A Fresh Look at Feeding the Transition Cow When Using High Forage Diets

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■ Take home messages

- Cows on high forage diets may be in negative energy balance for several weeks before calving but they suffer a smaller decline in pre-calving dry matter intake than cows on diets including concentrates.
- If cows are in poor condition score (< 3.0 on a 5 point scale) approaching calving, some supplementary feeding in the close-up dry period is likely to benefit them in terms of milk production because the cow has increased energy reserves to use for milk production.
- If forage quality in the dry period is moderate or poor, some supplementary feeding in the close-up dry period is like to benefit cows in terms of milk production.
- There is no evidence that feeding large quantities of a bulky forage like straw in the close-up dry period has any subsequent positive effect on intake or milk production.
- There is no evidence that feeding maize silage (which has a higher intake potential than grass silage) in the close-up dry period increases intake in the following lactation.
- Higher energy density diets in the close-up dry period will increase body condition score (BCS) at calving, but cows subsequently loose more BCS in early lactation. Nevertheless BCS at time of breeding can be increased.
- There was no interaction between pre and post-calving dietary energy densities.
- In the circumstances discussed in this paper, there was no effect of close-up dry period feeding on calf birth weight or calving difficulty.

Background

The transition period describes the change from a non-lactating cow to a lactating cow after parturition. As such, it is usually considered to extend from about 3 weeks before calving to about 3 weeks post-calving (Grummer, 1995). For this paper, the effects of dietary energy density in the pre-calving period (often called the close-up dry period or prefresh transition period) on subsequent performance in early lactation will be considered. The only aspect of post-calving nutrition that will be considered is to examine if there is an interaction between pre-calving diet and post-calving diet. Protein or mineral nutrition in the transition period will not be considered in this paper.

The feeding of cows in the transition period has received much attention in recent years (e.g., Broster, 1971; Grummer, 1995; Shaver, 1997). This is a period of dramatic changes in the endocrine and metabolic status of the cow. Grummer (1996) outlined the changes in plasma fatty acids, glucose and ketone concentrations. It has been reported that dry matter intake (DMI) declines as parturition approaches, with a gradual decline starting 3 weeks prepartum, and a rapid decrease in the final week prepartum. Hayirli et al. (2002) in a review of 699 dairy cow diets concluded that DMI declined by 0.32 in the last 3 weeks before calving, with 0.89 of this occurring in the last week before calving. This is at a time when energy requirements for fetal growth and mammary development are increasing (NRC, 2001). Thus cows can easily go into negative energy balance (NEB) in the last few weeks before calving unless the energy density of the diet is increased. On farms in Europe and North America, it has become quite common to feed concentrates in the close-up dry period, although in high forage systems as practised in Ireland, it is still relatively uncommon (Kennedy et al., 2002). There are two somewhat separate but related rationales for feeding concentrates in the close-up dry period.

- Reduce or eliminate the negative energy balance pre- calving

  If pre-calving NEB leads to sub-optimal body condition score (BCS) at calving, it can have negative effects. There is substantial evidence that cows in good (3.0 to 3.5 on a 5 point scale) BCS at calving have higher milk yield post-calving than cows in poor BCS (e.g. Grainger et al., 1982; Bertics et al., 1992). They may also have a better BCS by the time of breeding, which may have a positive impact on fertility. A NEB pre-calving is a contributory factor to fat mobilization. If this is excessive, fatty acids which spill into the blood can cause fatty liver. However, having cows overfat at calving has been shown to be counter-productive, with reduced intake, increased fat mobilisation and no benefit in milk production (Garnsworthy and Topps, 1982). Nevertheless, the hypothesis is that increasing the energy density of the pre-calving diet by introducing concentrates will increase milk production, may reduce metabolic disorders and may improve fertility if it results in having cows with an optimum BCS at calving.

