TRANSITION COW NUTRITION: PRIMING YOUR HERD TO PERFORM

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Summary

- Managing the grazing transition cow should be a simple affair. Do not complicate it unnecessarily.
- Cows should be at a body condition score of 5.0 one month precalving.
- Cows require 20% of their empty liveweight (liveweight without foetus) as metabolisable energy each day during the month precalving. For example, a 500 kg Holstein-Friesian requires 100 MJ ME/day.
- Cows fed more than they require precalving will not have greater production.
- Cows fed less than they require during the month precalving will mobilise condition, produce slightly less milk (approximately 4 kg MS) and cycle later (4 days per half body condition score unit difference at calving) than cows fed to requirements.
- Restricting cows after calving resulted in a significant decrease in milk production (approximately 100g MS/cow/day for every 1.0 kg pasture DM restriction or approximately 8g MS/MJ ME). There was also a significant depression in milk production (approximately 40g MS/cow/day) for the ten weeks following the feed restriction.
- In total, cows restricted (60 MJ ME/cow/day) for 35 days postcalving produced approximately 30 kg MS less than cows that were fed to appetite. This is equivalent to 14 g MS/MJ ME.
- Reducing the dietary cation-anion difference precalving is of little practical benefit in pasture-based systems.
- Supplement cows with magnesium precalving and magnesium and calcium postcalving.
- Starter drenches offer little benefit and in will not improve milk production in otherwise healthy cows.

Introduction

Traditionally, the non-lactating cow has been managed by neglect (Van Saun, 1991). Recently the dry period has risen in importance in the period of a cow's life and is no longer just considered a resting time between lactations. This change in focus has arisen from the suggestion that marginal quality feeds and deficient dry cow care are responsible for lower milk production, an increased incidence of periparturient health disorders and lower reproductive performance.

This "*transition period*", as it is called, is often defined as the interval beginning three weeks precalving and ending three weeks postcalving (Grummer, 1995). It is a period where the dairy cow must alter her metabolic priorities for available nutrients from foetal growth and net tissue deposition (mid-gestation) to milk production and the mobilisation of tissue reserves (early lactation). If the dairy cow cannot adapt quickly to these challenges, the substantial cost of calf growth during late pregnancy and milk synthesis during early lactation places the transition dairy cow in a state of severe negative energy balance (**NEBAL**) where energy output exceeds energy intake (Grummer, 1995).

A severe NEBAL during this time can predispose cows to metabolic disorders. Milk fever, ketosis, retained fetal membranes, metritis, displaced abomasa and increased susceptibility to mastitis primarily impact cows during this transition period. In addition, the duration and severity of NEBAL can negatively impact reproduction with a significant association between extent of NEBAL (amount of body condition lost) and decreased fertility (Buckley et al., 2003).

In recent years much research has been undertaken to examine this important time in the cow's life. However most of this research has been done in indoor-fed dairying systems where the dietary ingredients are very different to those fed to non-lactating cows in pasture-based systems. Many of these findings are being introduced liberally into pasture-based dairying systems around the globe, with little thought for the applicability of this advice. This paper addresses some of these nutritional concerns.

Dry matter intake and the energy requirements of the transition cow

Key Messages

- Cows require 20% of their non-pregnant liveweight (**LW**) in metabolisable energy (**ME**) daily during the last month precalving.
- There is no milk production benefit to providing more energy than is required precalving, and there is very little increase in body condition score (**BCS**).
- Feeding cows less than requirement precalving will
  - slightly reduce milk production during the first five weeks of lactation, however the difference is small (approximately 4.0 kg milksolids; **MS**)
  - delay ovulation as a result of reduced body condition score at calving by 4 days per half BCS unit.
- Postcalving feed restriction during the five weeks following calving significantly reduces milk production during the period of restriction (0.5 kg MS/day), and these cows continue to produce less milk for approximately 10 weeks after the period of restriction (0.2 kg MS/day).

Even though the energy requirements for pregnancy are minor compared with lactation, inadequate dry cow nutrition will result in a substantial drain of maternal nutrient reserves to sustain the developing foetus and to meet the increasing energy demand of the mammary gland (Bell, 1995; Roche et al., 2005). Nevertheless, the importance of dry matter intake (**DMI**) in the weeks preceding calving on subsequent milk production is unclear. Two issues of importance are generally raised regarding DMI during the transition period:

1. how much energy does a cow require?
2. what is the effect of offering cows less or more than this requirement?

