from January 9 to February 26). The cows were managed in compliance with good husbandry practices. The experiment was a randomized block design consisting of three dietary treatments precalving and two dietary treatments postcalving in a 3 × 2 factorial arrangement of treatments. At approximately 4 wk before expected calving date, the cows were blocked on the basis of expected calving date and BCS into groups of 6 and from within groups assigned at random to one of the following experimental treatments:

1. Grass silage/barley straw mixture on a 75:25 dry matter basis offered ad libitum (**SS**) precalving, with ad libitum grass silage and 4 kg/cow per d of concentrate postcalving (**LC**).
2. SS precalving with ad libitum grass silage and 8 kg/cow per d of concentrate postcalving (**HC**).
3. Grass-silage offered ad libitum (**S**) precalving and LC postcalving.
4. S precalving and HC postcalving.
5. Grass-silage offered ad libitum plus 3 kg/cow per d of concentrate daily (**C**) precalving and LC postcalving.
6. C precalving and HC postcalving.

The treatments were imposed from on average 34 d before actual calving day until the end of wk 8 in lactation. Precalving, the concentrates were offered once daily at 1000 h; postcalving they were offered in two equal feeds at 0830 and 1600 h.

Forage was offered once daily at 1030 h; the straw and silage were premixed in a diet feeder (Keenan Ltd., Bagnelstown, Ireland) for 30 min prior to feeding. Forage refusals were collected and weighed daily prior to feeding. The concentrate was offered in pelleted form and visual examination of the forage refusals indicated the absence of any residual concentrates. A precalving

mineral mix was applied onto the silage at a rate of 100 g/d per cow. The ingredient composition of the concentrates offered pre- and postcalving is shown in Table 1.

Immediately postcalving cows on LC were offered their total allocation of 4 kg/d of concentrate. Those on HC were offered 4 kg/d of concentrates for 2 d increasing to 6 kg/d for 2 d and on d 5 postcalving they were offered their total allocation of 8 kg. Postcalving silage was offered once daily at 1000 h, and daily refusals were weighed back at 0830 h.

Samples and Animal Measurements

Samples of silage offered were taken on Monday, Wednesday, and Friday and samples of silage refused were taken on Tuesday, Thursday, and Saturday each week. Concentrate samples were taken once weekly. The DMI was calculated on a daily basis.

Milk yield was recorded on a daily basis at both the morning and the evening milking. Milk composition (fat, protein, and lactose) was determined once weekly from successive morning and evening milk samples by automated infra-red analysis using a Milkoscan 203 (Foss Electric, Denmark) (IDF, 2000). Cow BW was measured on 1 d/wk. The dry cows were weighed before feeding in the morning and the lactating cows were weighed after morning milking. The BCS (Lowman et al., 1976) of the cows was determined at drying off, at the start of the trial, at calving, and on 1 d/wk thereafter for the remainder of the trial.

The weight of the calf was measured within 1 h of birth. Calving difficulty was measured for each cow on

Table 1. Ingredient composition and chemical composition of the pre- and postcalving concentrate supplements.

Ingredient	Precalving	Postcalving
Barley, g/kg	620	250
Beet pulp, g/kg	250	280
Soybean meal, g/kg	110	100
Corn gluten feed, g/kg	—	250
Rapeseed meal, g/kg	—	100
Oil (lard), g/kg	20	20
Chemical composition		
DM, g/kg	859 ± 7.3 ¹	868 ± 5.3
CP, g/kg DM	160 ± 4.4	199 ± 15.5
Ash, g/kg DM	43 ± 1.8	65 ± 6.0
NDF, g/kg DM	226 ± 3.3	278 ± 8.2
Crude fiber, g/kg DM	79 ± 14.1	90 ± 9.9
Fat, g/kg DM	30 ± 4.6	45 ± 3.2
Estimated starch, g/kg DM	356	189
Net energy, UFL ²	1.02	1.0
Net Energy for lactation, Mcal/kg ³	1.73	1.70

¹Mean ± SD.

²Estimated based on NE values for ingredients (INRA, 1989).