- Acclimatize the cow to concentrates pre-calving

  The purpose of this is that the cow will be better able to cope with and utilize a high concentrate diet post-calving. There is evidence (Dirksen et al., 1985) that when cows are put on a low energy density diet in the dry period, the cross sectional area of ruminal papillae decreases. This could reduce the absorption of volatile fatty acids, the end-products of ruminal fermentation. Furthermore, Dirksen et al. (1985) showed that introducing a high energy diet 2 weeks before calving could increase the cross-sectional area of the ruminal papillae. Thus the hypothesis is that cows adapted to concentrates pre-calving will be better able to cope with a high concentrate post-calving diet.

There are thus a number of potential benefits of feeding concentrates in the close-up dry period, which can be listed as follows.

- Increased milk production in early lactation,
- Improved ability to cope with high concentrate post-calving diets, leading to better cow health – reduced acidosis, ketosis, displaced abomasums,
- Improved fertility due to better BCS at breeding,
- Better calf health and performance.

These potential benefits have stimulated recent research in the area. Much of the research in this area has been concerned with high concentrate, low forage production systems. This paper reviews the energy nutrition of transition cows in high forage feeding systems. A number of experiments carried out in Ireland over the last few years are outlined, and their results are discussed in the context of other research in high forage systems, and the research that has been conducted in high concentrate systems.

Conventional Transition Period Feeding System in Ireland

In discussing transition feeding experiments, it is important to set them in the context of the overall production system. Kennedy et al. (2002) have recently described a number of seasonal (spring calving) milk production systems in Ireland based primarily on grass (grazed or conserved). The systems used low (376 kg), medium (810 kg) or high (1550 kg) amounts of concentrate per annum, and each concentrate amount was fed to medium or high genetic merit cows. The medium concentrate level is typical of commercial practise in

Ireland. In this treatment, concentrate feeding levels were 0 kg/d before calving (good quality grass silage only) with 7.5 kg/d fed immediately after calving. Turn-out to grass was in early March, and concentrate level was gradually reduced to 3 kg/d by 1 May and remained at this level until late June. No concentrates were fed from then until early October, when cows were again fed 2 kd/d until the end of lactation. The systems were run for 3 years and had 100% primiparous cows in year 1, with replacements rates of c. 20% in each of the 3 following lactations. Milk production curves are shown in Figure 1. Over 3 years, the medium merit cows yielded on average 6681 kg milk in a 45 week lactation, when fed the medium level of concentrates (7739 kg milk for the high merit cows). When fed the high amount of concentrates, the medium merit cows yielded 7196 kg milk/year (8461 kg milk for the high merit cows). These systems describe the backdrop against which the investigations of transition cow feeding discussed here were carried out.

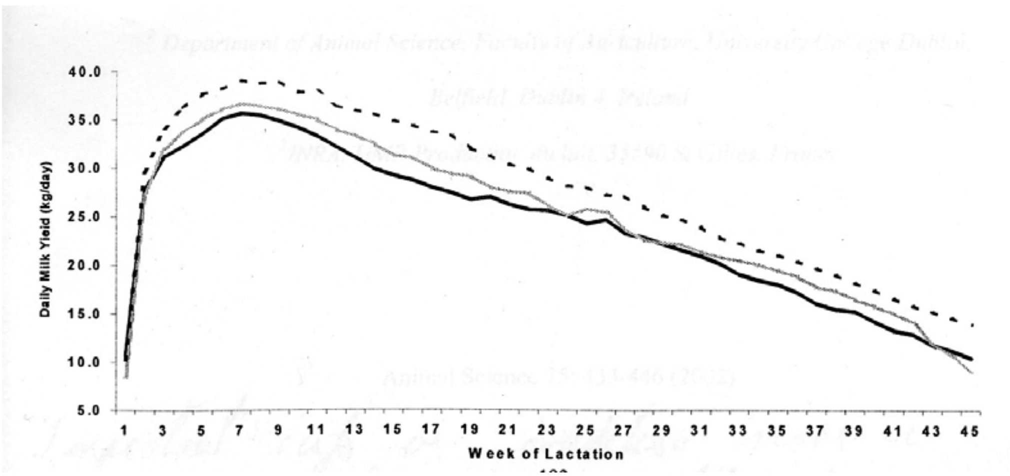


Figure 1. Lactation curves for spring calving dairy cows fed low (━), medium (▒▒▒) or high (- - -) levels of concentrates (Kennedy et al., 2002)

