Literature review of the effect of protein supply to pre-calving suckler cows on colostrum and calf performance

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Justification

In following the established practice for feeding pregnant ewes, some suckler beef farmers have increased the metabolisable protein (MP) supply to their dry cows by feeding soya bean meal in the last month prior to calving and have reported improvements in ease of calving, calf vigour and health but there is no documented evidence to support this practice. The purpose of this document is to review the information available on pre-calving nutrition of beef cows, with particular emphasis on protein supply, and its effect on the cow, and survival and subsequent performance of the calf.

Objective

This literature review will look at published information on the effects of metabolisable protein (MP) supply to pregnant suckler cows and heifers in the last trimester of pregnancy. From this information we aim to identify areas relating to pre-calving nutrition which would merit investigating further in terms of potential to have a positive effect on calf survival and performance in the UK.

1.0 Introduction: The farm context with reference to MP supply

Traditionally spring calving suckler cows are fed a flat rate ration for the dry period which restricts their energy and protein intake prior to calving and may fall short of meeting their protein requirements, especially if the production of colostrum is to be taken into account. This is done because overfat cows can suffer calving difficulty. Similarly, autumn calving cows are also often kept on low sward heights or on low quality hill pasture to avoid issues at calving time from being overfat. At grazing these cows are less likely to be protein deficient than housed cows on low quality conserved forages, so this review concentrates on the spring calving situation, when most English suckler cows calve and because they are housed and dietary intake can be controlled, this is where most of the experimental data is.

The ability of cows to conserve energy and protein as body reserves from periods of low cost summer grazing to meet winter pre-calving requirements is key to profitability. So the use of supplementary protein will, for the majority of cows, be in conjunction with the use of stored body reserves of protein.

However, in many herds there are often a range of body condition scores across the herd. This could include thin cows with low body reserves such as cows recently introduced to the herd as replacements after calving, older cows close to culling and cows which have previously had twins and may not have enough reserves of their own.

Condition score may thus be of relevance to the response recorded to feeding supplementary protein and in the literature review effects of this were sought.
Some of the effects seen in response to metabolisable protein supply in sheep diets could be specific responses to digestible undegradable protein (DUP) supplementation. DUP supplementation provides enhanced levels of MP above those supplied by microbial protein and can provide first limiting amino acids. Some supplemental amino acids such as arginine in sheep may have metabolic effects influencing lamb survival in addition to being a source of protein (McCoard et al). Similarly lysine and methionine have been shown to be limiting amino acids in lactating dairy cows. Where possible, specific effects of supplementary DUP have been identified. Finally there could also be intergenerational effects such that extra protein feeding affects the responsiveness of the next generation through epigenetic effects. This review however will not look at foetal programming.

2.0 Evidence that current UK recommendations under supply MP

The nutritional recommendations in the UK used for formulating suckler cow rations are derived from the AFRC (1993) review which is based on work carried out in the 1970s. Since then there have been significant developments in beef genetics and the type of beef animal bred on UK farms. At a meeting of beef cattle nutritionists, organised by EBLEX in 2014, it was concluded that the nutrient requirements published by the AFRC underestimate metabolisable protein (MP) requirements and these requirements for MP are lower than in other published systems (e.g. France and the United States).

Historically SAC consulting had added an arbitrary safety margin to elevate the AFRC (1993) metabolisable protein (MP) maintenance requirements for beef cattle more in line with what professional judgement seemed appropriate. Then in 2006 SAC Consulting reviewed the INRA (1989) and NRC Beef (2000) requirements and found these were clearly higher than the AFRC:-

AFRC (U.K.): $2.3W^{0.75}$

INRA (France): $3.25W^{0.75}$

NRC (U.S.): $3.8W^{0.75}$

Table 1 below shows the difference in maintenance requirements for cows on the 3 different MP systems.