³Estimated based on 1 UFL = 1.7 Mcal/kg (Vermorel, 1989).

a numerical score (1 (no assistance) to 6 (foetotomy)) related to the degree of assistance deemed necessary during parturition (Mee, 1991).

Laboratory Procedures and Analysis

The silage, straw, and concentrate samples were stored at -18°C and analyzed at the end of the trial. The DM of the grass silage and the straw was determined by drying at 40°C in an oven for 48 h. The concentrate and the dried silage and straw samples were milled through a 1 mm sieve, dried at 103°C for 4 h to determine the DM in the milled sample, and ashed at 550°C for 16 h in a muffle furnace to determine the ash content. The CP content was determined by the method of Sweeney (1989) on a Leco FP 428 nitrogen analyzer. The concentrate samples were analyzed for crude fiber (AOAC, 1984) and oil content (Usher et al., 1973). The ADF and NDF content of the silage and straw and the NDF content of the concentrates were measured according to the procedures of Van Soest et al. (1991) using Ankom equipment as outlined by Ankom Technology Corporation (NY, USA). Determination of **IVDMD** and digestible OM in the DM were carried out using the procedure described by Tilley and Terry (1963). Silage pH was measured by analyzing the juice pressed from the silage using a glass electrode and a pH meter (Radiometer pHM2 standard pH meter-radiometer, Copenhagen). The juice was also analyzed for VFA and ethanol by GLC (Rannft, 1973). Ammonia N was determined on expressed juice by a modification of the phenol/hypochlorite technique as described by O'Keefe and Sherington (1983). Lactic acid concentration was analyzed on a Ciba-corning Express clinical analyzer using the method of Boehringer Mannheim (Catalogue No. 139004).

Statistical Analysis

One cow was removed from the experiment for reasons not connected with the treatments. Repeated measures ANOVA for the effects of the precalving treatments on intake, BW change, and BCS change in the precalving period was carried out using the GLM procedure of SAS (SAS Institute, 1991). Treatment, time, and treatment by time interactions were tested.

Repeated measures ANOVA for the effects of precalving and postcalving treatments on intake, BW change, BCS change, milk yield, milk constituent yield, and milk composition in the postcalving period was conducted, again using the GLM procedure of SAS (SAS Institute, 1991). The model used included terms for precalving treatment, postcalving treatment, time, and all the interactions. Actual calving day and length of time on the precalving diet were used as co-variates.

Generally there was no significant interaction between the pre- and postcalving treatments for the variables measured (P -values ranged from 0.10 to 0.83 for individual variables except for total DMI ($P = 0.06$) and BCS change over the first 8 wk postcalving ($P = 0.05$)). Therefore, pre- and postcalving treatment effects are presented separately. The differences between precalving treatments and postcalving treatments were tested for significance (separately) using Student's t -test.

RESULTS

Chemical Composition of Silage and Concentrate

The chemical composition of the silages and straw used over the experimental period are shown in Table 2. Both silages had low DM contents of approximately 180 g/kg. The postcalving silage had lower pH and ammonia N values and higher IVDMD and digestible OM in the DM than the precalving silage. The straw had a lower IVDMD (484 g/kg) and estimated NE_L (0.75 Mcal/kg DM) than either of the silages.

Effects of Precalving Diet

DMI. Precalving forage intake was greater on S compared with the other two treatments. Differences between the treatments in mean forage intake postcalving were not significant (Table 3). Total DMI was lower on SS than S ($P < 0.05$) and lower on S than C ($P < 0.05$), precalving. Total DMI was higher ($P < 0.05$) on C for the first 8 wk postcalving compared with SS but not compared with S (Table 3). Postcalving, there were significant interactions between precalving treatment and wk for forage ($P < 0.05$) and total ($P < 0.001$) DMI (Figure 1). Differences in DMI between the treatments in the first 3 wk postcalving almost disappeared at wk 4 and all treatments had similar DMI from wk 4 to 8. There was no significant interaction between treatment and time precalving for either forage or total DMI. Intakes decreased in the final wk before calving on the 3 treatments.