■ Description of Recent Irish Experiments

In experiment 1, Ryan et al. (2003) assigned 56 cows to one of two treatments for 9 weeks pre-calving: grass silage ad libitum, with 3 kg/d concentrates for the last 5 weeks pre-calving, or a grass silage/straw mixture (75:25 on a DM basis) for the full 9 weeks pre-calving. After calving, all cows were fed grass silage ad libitum plus 8 kg/d of concentrates. The silage used was reasonably well preserved and highly digestible (Table 1). Cows were group fed, but individual intakes were measured over 6 days at on average 21 days before calving and again over 6 days at on average 30 days post-calving using the n-alkane technique.

In experiment 2, Butler et al. (2002) used 60 cows in a 2 x 2 factorially designed experiment with two pre-calving treatments, followed by two post-calving treatments. The pre-calving treatments (imposed for an average of 30 days) were grass silage ad libitum or grass silage:concentrates in a 0.7:0.3 mixture (DM basis). The post-calving treatments were grass silage:concentrates in a 0.65:0.35 mixture or a 0.45:0.55 mixture (apart from week 1 post-calving when a 0.65:0.35 mixture was fed). The cows were group fed, but individual DM intake was measured over 6 days prior to calving on 28 cows (at on average 16 days before calving) and on 40 cows post-calving (at on average 23 days after calving) using the n-alkane technique. The silage used was well preserved and very digestible (Table 1).

In experiment 3, McNamara et al. (2003a and b) used 60 cows in a 3 x 2 factorially designed experiment with three pre-calving treatments, followed by two post-calving treatments. The pre-calving treatments (imposed for an average of 34 days) were grass silage/straw (0.75:0.25 on a DM basis), grass silage alone or grass silage plus 3 kg/d of concentrates. All forages were fed ad libitum. The post-calving treatments were ad libitum access to grass silage plus 4 or 8 kg/d of concentrates. Intake was measured individually throughout the experiment. The silage fed pre-calving was moderately preserved, and of moderate digestibility, whereas the silage fed post-calving was well preserved and of very high digestibility (Table 1).

Table 1. Feed analysis in the experiments of Ryan et al. (2003), Butler et al. (2002), McNamara et al. (2003) and Murphy et al. (2001)

	DM (g/kg)	pH	Ash (g/kg DM)	CP (g/kg DM)	NH_3-N (g/kg TN)	DMD (g/kg)
Ryan et al. (2003)						
Grass silage	204	4.1	87	147	150	731
Straw	851		53	44		597
Butler et al. (2002)						
Grass silage	207	4.2	93	179	137	773
McNamara et al. (2003)						
Grass silage pre-calving	181	4.3	81	154	107	711
Grass silage post-calving	183	3.9	82	168	51	762
Straw	845		43	48		484
Murphy et al. (2001)						
Grass silage	194	3.8	77	147		726
Maize silage	288	3.9	49	88		716

In experiment 4, Murphy et al. (2001) used 40 cows in a 2 x 2 factorially designed experiment with two pre-calving treatments, followed by two post-calving treatments. The pre-calving treatments (imposed for an average of 32 days) were grass silage or grass silage/maize silage (50:50 mixture on a DM basis). The post-calving treatments were pasture or pasture/maize silage (2 – 3 kg DM /d). Turnout to pasture was on March 8 by day and March 14 by day and night. (Cows calved before turnout date were fed grass silage instead of pasture until turnout, i.e. allocated to grass silage or grass silage/maize silage mixture as appropriate). Both post-calving groups were initially fed 7 kg/d of concentrates, reducing to 5 kg on March 16, to 3 kg on April 19, and to 1 kg on May 5, where it remained until the end of the experiment on June 4. The grass silage fed pre-calving was well preserved, and of moderate digestibility, and the maize silage was of reasonable quality with a starch content of 270 g/kg DM (Table 1). Intake was not measured.