How much energy does a cow require?

Recent research at Dexcel established the energy requirement of grazing transition cows in the weeks preceding calving to be approximately 20% of a dairy cow's empty liveweight (**LW** without the calf - Roche et al., 2005). This is slightly higher than previous recommendations. Therefore a 450 kg crossbred requires 90 MJ ME/day, a 500 kg Holstein-Friesian requires 100 MJ ME/day and a large 550 kg Holstein-Friesian requires 110 MJ ME/day.

Table 1: Examples of dry matter intake requirements[a] (kg/cow/day) of cows during the last 3 weeks before calving to prevent them losing BCS

		Friesian x Jersey (450 kg)		**Holstein-Friesian (500kg)**		**Holstein-Friesian (550kg)**	
Energy requirements		**90 MJ ME**		**100 MJ ME**		**110 MJ ME**	
				Example			
Feed	Energy (MJME/kg DM)	1	2	1	2	1	2
Pasture	11.0			2.0		2.0	
Good Silage	10.5			4.0	2.0		2.0
Poor Silage	8.5	3.0				4.0	
Cereal Silage	10.0	3.0	2.0			4.0	
Straw	6.5		3.0		4.0	2.0	4.0
Choumoillier[b] (Kale)	12.0	3.0	4.5	3.0	4.5		4.5
Total Intake (kg DM/cow/ day)		9.0	9.5	9.0	10.5	12.0	10.5

*__Note:__ a) these are 'down the cow's throat' requirements

b) supplementation with straw is advisable when kale is being fed

There are many different feed mixtures that would provide the energy requirements of cows during the last month before calving. Table 1 shows some examples of combinations of feed required to meet the MJ ME requirements for three different weight cows. For example, winter saved pasture is 11 MJ ME and good quality pasture silage is 10.5 MJ ME. A herd of Holstein-Friesian cows (500 kg liveweight) require 100 MJ/cow/day. If only 2 kg of pasture DM/cow/day (22 MJ ME) and 4 kg of pasture silage DM/cow/day (42 MJ ME) is eaten, 38 MJ/day is required from supplements to prevent BCS loss precalving. This is equivalent to 3 kg of kale.

What is the effect of offering a cow less or more energy than required?

Knowledge of these requirements allows us to offer a cow sufficient feed so as not to cause BCS mobilisation before calving. However, the effect of a precalving energy restriction, or alternatively feeding cows energy surplus to their requirements on subsequent milk production and fertility has been unclear.

An increased level of feeding precalving and an associated increase in body condition score at calving has generally been believed to increase milk yield after calving (Overton and Waldron, 2004). However, Roche et al. (2005) reported only a small difference in milk production (4 kg MS) immediately postcalving between grazing cows consuming 54% of their energy requirements for the month prior to calving (5.4 kg DM pasture/cow/day) and those eating 110% (11.0 kg pasture DM/cow/day). Recent research (J.R. Roche, unpublished) confirmed this small effect of precalving DMI and found that this small effect was even dependent on level of feeding postcalving. If cows were well fed postcalving, a severe precalving restriction reduced MS production by 7 kg. If cows were restricted postcalving, either because of insufficient feed or poor quality feed precalving feeding did not affect milksolids production. Restricting cows precalving did delay the interval to first ovulation, probably because of reduced BCS at calving (4 days for each 0.5 BCS unit at calving).

In comparison, a similar feed restriction postcalving (4.9 kg pasture DM during the five weeks following calving; J.R. Roche, unpublished) reduced milk production by more than 30 kg MS, showing that level of feeding in the weeks following calving is more important than DMI before calving. Therefore in a farm system limited by feed resources, priority for feed should be given first to the colostrum and milking cows.

Is the type of energy offered precalving important?

Key Messages

- Energy supplements precalving are unlikely to improve health or production if the animal is otherwise well managed.
- Precalving decline in dry matter intake is greater in cows offered concentrate supplements precalving.
- Rumen microorganisms require an adaptation period to high starch or sugar feeds. Therefore if feeding immediately postcalving, precalving adaptation is required.
- Energy supplements will not improve the development of rumen absorptive capacity (papillae development) beyond that achieved when feeding high quality forages.