Total DMI on d 1 precalving was weakly positively correlated with DMI on d 21 postcalving ($r = 0.11$; $P = 0.42$) across treatments. Within treatments, correlations between DMI on d 1 precalving and DMI on day 21 postcalving were -0.28 ($P = 0.23$), 0.17 ($P = 0.49$), and 0.16 ($P = 0.52$) for SS, S, and C respectively. Correlations between intake on other days and weeks pre- and postcalving were also low.

BW and BCS. Cows on C were heavier ($P < 0.01$) than those on SS at calving (Table 4). Mean daily BW change was not different ($P > 0.05$) between the three treatments precalving. Cows on C lost more BW ($P < 0.01$) than those on the other two treatments for both

Table 2. Chemical composition of the grass-silage and straw offered.

	Grass-silage		Straw
	Precalving	Postcalving	Precalving
DM, g/kg	181 ± 5.2 ¹	183 ± 7.3	845 ± 15.1
pH	4.28 ± 0.32	3.90 ± 0.16	
CP, g/kg DM	154 ± 12.8	168 ± 15.1	48 ± 4.1
NDF, g/kg DM	562 ± 38.9	475 ± 27.2	806 ± 10.6
ADF, g/kg DM	373 ± 21.3	348 ± 18.9	527 ± 12.1
Ash, g/kg DM	81 ± 7.4	82 ± 5.7	43 ± 3.2
IVDMD, g/kg DM	711 ± 31.0	762 ± 18.0	484 ± 35.2
DOM in DM	651 ± 24.3	697 ± 17.5	458 ± 34.7
Net energy, Mcal/kg DM ²	1.36 ± 0.05	1.43 ± 0.05	0.75 ± 0.05
Ammonia N, g/l	107 ± 29.4	51 ± 8.5	
Lactic acid, g/l	16 ± 8.7	25 ± 5.8	
Water soluble carbohydrate, g/l	1.7 ± 1.0	2.5 ± 0.8	
Acetic, g/l	10.1 ± 1.22	10 ± 3.0	
Propionic, g/l	1.1 ± 0.72	1.1 ± 0.7	
Butyric, g/l	1.7 ± 2.52	0.9 ± 0.9	

¹Mean ± SD.²See footnote in Table 1.

the first 4 and first 8 wk postcalving. However, cows on C were neither gaining nor losing BW between wk 5 and 8 after calving and cows on SS and S gained over 0.5 kg/d in this period. The BCS change precalving was different ($P < 0.05$) between C and SS. Cows on C gained BCS while those on SS lost condition. Also cows on C had a higher BCS at calving ($P < 0.01$) than those on SS. Over the first 8 wk of lactation cows on C lost more BCS ($P < 0.05$) than cows on the other 2 treatments.

Calf birth weight and calving difficulty. Calf birth weights (45, 44, and 41 kg s.e.d. 2.1 for SS, S, and C, respectively) and calving difficulty (1.6, 1.4, and 1.2 for SS, S, and C, respectively) were not different ($P > 0.05$) between precalving treatments.

Milk production. Mean milk yields, milk constituent yields, and milk composition in the first 8 wk of lactation, for the precalving treatments, are shown in Table 5. Milk fat and protein yields were greater ($P < 0.05$) for C compared to S, and the differences in yields of milk ($P = 0.067$) and lactose ($P = 0.11$) between these

treatments were close to statistical significance. Cows on SS had lower milk, protein, fat, and lactose yields ($P < 0.05$) compared with the other 2 treatments. Treatment SS also had a lower ($P < 0.05$) milk fat concentration compared to C. There was a significant interaction with time for milk yield ($P < 0.01$), fat yield ($P < 0.05$), protein yield ($P < 0.001$), and lactose yield ($P < 0.01$) but not for fat, protein, or lactose concentrations (Figure 2). The pattern of production was similar for milk and lactose yields, but the difference between treatments declined as lactation wk increased. Peak milk yield was recorded for all the treatments 3 to 4 wk after calving, with the yield being maintained until wk 6, after which it started to decline. Fat and protein yields declined over time on C, whereas they remained relatively constant on SS and S except for the atypical value in wk 2.