▪ Discussion

Effect of Dietary Energy Density Pre-Calving On Pre-Calving Intake, Energy Balance and Body Condition Score Change

Increasing the energy density of the pre-calving diet increased pre-calving dry matter intake (Figure 2) significantly in one experiment (McNamara et al., 2003a) with no significant impact in the other two experiments (Butler et al., 2002; Ryan et al., 2003). Net energy (NE) intake was not reported in the latter two experiments, but if it is calculated, there was always an increase in NE intake as the energy density of the diet increased (Figure 3). It should be noted that in experiments 1 and 2, DM intake was only measured for a six day period which averaged day 21 before calving in the experiment of Ryan et al. (2003) and day 16 before calving in the experiment of Butler et al. (2002). Thus it is possible that there were differences in DM intake in the critical last week before calving that were not detected.

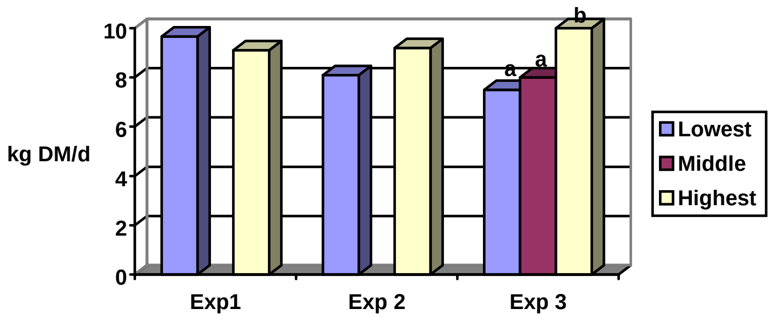
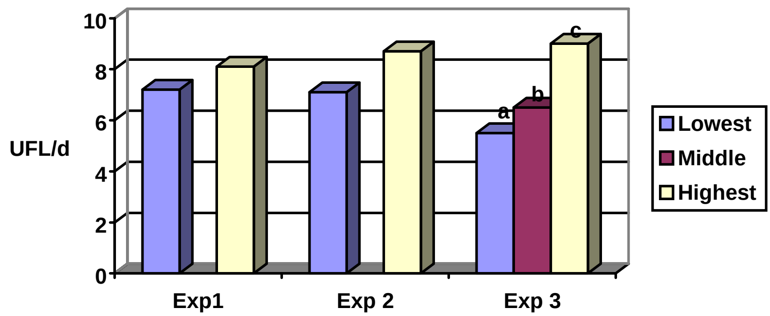


Figure 2. Effect of pre-calving dietary energy density within experiment on dry matter intake pre-calving. Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets).



UFL: the net energy for maintenance/lactation of 1 kg of barley (air dry)

Figure 3. Effect of pre-calving dietary energy density within experiment on energy intake pre-calving. Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets).

McNamara et al. (2003a) did measure daily intakes before calving (Figure 4). NRC (2001) have developed an equation based on data of Hayirli et al. to predict pre-calving DMI (based on 527 cows):

$$\text{DMI (\% of BW)} = 1.97 - 0.75e^{0.16t}$$

where t is days pregnant – 280. In agreement with that equation, McNamara et al. (2003a) reported little decline in intake until the very last week before calving. The decline in intake in the last week was somewhat lower than expected according to the NRC (2001) equation, and was very small for cows on the silage only or silage/straw diet. Other authors have also reported little pre-calving decline in DMI on high forage diets (Coppock et al., 1972; Vazquez-anon et al., 1994; Roche et al., 2001). The US data on which the NRC (2001) and Hayirli et al. (2002) reviews are based are largely from high concentrate feeding systems. Thus the conclusion is that there is a difference in the degree of pre-calving DMI decline between high forage and high concentrate feeding systems.