Table 1: Metabolisable protein requirements for maintenance in cows of different weights

	Metabolisable Protein (MP) Requirement for Maintenance		
Cow liveweight	**AFRC** $\mathbf{2.3W^{0.75}}$	**INRA** $\mathbf{3.25W^{0.75}}$	**NRC** $\mathbf{3.8W^{0.75}}$
500kg	243	343	402
600kg	279	394	461
700kg	313	442	517

Although in the UK rations have been seemingly satisfactory for spring calving beef cows taken through the winter on a flat rate, they are clearly lower than other systems. It could be queried that colostrum production is not accounted for in rationing in the weeks approaching calving. In practice the length of the calving period, body condition and composition of body change will affect how rations perform on different cows. There are no estimates from the literature of the protein and energy requirements for udder development and production of colostrum and in practice there have been no reports of cows not having normal udder development and colostrum production from the use of AFRC (1993) rations. There have however been some cases on farms where despite normal amounts of colostrum, on analysis calves appear to have low colostral antibody intake as determined by IgG estimations from neonatal blood. Anecdotally this has occurred where stockmanship of a high standard has been applied ensuring all calves suck within the early period before gut closure occurs, and has not been affected by high Iodine supplementation to the dam which are known to reduce absorption in sheep (Boland, 2004).

If it is assumed that over the last few days of pregnancy 1kg colostrum is produced per day, this has a major influence on protein requirements as shown on table 2 below. This is based on an assumed composition of colostrum (/kg) of 143g protein, 36g fat, 31g lactose, 2.6gCa, 2.4gP, 0.4gMg, 0.7gNa and 8.2MJ ME (Roy, 1980).

Table 2: MP requirements for a 650kg suckler cow 1 week pre-calving with and without allowance for colostrum

	No allowance for colostrum	**Allowance for 1kg colostrum/day**
MP g/d (AFRC 1993)	461	671
MP g/d (NRC 2000)	654	864

3.0 Limitations of AFRC (1993) and the MP system

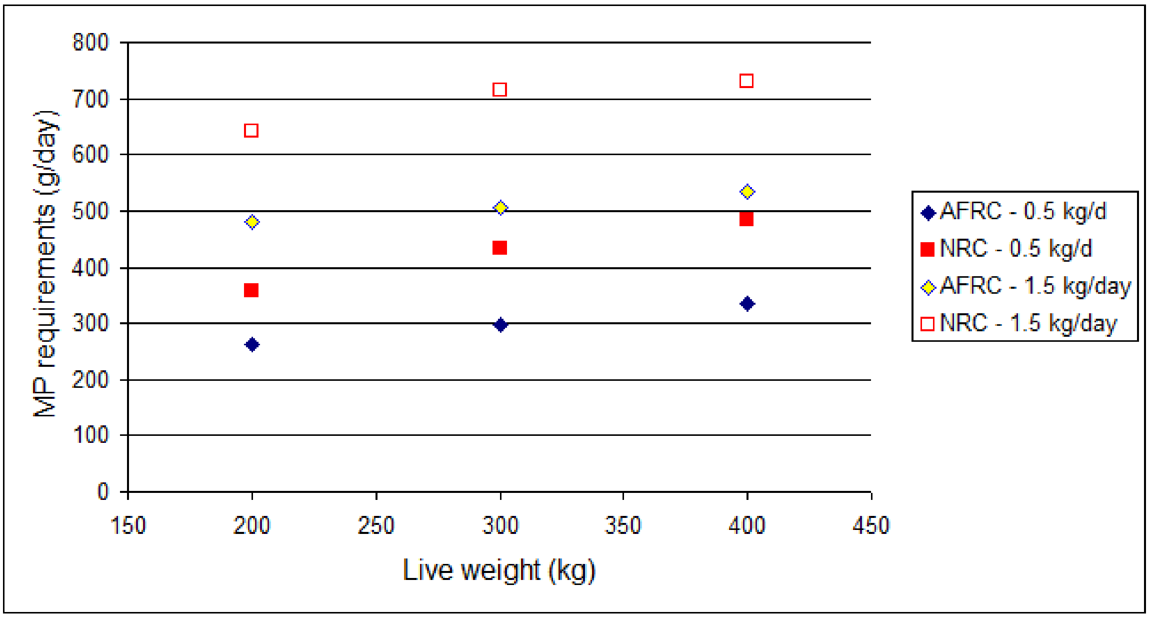
The MP system has been criticised for its inadequacy in predicting energy supply to micro-organisms. Rumen microbial protein is vital to the overall supply of metabolisable protein. When an animal's diet is depleted of nitrogen, the amount of N excreted will eventually reach a fairly stable minimum level, as long as energy requirements are met. If energy requirements are not met then protein from the body may be broken down to provide energy and the excretion of nitrogen will increase again (Cottrill et al, 2009). Another loss can occur from endogenous matter lost during the process of digestion which is termed metabolic faecal nitrogen loss (MFN). MFN includes protein sources such as enzymes and epithelial cells and microbial cells from the hind gut and microbial cells from the rumen. (Cottrill et al 2009).