Effects of Postcalving Diet

DMI. Mean forage intake was lower ($P < 0.01$) on HC compared with LC but total DMI was greater ($P < 0.001$) on HC (Table 6).

BW and BCS. Cows on LC lost more BW ($P < 0.05$) than HC in both wk 1 to 4 and wk 1 to 8 postcalving (Table 7). However, from wk 5 to 8, both treatments actually gained BW and differences between treatments were not significant. Cows on HC, on average, gained BW over the first 8 wk. Both treatments lost body condition over the first 8 wk but the difference between them was not significant.

Milk yield. Milk yield ($P < 0.05$), fat yield ($P < 0.001$), protein yield ($P < 0.001$) lactose yield ($P < 0.05$), and protein concentration ($P < 0.01$) were increased on HC compared with LC (Table 8). Milk fat or lactose concen-

Table 3. Effect of precalving diet¹ on forage and total DMI (kg DM/cow per d) in the last 4 wk precalving and the first 8 wk postcalving.

	SS	S	C	SED ²
Precalving				
Forage	7.4 ^a	8.1 ^b	7.4 ^a	0.28
Total	7.4 ^{a3}	8.1 ^b	9.9 ^c	0.29
Postcalving				
Forage	8.6	8.7	9.1	0.30
Total	13.5 ^a	13.8 ^{ab}	14.2 ^b	0.31

¹SS = silage/straw 75/25 on a DM basis ad libitum; S = silage ad libitum; C = silage ad libitum +3 kg/day of concentrate.²SED = standard error of the difference.³Means within rows having different superscripts differ significantly ($P < 0.05$).

Figure 1. Effect of precalving treatment (◆ SS; ■ S; ● C) on (a) forage dry matter intake and (b) total DMI pre- and postcalving and the effect of postcalving treatment (■ LC; ▲ HC) on (c) forage and (d) total DMI postcalving. Treatments SS, S, and C correspond to the precalving treatments of silage/straw 75/25 on a DM basis ad libitum, silage alone ad libitum, and silage ad libitum +3 kg/day of concentrate, respectively. Treatments LC and HC correspond to the postcalving treatments of 4 kg/d concentrate + silage ad libitum and 8 kg/d concentrate + silage ad libitum, respectively.

trations were not ($P > 0.05$) affected by postcalving treatment. There were significant interactions between postcalving treatment and time for milk yield ($P < 0.001$), fat yield ($P < 0.01$), protein yield ($P < 0.05$), and lactose yield ($P < 0.001$) but not for fat protein or lactose

concentrations (Figure 3). For milk and lactose yields the pattern of production with time was similar for HC and LC but the difference between the treatments increased as wk number postcalving increased. Fat and protein yields remained relatively constant following

Table 4. Effect of precalving diet¹ on BW and BCS at calving and pre- and postcalving BW (kg/day) and BCS change.

	SS	S	C	SED ²
BW				
Gain for 4 wk precalving	0.22	0.10	0.54	0.243
At calving	597 ^{a3}	620 ^{ab}	635 ^b	12.6
Change wk 1 to 4 postcalving	-0.23 ^a	-0.37 ^a	-1.25 ^b	0.267
Change wk 5 to 8 postcalving	0.57 ^a	0.56 ^a	-0.01 ^b	0.219
Change wk 1 to 8 postcalving	0.18 ^a	0.10 ^a	-0.58 ^b	0.169
BCS				
Change over 4 wk precalving	-0.09 ^a	0.01 ^{ab}	0.12 ^b	0.081
At calving	2.62 ^a	2.76 ^{ab}	2.87 ^b	0.086
Change wk 1 to 4 postcalving	0.001	0.004	-0.08	0.087
Change wk 5 to 8 postcalving	0.10 ^a	0.03 ^a	-0.13 ^b	0.064
Change wk 1 to 8 postcalving	0.02 ^a	0.06 ^a	-0.26 ^b	0.110

¹SS = silage/straw 75/25 on a DM basis ad libitum; S = silage ad libitum; C = silage ad libitum +3 kg/day of concentrate.

²SED = standard error of the difference.

³Means within rows having different superscripts differ significantly ($P < 0.05$).