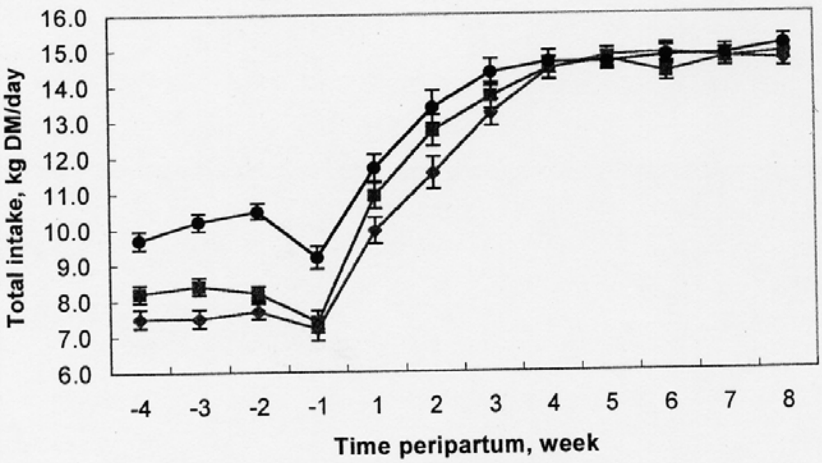


Figure 2.1. (b)

Figure 4. Dry matter intake pre and post calving for cows fed silage/straw (♦), silage only (■) or silage/concentrates (●) pre-calving (McNamara et al., 2003a)

In the experiment of McNamara et al. (2003b) there was a drop in energy balance in the last two weeks before calving because of the rise in energy requirements (Figure 5). It is also interesting to note that the cows fed the standard (silage only) and low energy density diets were in NEB even from 4 weeks before calving. A higher proportion of concentrates in the pre-calving diet may have been necessary to eliminate the NEB before calving. For instance, Vandehaar et al. (1999) fed a diet with 0.512 concentrate pre-calving compared to 0.26 in the study of McNamara et al. (2003b).

Body condition score change is a crude indicator of energy balance. Figure 6 shows the BCS change over 4-5 weeks pre-calving in experiments 1, 2 and 3. It is clear that increasing the energy density of the diet pre-calving resulted in a higher BCS at calving in experiments 1 and 3. This was not the case in experiment 2, which does not coincide with the NE intake data. However, the NE intake data is based on 6 days of intake measurement at 16 days pre-calving on average, and does not include the final week pre-calving when, as discussed above, concentrate supplemented diets suffer a larger drop in DMI than silage only diets. In any case, there were no differences in BCS at calving in this experiment and they were above 3.25 for both treatments. In fact, cows gained BCS before calving on both treatments. The silage quality was excellent in this experiment The conclusion is that where the silage quality is very good, there is less to be gained from feeding concentrates in terms of BCS and energy balance in the pre-calving period than when the silage quality is poorer (i.e. 72-73% DMD or less).