AFRC (1993) does not include an allowance for MFN, and this may explain why requirements using the UK MP system tend to be lower than most other protein systems. Losses of MFN are related to dry matter intake (DMI) and estimates of MFN are fairly similar between systems when expressed as a percentage of DMI.

Although AFRC (1993) did not include an allowance for MFN in its estimates of MP requirements, it assumed that the efficiency with which MP is used (k_{pm}) to be 1.0, compared with 0.67 assumed by NRC (2000). This difference to a degree compensates for correcting MFN for microbial N (Cottrill et al, 2009).

Given that suckler cow diets are generally restricted in terms of dry matter intake to avoid calving difficulty MFN adjustments to MP supply may be of less importance than in sheep diets for example where multiple foetuses call for the maximum intake possible in late pregnancy. Figure 1 shows a comparison of MP requirements for growing cattle estimated from AFRC and NRC figures.

Figure 1: A comparison of the MP requirements for beef cattle gaining either 0.5 or 1.5 kg/day, estimated by AFRC (1993) and NRC (2000) (Cottrill et al, 2009)



A review of the AFRC MP system for DEFRA concluded that estimates of requirements of metabolisable protein for maintenance are too low (Cottrill *et al.* 1996), and is supported by recommendations that were then published in North America (NRC, 2000). For example, AFRC (1993) and NRC (2000) estimated maintenance requirements for a 300 kg beef animal of 166 and 274gMP/day^{-1}, respectively. There is potential for farmers to be underfeeding MP or overestimating the gain from an indicated supply of MP.

Cottrill et al (2009) proposed that a value of 3.8 g MP/kg$^{0.75}$ be adopted to estimate MP requirements for maintenance in the UK. The same approach has been taken for dairy cows in a DEFRA Link project (Feed into Milk, 2004), which has been widely accepted in the UK. It also depends on the live weight of the cow as well. Wright and Russel 1984 showed that the composition of empty body weight change was dependant on the empty body weight – heavier cows contain more fat and less water, protein and ash. They found there to be no differences between genotypes. They showed that the protein concentration in the smallest cows to the largest cows (300-600kg empty body weight) was 125g/kg compared to 40g/kg respectively.

4.0 Effect of Nutrient Restriction on Immunity of the Cow/Neonate

Blecha et al (1981) looked at protein restriction in the beef cow and the effect on immunoglobulin content in blood and colostral whey and the subsequent absorption of immunoglobulins by the calf. They found that in first calved heifers there were no significant correlations between the concentration of immunoglobulins in the sera or colostrum and the consumption of protein in the pre-calving ration. However, they found that the absorption of some immunoglobulins by the calf was positively correlated to maternal protein consumption. An older but related paper by Fishwick and Clifford (1975) also found no differences in immunoglobulins between cows restricted and not restricted in protein. Blecha et al (1981) concluded that there was some factor involved in the absorption of IgG from the intestinal tract of the suckled neonate that was affected by the protein content of the diet fed to the dam. Whether this was low enough to have an effect on disease and survivability of the calf is unknown. This paper supports older work and its results indicate that protein content of the ration in the last trimester significantly affects the calves' ability to absorb immunoglobulins IgG1 and IgG2 from the colostrum, however like many trials the sample of animals was small - Blecha's trial only had 10-11 animals per treatment. There are farmers in the UK who only feed straw in the last few weeks before calving and could be risking having calves with a poorer ability to absorb the essential immunoglobulins from colostrum that will help them fight disease. A summary of the estimated MP supplied in Blecha's trial using Feedbyte® is shown in table 3.