Table 5. Effect of precalving diet¹ on milk and constituent yields and milk composition in wk 1 to 8 postcalving.

	SS	S	C	SED ²
Milk yield, kg/cow per d	24.1 ^a	26.2 ^b	28.2 ^b	1.05
Milk fat, g/cow per d	933 ^a	1063 ^b	1171 ^c	55.1
Milk protein, g/cow per d	736 ^a	797 ^b	874 ^c	30.1
Milk lactose, g/cow per d	1111 ^a	1213 ^b	1295 ^b	48.9
Milk fat, g/kg	38.6 ^a	40.3 ^{ab}	41.5 ^b	1.34
Milk protein, g/kg	31.6	31.5	32.3	0.68
Milk lactose, g/kg	46.1	46.2	46.0	0.32

¹SS = silage/straw 75/25 on a DM basis ad libitum; S = silage ad libitum; C = silage ad libitum +3 kg/day of concentrate.

²SED = standard error of the difference.

³Means within rows having different superscripts differ significantly ($P < 0.05$).

an increase over the first 2 to 3 wk postcalving on HC but tended to decrease after wk 2 to 3 postcalving on LC.

DISCUSSION

Feed Quality

The silage offered during the experiment was of high quality as indicated by the *in vitro* digestibilities and CP contents. Preservation quality was good as indicated by the pH, ammonia nitrogen, lactic acid, and VFA concentrations. The concentrations of these components indicated a slightly better preservation quality in the silage offered postcalving compared with that offered precalving. The general composition of the silages and straw was typical of the composition of these feeds fed commercially. The postcalving concentrate had greater CP, fiber, and oil contents and a lower estimated starch content than the precalving concentrate but both had compositions typical of concentrates fed at these times. Precalving the energy densities of the diets were 1.24, 1.36, and 1.55 Mcal/kg DM for SS, S, and C, respectively.

Effects of Precalving Diet

In this study the experimental precalving diets were offered for, on average, the final 34 d of the dry period in an attempt to quantify the effects of dietary energy density in the second half of the dry period. Broster (1971) concluded that supplementary feeding precalving could affect milk production in the subsequent lactation and that BW gain precalving determined production responses postcalving. He stressed that supplementation may have its greatest effects where the basal ration is of a poor quality with effects diminishing to zero when basal rations are of good quality.

DMI. Increasing the energy density of the diet in the precalving period led to an increase in DMI. Because of the correlation observed between DMI pre- and post-

calving (Grummer 1995), increasing DMI precalving should result in higher DMI postcalving. The correlations between individual cow intakes on d 1 precalving and d 21 postcalving, within treatments, were not significant, in contrast to Grummer (1995). Mean DMI of cows on C was however, greater than that of SS over the first 8 wk postcalving. Therefore, the higher total DMI precalving for C compared to SS was reflected in a higher DMI postcalving. Increased postcalving DMI may not be attributable solely to increased precalving DMI. For example in the present study including concentrates with silage precalving, though significantly increasing DMI precalving, did not lead to a statistically significant increase in DMI postcalving despite a numerical difference. This finding would agree with the results of Johnson and Otterby (1981), Nocek et al. (1986), Ryan (1999), Holcomb et al. (2001), Keady et al. (2001), and Butler et al. (2002). Including straw in the diet precalving appeared to negatively impact on DMI immediately after calving as shown in Figure 1, suggesting perhaps that the rumen of cows receiving straw was poorly acclimatized to the concentrate supplements postcalving. This would support Dirksen et al. (1985) who stated that cows that are fed high energy diets precalving have a more adapted mucosa for higher intake of concentrates postcalving and better absorption of VFA.