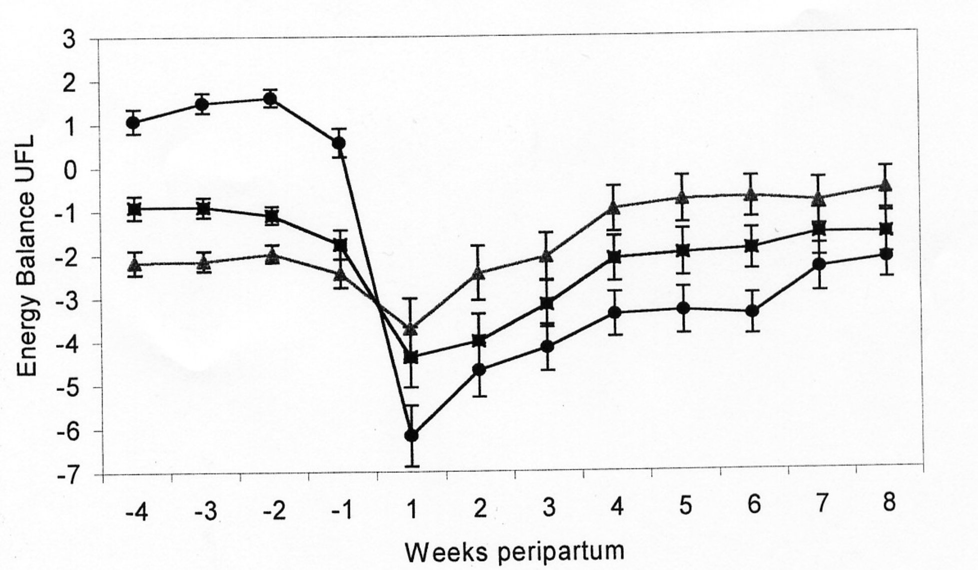


Figure 5. Energy balance (UFL/d) pre and post calving for cows fed silage/straw (♦), silage only (■) or silage/concentrates (●) pre-calving (McNamara et al., 2003b)

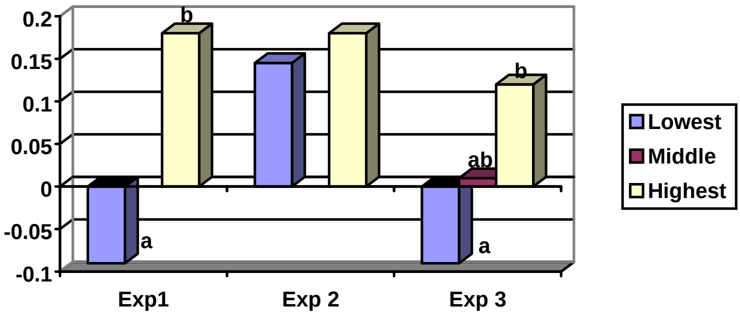


Figure 6. Effect of pre-calving dietary energy density within experiment on body condition score change pre-calving. Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets)

Effect of Pre-Calving Diet on Post-Calving Intake, Milk Production and Energy Balance

Pre-calving dietary energy density had little effect on post calving DMI (Figure 7). It should be noted that DM intake was only measured for six day periods which averaged day 30 post-calving in the experiment of Ryan et al. (2003) and day 23 post-calving in the experiment of Butler et al. (2002). DMI was continuously measured by McNamara et al. (2003a) and is shown in Figure 4. Initially after calving, there were differences between treatments in DMI, which mirrored the differences in pre-calving DMI, but these differences had disappeared by week 4 of lactation.

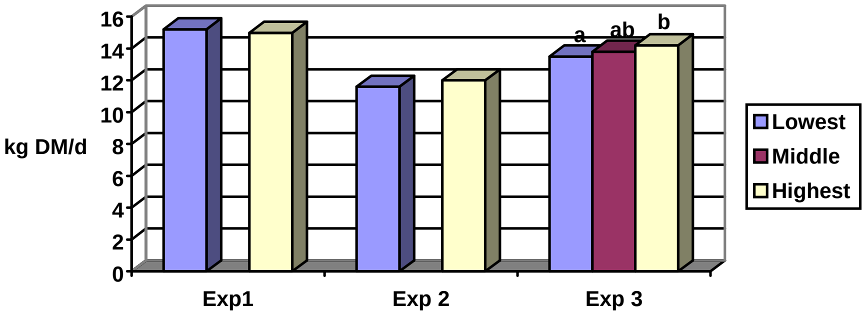


Figure 7. Effect of pre-calving diet on post-calving dry matter intake. Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets).