Table 3: Dietary treatments from Blecha et al - rations of differing crude protein and isoenergetic (56 MJ/day)

	Dietary treatment					
	1	2	3	4	5	6
Bluegrass straw (kgDM)	6.34	6.34	6.34	6.34	6.34	6.34
Barley (kgDM)	1.22	0.98	0.73	0.49	0.24	-
Soya (kgDM)	-	0.24	0.49	0.73	0.98	1.22
Crude protein in total ration (%)	6.9	8.1	9.4	10.6	11.8	13.0
ERDP supplied in ration (g/day)	281	342	405	465	529	589
DUP supplied in ration (g/day)	178	202	227	252	277	302
MP supplied in ration (g/day)	357*	420*	485*	546	571	596
Estimated MP required AFRC (1993) at 8wks pre-calving	302	302	302	302	302	302
Estimated MP required NRC (2000) at 8wks pre-calving	574	574	574	574	574	574

*In practice this MP is not achievable as ration is ERDP limited.

Notes: the above rations supplied 56MJ/day metabolisable energy the ERDP, DUP and MP was worked out using the ration information provided. The heifers in this experiment were approximately 429kg live weight at 178 days gestation when the experiment began, assuming they gained 0.5kg/day until calving they would be around 475kg at calving, the table is worked out using 450kg heifers – lighter than today's heifers.

Hough et al (1990) also looked at nutritional effects in late gestation on production measures and passive immunity of the calf. This was a 2 year study of cattle in the last 90 days of pregnancy. The control was 100% of NRC (1984) requirements for protein and energy compared to severely restricted protein and energy (57% of requirements). This study doesn't just focus on protein as diets were also energy restricted as well. All cows were fed adequately after calving. The study involved a relatively small number of cows (n=26) and the calves were given one of two different treatments: 1) colostrum from their dam or 2) colostrum from a cow in the other treatment group. The key results were in agreement with Blecha et al (1981), maternal nutrition did not affect colostrum immunoglobulin content, however it was found in this study that the calves' ability to absorb colostrum immunoglobulins was also not affected (in contrast to Blecha et al and Burton et al). Hough stated that it has been shown in many studies that cortisol and Tri-iodothyronine (T3) have been necessary for the maturation of the lining of the intestinal epithelium and this could explain the findings of Burton et al and Blecha et al. This was not the case in the Hough et al (1990) study, where they found that the IgG content of the colostrum from the restricted cows was higher. Serum cortisol levels were elevated and T3 was decreased in calves born to dams of restricted nutrient intake which suggested calves were responding to nutritional stress of their dams by endocrine compensation. Hough et al concluded that there was perhaps some constituent of colostrum that was altered by restriction of the dam that is affecting immunoglobulin absorption. A summary of the estimated MP supply (using Feedbyte®) in Hough's trial is in table 4.

Table 4: Dietary treatments from Hough et al (1990) – year 1 and year 2 control being 100% of NRC (1984) and restricted being 57% of NRC (1984) requirements

	Yr 1 control	Yr 1 restricted	Yr 2 control	Yr 2 restricted
Crude protein of ration (%)	9.9	9.9	9.6	9.6
Metabolisable energy of ration (MJ)	87	49	87	49
ERDP (g/day)	555	315	538	302
DUP (g/day)	202	109	173	97
MP (g/day)	620	310	591	289
Estimated MP required AFRC (1993) at 8wks pre-calving	357	357	357	357
Estimated MP required NRC (2000) at 8wks pre-calving	535	535	535	535

Notes: energy and protein were restricted in above experiment assuming a 600kg LW cow.