BW change and BCS. Precalving feeding effects on BW change and BCS change are related to the length of time that cows are on the precalving transition diet. Most of the studies in the literature would have had longer precalving supplementation periods than the current one. The BW gains in the final 4 wk of gestation of cows on SS and S were relatively low whereas those on C gained 0.54 kg/d. At this stage the fetus and associated tissues would be increasing in BW by approximately 0.6 kg/d (ARC, 1994) and this indicates that cows would need to be gaining this amount of BW in order to maintain their BCS. Because of its low intakes,

Figure 2. Effect of the precalving treatments (◆ SS; ■ S; ● C) on (a) milk yield, (b) fat yield, (c) protein yield, (d) lactose yield, (e) fat concentration, (f) protein concentration and (g) lactose concentration in the first eight wk postcalving. Treatments SS, S, and C correspond to the precalving treatments of silage/straw 75/25 on a DM basis ad libitum, silage alone ad libitum, and silage ad libitum +3 kg/day of concentrate, respectively. Treatments LC and HC correspond to the postcalving treatments of 4 kg/d concentrate + silage ad libitum and 8 kg/d concentrate + silage ad libitum, respectively.

Figure 3. Effect of the postcalving treatments (■ LC; ▲ HC) on (a) milk yield, (b) fat yield, (c) protein yield, (d) lactose yield, (e) fat concentration, (f) protein concentration and (g) lactose concentration in the first eight wk postcalving. Treatments SS, S, and C correspond to the precalving treatments of silage/straw 75/25 on a DM basis ad libitum, silage alone ad libitum, and silage ad libitum +3 kg/day of concentrate, respectively. Treatments LC and HC correspond to the postcalving treatments of 4 kg/d concentrate + silage ad libitum and 8 kg/d concentrate + silage ad libitum, respectively.

Table 6. Effect of postcalving concentrate supplementation on forage and total DMI in the first 8 wk postcalving.

	Concentrate supplementation		SED ²
	LC ¹	HC	
Forage	9.2 ^{a 3}	8.4 ^b	0.24
Total	12.6 ^a	15.1 ^b	0.25

¹LC = 4 kg/d concentrate + silage ad libitum; HC = 8 kg/d concentrate + silage ad libitum.

²SED = Standard Error of the Difference.

³Means within rows having different superscripts differ significantly ($P < 0.05$).

silage alone would not appear to be an adequate diet in the close-up dry period.

Ingvartsen et al. (1999) stated that a higher preparum feeding level, resulting in a higher BW and BCS at calving, increased postpartum mobilization in most experiments. This was observed here and also by Grainger et al. (1982) and Garnsworthy and Topps (1982). This indicates that in order to avoid excessive BW and BCS loss in the early postpartum period, cows should be in such a condition at drying off that it does not require the cow to gain much BW or BCS during the dry period.

Calf birth weight and calving difficulty. Precalving diet had no effect on calving difficulty or calf birth weight as found by other authors (Nocek et al., 1986; Flipot et al., 1988; Ryan, 1999, and Butler et al., 2002). This is probably not surprising as cow BW gain or BCS gain were low in the precalving period indicating that energy intake was not excessive at this time. Therefore, calf birth weight and consequently calf size was not affected.

Milk production. The positive effect of increased dietary energy density precalving on early lactation milk yield and milk constituent yield in this study can be attributed to a number of factors such as improved intakes and greater BW and BCS loss in the first 4 wk of lactation. This positive response is in agreement with

Ryan (1999), who reported that cows on a higher energy diet precalving produced more milk (1.3 kg/cow per d), and protein (60 g/cow per d) in the first 4 wk of lactation and more fat (70 g/cow per d) and protein (40 g/cow per d) in the first 8 wk of lactation than those on a lower energy diet. Keady et al. (2001) also observed that precalving supplementation with 5 kg/cow per d of concentrates increased milk fat concentration and fat + protein yield. Over the first 8 wk of lactation, C apparently supplied enough energy (from intake and BW loss) to produce about twice the amount of additional milk compared with SS than it actually produced. This suggests that the energy content of BW loss in early lactation may be overvalued.