There was always a trend that increasing the energy density of the pre-calving diet increased subsequent milk production in early lactation (Figure 8), but this only reached significance in the experiment of McNamara et al. (2003a). It was significantly higher for the high energy density pre-calving diet in weeks 1 – 4 in the experiment of Ryan et al. (2003), but this had disappeared by week 8, and so over the first 8 weeks of lactation, the difference was not significant. In the experiment of Butler et al. (2002) there was no significant effect (P = 0.387) for weeks 1-4. This could be related to the effect of pre-calving treatments on BCS at calving: there was no effect in this experiment and both treatments had mean BCS above 3.25; in the other experiments, the high energy density diets gave the highest BCS at calving, but it was 3.0 (Ryan et al., 2003) or 2.87 (McNamara et al., 2003a). As discussed above, it has previously been demonstrated that cows in sub-optimal BCS at calving will suffer in terms of milk yield. The conclusion is therefore that if feeding a higher energy density diet pre-calving alleviates a low BCS at calving, there is likely to be an advantage in subsequent milk production, but otherwise no gain in milk production is likely in a high forage feeding system. This agrees with some previous reports where feeding concentrates pre-calving had little or no effect on milk production (e.g. Emery et al., 1969; Nocek et al., 1986; Vandehaar et al., 1999).

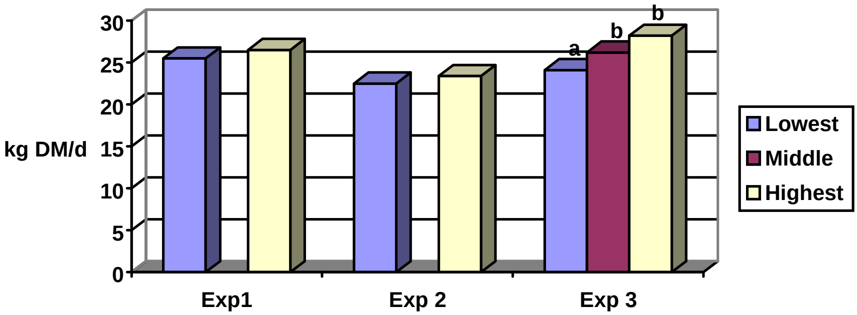


Figure 8. Effect of pre-calving diet on milk yield (weeks 1-8). Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets).

McNamara et al. (2003b) reported energy balance post-calving (Figure 5). The order of NEB pre-calving (silage/straw > silage > silage/concentrates) completely reversed itself post-calving. The effect of pre-calving diet on BCS change post calving (weeks 1-8) is shown in Figure 9. In all cases, cows lost BCS, but the loss was much greater in Experiment 2 than the other 2 experiments. This coincided with the higher BCS at calving of cows on this experiment than on the others. Within experiment, dietary energy density pre-calving had no effect on BCS loss post-calving except in experiment 3, where the higher the energy density pre-calving (and the higher the BCS at calving), the higher the BCS loss post-calving. Thus the conclusion is that if increasing the energy density of the pre-calving diet alleviates a low BCS at calving by improving energy balance pre-calving, the extra body energy reserves are available for milk production in the subsequent lactation.

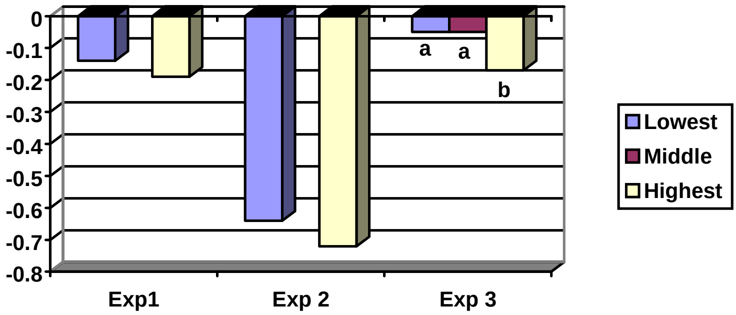


Figure 9. Effect of pre-calving dietary energy density within experiment on body condition score change post-calving (weeks 1 to 8). Energy densities are described as lowest or highest within an experiment (and also middle energy density in exp. 3 where there were 3 pre-calving diets)

■ Effect of Pre-Calving Diet on Fertility, Cow Health and Calf Health

The implication of the discussion above on energy balance and BCS loss in early lactation is that pre-calving concentrate feeding to increase BCS at calving does not appear to be effective at reducing NEB in early lactation. Nevertheless, BCS tended to remain higher at 8 weeks post-calving for cows with higher BCS at calving. No differences of note were found in the overall reproductive performance of cows fed different pre-calving diets but this was not surprising given the small numbers of animals used.