Commonly used justifications for the inclusion of supplements in the diet of the dry cow include:

- if a cow is to fully utilise the supplements she receives during lactation, her digestive system needs to become accustomed to the 'lactating diet' during the dry period
- DMI declines in the weeks preceding calving, necessitating the provision of a more energy dense diet to ensure energy intakes are maintained.

Adapting the cow's digestive system

Although it is understandably important to adapt a cow's rumen micro-flora ('the bugs') to an increased allowance of starch or sugar-based feeds, why a cow's digestive system must become accustomed to the lactating ration precalving is less clear. This belief is based on the research of Dirksen et al. (1997), who showed greater ruminal papillae development in cows supplemented with concentrate feeds compared with those fed forage (straw).

The ruminal mucosa (papillae) do play a vital role in pH regulation, primarily through the absorption of volatile fatty acids. However, it has been shown that the growth and structure of these papillae are induced and maintained by chemical stimuli, namely volatile fatty acids produced during digestion/fermentation in the rumen (Dirksen et al., 1997). High quality forage diets generally produce higher concentrations of acetate, lower concentrations of propionate and similar concentrations of butyrate, compared with a diet high in concentrates. It has been shown that butyrate has the greatest effect of these acids on papillae development (Sakata and Tamate, 1978; 1979). This implies that a high quality forage diet precalving will prepare the rumen equally well for lactation as one which contains concentrates.

Avoiding the precalving decline in DMI

Similarly, there are inconsistent reports on the extent to which DMI declines in the weeks preceding calving, and therefore in the necessity to offer a more energy dense diet to compensate for this. Maintaining DMI during the last two weeks of gestation has proven difficult to achieve under TMR-feeding regimens (Bertics et al., 1992; Grummer, 1995). However, until recently little information was available on the precalving decline in DMI when dairy cows are fed a diet of fresh and conserved pasture.

Data from two independent experiments (Roche et al., 2003a; 2003b) where cows were fed pasture and pasture hay precalving, were used to study the decline in DMI in the 14 days prior to calving. No depression in DMI was recorded excluding the final 2 days precalving.

Starter drenches - are they worth the money?

Key Messages

- Starter drenches aim to provide cows with a rapidly available energy supplement, by-pass fat and some minerals. They are a very expensive source of energy.
- Monopropylene glycol or bypass fat do not improve milk production, BCS change or reproduction in otherwise healthy animals.
- Starter drenches should only be used in high-risk animals such as old cows (greater than 8 years) or very fat cows (greater than BCS 7.0).

The use of starter drenches during the colostrum period has been recommended as a means to prevent metabolic disorders and improve production. Mineral nutrition during this period will be discussed in the next section. However, research here in New Zealand and in the U.S. in recent years has shown little or no benefit to supplementing cows with either monopropylene glycol or bypass fat during early lactation, and particularly not in grazing cows. These results were found across a range of milk yields from 1.5 to 3.0 kg MS/day.

Individual cows could be supplemented with a starter drench postcalving, if they were identified to be a high risk for metabolic disorders (e.g. milk fever, ketosis). Such cows would include very old (>8 years) and very fat (> BCS 7) cows.

Mineral nutrition and altering the dietary cation-anion difference during the transition period

Key Messages

- Cows require 35 g elemental magnesium each day in the month precalving.
- Magnesium sulphate offers greater protection than either magnesium chloride or magnesium oxide. However magnesium sulphate is difficult to feed.
- Add 60 g Magnesium sulphate per cow/day to the water trough and dust the pasture or silage with 60-80 g magnesium oxide.
- Supplement cows with 150g ground limestone each day during the colostrum period. If dusting with limeflour, double the recommended rate (300g/cow/day) to account for potential losses.
- Reducing dietary cation-anion difference (**DCAD**) below 0 mEq/100g increases calcium absorption and reduces the risk of milk fever.
- Small reductions in DCAD do not prevent milk fever.
- Manipulation of DCAD precalving is difficult with high potassium forages.