In the current experiment, as precalving dietary energy density increased from low (SS) to intermediate (S) to high (C), the responses averaged over the first 8 wk of lactation were: milk, 2.1 and 2.0 kg/cow per d; milk fat, 130 and 108 g/cow per d; and milk protein, 61 and 77 g/cow per d. These higher responses compared to those of Ryan (1999) may be due to a combination of the poorer BCS of the cows on this experiment (on average, 2.75 at calving compared to 2.87 in the experiment of Ryan (1999)) and the fact that all the cows in the present study were in their second lactation. In the experiment of Ryan (1999) the majority of cows were in their 3rd or greater lactation. In an experiment carried out by Butler et al. (2002), where cows had a BCS of 3.32 at calving, no significant effect on postcalving performance was observed as a result of concentrate supplementation in the final 4 wk of the dry period. Other studies (Nocek et al., 1986; Boisclair et al., 1986; Grum et al., 1996; Vandehaar et al., 1999; and Holcomb et al., 2001) also showed no effect of precalving diet on early lactation milk yield, milk composition, or milk constituent yield. Reasons for the ambiguity of the responses may be variations in cow parity, BCS at calving, quality of the basal diet, or the potential of the cows.

The unusually high response to precalving feeding in this situation may have been the result of cows enter-

Table 7. Effect of concentrate supplementation on BW and BCS changes in the first 4 and 8 wk postcalving.

	Wk	Concentrate supplementation		SED ²
		LC ¹	HC	
BW	1 to 4	-0.85 ^{a 3}	-0.40 ^b	0.210
	1 to 8	-0.35 ^a	0.15 ^b	0.133
BCS	1 to 4	0.01	-0.03	0.070
	1 to 8	-0.09	-0.03	0.089

¹LC = 4 kg/d concentrate + silage ad libitum; HC = 8 kg/d concentrate + silage ad libitum.

²SED = Standard Error of the Difference.

³Means within rows having different superscripts differ significantly ($P < 0.05$).

Table 8. Effect of concentrate supplementation postcalving on milk and constituent yield and milk composition in the first 8 wk postcalving.

	Concentrate supplementation		SED ²
	LC ¹	HC	
Milk yield, kg/cow per d	24.5 ^{a 3}	27.8 ^b	0.85
Milk fat, g/cow per d	971 ^a	1141 ^b	45.0
Milk, protein g/cow per d	733 ^a	872 ^b	24.3
Milk, lactose g/cow per d	1128 ^a	1285 ^b	39.7
Milk, fat g/kg	39.5	40.9	1.08
Milk, protein g/kg	30.0 ^a	31.4 ^b	0.43
Milk, lactose g/kg	46.1	46.1	0.26

¹LC = 4 kg/d concentrate + silage ad libitum; HC = 8 kg/d concentrate + silage ad libitum.

²SED = Standard Error of the Difference.

³Means within rows having different superscripts differ significantly ($P < 0.05$).

ing the trial in moderate to low BCS. Even at calving, cows on treatment C were well below the recommended 3.0 to 3.5 BCS (Buckley et al., 2001). Grainger et al. (1982) stated that cows in better condition after calving gave a greater response to extra pasture because of greater partitioning of energy towards milk production. Furthermore, Grainger et al. (1982) and Rogers et al. (1979) have shown a positive effect of body condition at calving on subsequent milk yield, but over a much wider range of condition scores than obtained in this study. Therefore, studies where precalving diets resulted in differences in BCS at calving would be expected to show effects on postcalving production. As the cows on C were in higher BCS (2.62, 2.76, and 2.87 for SS, S, and C, respectively at calving) they had more condition to mobilize than cows on the other treatments. A difference of 0.25 of a BCS resulted from feeding the highest and lowest energy density diets precalving. This difference was similar to that of Ryan (1999) who found a condition score difference of 0.27 between precalving treatments. This was, however, after a feeding period of 9 wk. The response to precalving supplementation in the first 8 wk of lactation of 1.1 kg of milk per kg of concentrate fed in the present study would be unusually high but again may have resulted from the cows being in low to moderate BCS in the dry period. These findings are somewhat different to those reported by Garnsworthy and Topps (1982) who stated that higher BCS at calving would lead to DMI depression in early lactation. Garnsworthy and Topps (1982) were however, comparing cows in different BCS categories of (low) 1.5 to 2, (medium) 2.5 to 3, and (high) 3.5 to 4 on a scale of 1 (being thin) to 4 (being obese). The 3 treatment means in the current study would all fall between the low and medium groups and therefore excess BCS was unlikely to have been detrimental to intake.