One of the dangers of a high forage diet pre-calving is a large NEB pre-calving which results in significant fat mobilization and the possibility of fat accumulation in the liver. Plasma glucose and NEFA were measured in cows at calving in experiment 1, 2 and 3, and approximately 4 weeks pre-calving (just after treatments were applied) in experiments 1 and 2. B-HB (beta-hydroxybutyrate) was also measured in experiments 2 and 3. On none of these occasions were there significant differences in any of these parameters.

In these studies, no significant effect of pre-calving treatment on calf birth weight or calving difficulty was measured, and there were no incidences of clinical ketosis or displaced abomasums.

Effect of Replacing Grass Silage with Maize Silage in the Pre-Calving Diet

Maize silage generally supports higher DM intakes than grass silage. Feeding it to cows pre-calving thus represents an alternative strategy to increase DM and energy intake in pre-calving cows rather than feeding concentrates. However, including maize silage in the diet did not result in any increase in BCS at calving or subsequent milk production in experiment 4. Intakes were not measured, but one would have expected an increase due to maize silage feeding, and a subsequent increase in BCS at calving. It would be interesting to examine the effect of maize silage inclusion in dry cows diets where BCS is lower.

Interaction of Pre and Post-Calving Diets

In experiments 2 and 3, factorial designs were used with 2 different post-calving concentrate levels. In neither case was there any strong evidence of a significant interaction between pre and post-calving treatment. Kokkonem et al. (in press) have also recently reported no interaction between pre-calving forage:concentrate ratio and post-calving rate of concentrate increase (slow or fast). If a benefit was to be found to acclimatising the rumen to concentrates prior to calving, one would expect to find it more easily on the high concentrate diets and an interaction would not have been surprising. The absence of such an interaction suggests that the rumens of cows on high forage diets pre-calving were capable of dealing with the concentrate levels fed in the post-calving diets in these experiments (up to 0.55 of DM in experiment 2).

Including Straw in the Pre-Calving Diet

In the two experiments (1 and 3) where a substantial portion of the silage was replaced with straw, BCS at calving and subsequent milk production were reduced. The silages used were of moderate digestibility (731 and 711 g/kg DMD), and the data indicate that including large amounts of straw with this quality of silage is actually detrimental. If the silage quality was excellent as in experiment 2 (762 g/kg DMD) and cows were in good BCS, it is possible that there would be a lesser penalty in terms of milk production loss from including the straw. A lesser amount of straw may not have had the same detrimental effects.

■ Conclusions

In high forage feeding systems, increasing the energy density of the pre-calving diet improves subsequent milk production if it alleviates a low BCS at calving. Thus situations where it is likely to be beneficial are when cows are in low BCS at calving, or are fed a less than excellent quality silage in the dry period. It is difficult to totally eliminate the NEB pre-calving, but this appears not to be of huge significance once the BCS at calving is not sub-optimal. Feeding concentrates pre-calving appears to have little impact on cow health in a high forage situation, but in the conditions of the experiments reviewed here, there were no challenging problems with cow health. Additionally, there was no evidence that pre-calving feeding of concentrates helped to acclimatise the rumen to high concentrate diets post-calving, although the high concentrate diets may not have been sufficiently challenging for the effect to be demonstrated. These conclusions are somewhat at variance with the recommendations resulting from research in high concentrate production systems. The differences in the levels of concentrates could account for the differences in the conclusions drawn from the research.

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