A close relationship exists between the mineral content of the soil, the mineral content of plants and the health of animals (Hungerford, 1990), although anomalies occur due to differences in mineral requirements between animals and plants. Mineral supplementation of grazing dairy cows during the transition period is primarily aimed at preventing metabolic disorders, in particular milk fever (hypocalcaemia). A range of strategies exist to accomplish this goal with varying degrees of success. Focus is generally on the dietary concentration of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chlorine (Cl) and sulphur (S). Interest in the latter four minerals has generally been in relation to their effect on the acidity or alkalinity (pH) of body fluids, although recent research suggests that they may have effects on calcium homeostasis beyond altering blood pH.

Calcium

A surplus of dietary calcium during the precalving period has traditionally been believed to suppress the natural mechanisms controlling calcium absorption. Braithwaite (1974) reported that absorption of calcium was actively regulated and that this regulation was dependent on dietary calcium concentration. For example, if a cow required 10g Ca/day and consumed 40g Ca/day, she would absorb 25% of Ca intake. In comparison, if she consumed 100g/day, only absorb 10% would be absorbed. At calving, the demand for calcium increases rapidly. Assume the 2 cows above produce 12kg colostrum each in their first day, they require approximately 35g Ca (25g Ca in colostrum + 10g for maintenance). Cow 1 absorbing 25% only requires 140 g dietary Ca to meet requirements, compared with cow 2 who needs 300g. At 0.8% dietary Ca, cow 1 has to consume 17.5kg DM while cow 2 would be expected to eat 37.5kg to achieve calcium requirements. Hence cow 2 is more prone to milk fever.

Consistent with this, recent research (Jorgensen and Thilsing-Hansen, 2000; Thilsing-Hansen and Jorgensen, 2000; Jorgensen et al. 2001; Wilson, 2001a,b) has shown a substantial increase in blood calcium and a reduction in the incidence of hypocalcaemia through lowering the availability of dietary calcium precalving. Based on these findings, precalving diets should contain as little calcium as possible.

A possible solution exists in considering a high Ca diet postcalving as an alternative to a very low precalving Ca diet. Providing cows with more Ca immediately postcalving (up to 1.5% of the diet) has been shown to increase blood Ca during the critical period (Roche et al., 2002; 2003b), reducing the risk of milk fever. Ground limestone can be incorporated into concentrate pellets, added to crushed grain or molasses, or spread on silage or pasture to increase the daily Ca intake of the cow. The colostrum period is the most important time for Ca supplementation.

Magnesium

Magnesium is important for maintaining calcium homeostasis. Reinhardt et al. (1988) reported a reduced production of both parathyroid hormone and 1,25-dihydroxyvitamin D_3 in hypomagnesaemic cows. These hormones control the intestinal absorption of Ca and bone mobilisation. Therefore cows that are deficient in Mg around calving are at a greater risk of milk fever.

This is particularly important in grazing systems, where inclement weather around calving reduces magnesium intake, and where high dietary potassium and crude protein concentrations reduce the absorption of Mg. Roche (unpublished) observed that 70% of grazing cows were hypomagnesaemic (<0.8 mmol Mg per litre of blood) on the day of calving. Therefore Mg supplementation during the month prior to calving and during early lactation is vitally important for preventing milk fever in grazing systems.

Recommended dietary Mg concentrations precalving are 0.35% DM. Table 2 provides an estimate of how much supplementary Mg is required to meet cow requirements and Table 3 provides the amount of different Mg sources required to provide this much Mg.

Table 2: Desired dietary Magnesium concentrations and the quantity of supplementary Mg required (grams/cow/day) for different size animals

	Mg requirement (% of diet)	**Supplementary Mg (g/cow/day)**		
		Jersey	**Crossbred**	**Friesian**
Dry	0.35%	12	16	20
Lactating	0.28%	15	17	20

Table 3: Different quantities (grams) of alternative Magnesium sources to supply the required amounts of pure Magnesium (down the cow's throat)

Magnesium Source	Example Product	Magnesium required (g/cow/day) 12 g	14 g	16 g	18 g	20 g
Mg Oxide (45% Mg)	CausMag	22	25	29	33	36
Mg Sulphate (10% Mg)	MagS	122	142	162	182	202
Mg Chloride (12% Mg)	MagC	100	117	134	151	167

Magnesium sulphate supplementation precalving appears to be more effective in preventing milk fever than either magnesium oxide or magnesium chloride (Roche et al., 2002). This is consistent with findings of Oetzel (1991). However, concern about dietary sulphur content and the poor solubility of $MgSO_4$ provide cautionary recommendations of 60 g $MgSO_4$/cow/day (in the water trough) and 60–80 g MgO dusted on pasture or silage.