In the present study, precalving concentrate feeding had no significant effect on milk composition (i.e., S versus C) and this would agree with the findings of Ryan (1999) and Butler et al. (2002). Ryan (1999) found that the higher energy diet precalving increased protein yield in early lactation. The current study also found a significant increase in milk protein yield, resulting from the increased milk yield rather than an increase in milk protein concentration.

The differences between the precalving treatments in postcalving yields of milk and constituents were greatest in the weeks immediately after calving and decreased as lactation increased. This was probably as a result of differences in BCS at calving, the loss of BCS, and DMI, which were at their greatest in the first few wk postcalving.

Effect of Postcalving Diet

DMI. As expected, increasing daily concentrate allocation from 4 to 8 kg per cow postcalving significantly increased DMI. This would be in agreement with previous reports from most authors (Gordon, 1984; Flipot et al., 1988; Crosse and Murphy, 1990; and Butler et al., 2002). The substitution rate (kg DM of forage decrease per kg of DM increase in concentrate) decreased with time after calving. The substitution rate was 0.48 and 0.28 for the first 4 wk and the first 8 wk postcalving, respectively.

BW and BCS. The results of the current study agree with those of Broster and Leaver (1969), Nocek et al., (1986), and Butler et al. (2002), who reported that higher energy feeding postcalving significantly reduced BW loss in early lactation. Crosse and Gleeson (1986) however, found that there was no significant difference in BW or BW loss between cows receiving 5.5 kg/d and 8.2 kg/d in early lactation but they noted that animals on the higher level of concentrate feeding postcalving gained more BW and were significantly heavier at the end of lactation. Postcalving diet had no significant effect on BCS loss for the trial period in the present study. This would agree with Crosse and Gleeson (1986) who reported that cows receiving the higher levels of concentrate tended to have higher BCS, in line with increased BW but these differences were not significant at any stage. Butler et al. (2002) also found that there was no difference ($P > 0.05$) in BCS loss over the first 8 wk of lactation. The period of treatment may need to be longer in order to detect significant differences in BCS change.

Milk production. The response to concentrates in the first 8 wk of lactation was 0.95 kg of milk per kg of additional concentrate DM fed. This response concurs with that reported by Crosse and Gleeson (1986) who found that increasing concentrate usage from 5.5 to

8.2 kg/cow per d increased milk yield by 0.93 kg per additional kg of concentrate while the cows were indoors on silage. The response to concentrates postcalving differed with the dietary treatments precalving. The responses for SS, S, and C were 0.4 kg, 0.87 kg, and 1.24 kg of milk per kg of additional concentrate fed postcalving. The lowest response was on treatment SS and this probably indicates a poorer ability of animals on this high fiber treatment to adjust (rumen acclimatization) to the concentrate supplementation postcalving.

Milk fat yield was significantly higher during the first 8 wk postcalving for cows on HC compared to LC. This was not however, coupled with a significant increase in milk fat concentration. In contrast Gordon (1984) observed a higher milk fat concentration for cows on a high compared with a low level of concentrate feeding in early lactation. There was a significant increase in milk protein concentration and yield in the first 8 wk postpartum on HC compared with LC. This resulted from the increased energy intake as a result of increased DMI. Other authors have also reported similar findings (Gordon, 1984; Crosse and Murphy, 1990; and Butler et al., 2002). Milk lactose concentration is difficult to alter nutritionally, and was not affected by increasing concentrates in the postcalving period.

CONCLUSION

The results of this study show that there is a benefit in terms of improved BW and BCS at calving and improved production in the early postcalving period to increasing the energy density of the diet in the last 4 wk of the dry period. The response was apparently achieved from a combination of increased tissue loss and DMI postcalving for those cows on the higher energy density diet precalving. Cows on a high fiber diet in the final 4 wk precalving may have difficulty in adjusting to a high concentrate diet immediately postcalving and forage intake may be low. Increasing the energy density of the diet postcalving by increasing concentrate supplementation improved production as anticipated. On grass-silage based diets there did not appear to be a strong correlation between DMI in the pre and early postcalving periods.

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