Note: If supplementing MgCl or $MgSO_4$ in the water trough, they should be introduced gradually so as not to cause water refusal. MgO is not suitable for water trough treatment.

If dusting CausMag on pasture, double the above to allow for field losses (Table 4). E.g. Crossbred cows need 16 grams Mg = 29 grams CausMag = 60 grams/cow/day dusted or 6 kg per 100 cows per day.

Table 4: Amount (grams) of CausMag dusted on pasture (assuming 50% field losses)

Magnesium Source	Example Product	Magnesium required (grams/cow/day) 12 grams	14 grams	16 grams	18 grams	20 grams
Mg Oxide (45% Mg)	CausMag	44	50	60	66	72

Potassium

The effect of potassium on Ca homeostasis remains unclear. Goff and Horst (1997) reported an increase in the incidence (from 10% to 50%) of clinical hypocalcaemia as dietary potassium concentration exceeded 1.1% DM. The total incidence of hypocalcaemia (plasma Ca concentrations < 1.9 mmol/litre) reported was extremely high (90-100%) across all dietary potassium and calcium concentrations. This high incidence of hypocalcaemia is not evident in pasture-based systems, where dietary potassium concentrations (Roche et al, 2000) are often in excess of 4%. Roche et al. (2002; 2003c) reported that 30 to 40% of cows fed high K pastures (>3.5% DM) had plasma calcium concentrations below 2 mmol/l on the day of calving. The incidence of clinical hypocalcaemia (plasma calcium < 1.4 mmol/l) varied between 0 and 14%, but was not affected by dietary K. There was also no difference in plasma Ca concentration at calving in cows offered pasture varying in K concentration from 3.5 to 4.2% DM, and this was despite a linear decline in pasture calcium concentration as potassium increased (Roche et al. (2002)).

However, K is still important. Potassium interferes with the absorption of magnesium in the rumen (Underwood and Suttle, 1999) and although there is post-ruminal compensatory absorption (Ram et al., 1998), an increased potassium concentration in the diet reduces magnesium absorption. Therefore it is still important to try to keep K low (e.g. do not apply K fertiliser in late autumn/winter, or do not keep springer cows in paddocks getting effluent).

Dietary cation-anion difference

The dietary cation-anion difference (DCAD) is the difference, in milliequivalents (meq), between biologically strong cations (Na and K) and anions (Cl and S) in the diet. A negative DCAD therefore refers to a diet containing more strong anions than cations. Although, it is difficult to separate the effects of DCAD and potassium, it is important in a pasture-based system to do so, based on recent findings regarding the influence of potassium on calcium homeostasis (Roche et al., 2002).

A lower DCAD would, in theory, reduce blood pH (Stewart, 1981; 1983). Although blood pH is perhaps the most regulated process in the body (Houpt, 1993) it can vary and there is general agreement that this variation has an effect on Ca metabolism. A reduction in blood pH has been shown to increase calcium absorption and the amount of calcium excreted in urine (Schonewille et al., 1994; Roche et al., 2003a,b). However, it has been shown that a DCAD approximating 0 meq/100g or lower is required to reduce blood pH (Figure 1) and increase Ca absorption (Roche et al., 2003a). This is consistent with management practices undertaken in confinement systems successfully using this technology.

The requirement for such a low DCAD restricts the effective use of this technology in grazing dairy cows. High DCAD in the base feed and a lack of knowledge on how much the cows are eating reduce the effectiveness with which DCAD can be manipulated in grazing animals. The amount of "anionic salts" required to accomplish such a reduction varies from 500g to 1kg/cow/day, depending on the base DCAD and the salts chosen. These amounts are not practical and are potentially dangerous. Furthermore, the DCAD of pasture varies widely from paddock to paddock and the effect of pasture potassium concentration on DCAD is not as straightforward as in other systems. Roche et al. (2002) reported both a positive and negative relationship between pasture potassium concentration and DCAD in 2 separate years.

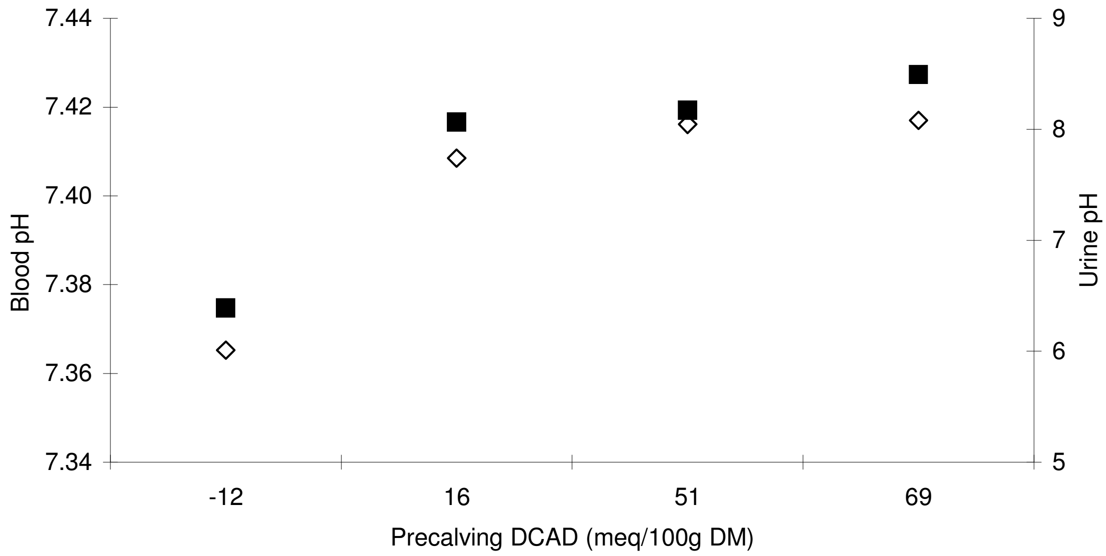

Figure 1: Blood (■) and urine (◇) pH declined when DCAD declined close to zero

Supplementing the freshly calved cow with calcium, to counteract the sudden depression in plasma calcium caused by the onset of lactation, may be a far more sensible and practical approach for dairy farmers in pasture-based systems. The lowest blood calcium concentration in pasture-fed cows occurs 24 hours after calving, potentially allowing time for calcium supplements to be administered (Roche et al., 2001).

Effect of sulphur and chlorine, but not DCAD

As previously mentioned, the DCAD of pasture-based periparturient diets is high and to reduce it sufficiently to change blood pH requires impractical and potentially dangerous amounts of anionic salts. However, there is substantial anecdotal (farmer and veterinary) evidence in pasture-based systems that supplementing cows with smaller quantities of either $MgSO_4$ or $MgCl_2$ than would cause a decrease in blood pH, reduces the incidence of hypocalcaemia. Roche et al. (2002) also showed a reduced incidence of clinical hypocalcaemia in pasture-based dairy cows when $MgSO_4$ and $MgCl_2$ replaced MgO as the pre-calving Mg supplement, even though there was no evidence of an effect on acid-base status. Furthermore, it appeared that $MgSO_4$ was more effective than $MgCl_2$ in maintaining blood calcium levels around calving, even though sulphur would be regarded as a less acidifying salt than chlorine. This research suggests that sulphur and chlorine may have effects on calcium homeostasis that are unrelated to acid-base biochemistry. Others have also reported (Oetzel, 1991; Enevoldsen 1993) that sulphur is more important than sodium, potassium and chlorine in maintaining blood calcium at calving.

Conclusions

Management of the pasture-based transition dairy cow should not be complex. Care should be taken that an optimal body condition score is achieved (5 for cows and 5.5 for heifers and 3 year olds). Cows require approximately 20% of their empty body weight (at condition score 3) in metabolisable energy every day for the last month precalving to avoid condition score loss. However, in situations where feed is scarce or expensive, the lactating cow should take priority over the dry cow for feed.

Managing metabolic disorders requires putting the necessary measures in place to ensure precalving calcium intake is minimised and calcium is supplemented postcalving. Cows should receive magnesium supplementation daily pre- and postcalving.

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