5.0 Importance of maternal reserves to protein supplementation responses

The cows in the Hough et al (1990) trial were aged between 4 and 8 years. Cows were in good condition and although they lost weight they had reserves to do so. It may have been be a different outcome if the cows had been lean to begin with. McGee et al (2006) looked at the effect of age on nutrient restriction and what effect this had on immunglobulin concentrations, colostrum yield, composition and immunoglobulin status in progeny. Colostrum yield was lower for heifers compared to the cows but interestingly there was no difference between the multiparous cows offered grass silage and straw in terms of colostrum yield. It is worth noting however the straw in year 3 of the experiment was above average quality with grass through it and in years 1 and 2 some of the cows on the straw only ration suffered from constipation (from less than 2 weeks on straw). They concluded calves from cows that were fed straw pre-partum, whether they were primiparous or multiparous, had significantly lower serum IgG levels and concluded that younger cows have a lower immune status than older cows regardless of pre-calving diet. Calves from heifers had lower mass of immunoglobulins fed at birth, lower birth weight and volume of colostrum fed which makes a case for supplementing heifers. McGee stated that the time to first suckling in practice may be longer than in their study (which was 1hour) and factors affecting calf getting enough good colostrum are exacerbated in heifers where mothering ability has not been as well established as in multiparous cows. Table 5 shows the estimated MP supply (using Feedbyte®) for McGee's trial.

Table 5: McGee et al (2006) – dietary treatments - rations of either ad-lib silage or straw over 3 years with differing analysis of forages

	Yr 1 silage	Yr 1 straw	Yr 2 silage	Yr 2 straw	Yr 3 silage	Yr 3 straw
Crude protein % of total ration	12.7	6.5*	14.5	6.5	15.1	6.4
Estimated Metabolisable energy (ME) of ration (MJ)	119	57	105	69	111	100
ERDP supplied in total ration (g/day)	1046	243	1172	279	1229	265
DUP supplied in total ration (g/day)	251	227	285	272	300	298
MP supplied in total ration (g/day)	796	381[1]	757	450[1]	793	467[1]

Estimated MP required AFRC (1993) at 8wks pre-calving++	357	357	357	357	357	357
Estimated MP required NRC (2000) at 8wks pre-calving++	535	535	535	535	535	535

Notes: the above rations *straw was estimated as there was no figure for yr 1, yr 3 straw had a very high dry matter digestibility) hence the additional energy supplied. ++Estimated 650kg cow [1] In practice this MP is not achievable as ration is ERDP limited.

Quigley et al (1998) stated that it was not clear whether modification of the pre-partum ration with ruminally protected protein sources or amino acids would improve energy or protein balance of neonatal calves or improve IgG absorption. Although milk production may be increased with additional protein, it is not clear whether colostrum quality will be improved in the same way. Hook et al (1989) found that dairy heifers fed a 13% crude protein pre-partum ration did not produce more colostrum or colostrum with more IgG or IgM than heifers that were fed a 9.9% crude protein ration. This is a study however that is 25 years old and from the dairy sector. Cows have changed in size and production level massively since that time.

Gunn et al (2013) fed excess crude protein to gestating and lactating beef heifers and studied effects on parturition, milk composition, ovarian function, reproductive efficiency and pre-weaning progeny growth. The rations fed were similar in terms of energy supplied but one group of heifers were fed a ration of a minimum of 150% of NRC requirements for protein from 192 days into gestation to 118 days into lactation.

There was an increased incidence of dystocia and heavier birth weights in calves whose dams were fed on the higher protein ration. However, approximately 50% of the total dry matter intake in the high protein ration was from distiller's dark grains (DDG) that are associated with increased levels of internal fat due to their high unsaturated fat content. Fat deposition in the heifers was not studied in this trial. Similar effects of this level of distillers grains in sheep diets in pregnancy caused overfatness and prolapse in studies by Vipond et al (1995). Although incidence of dystocia was higher there was no difference recorded in calf vigour shortly after birth. Total milk production also did not differ between treatments in this study but the composition of the milk did. The proportion of milk fat and total milk solids was higher in the control group. This could be due to the high level of DDGs fed and the fat and oil content of the DDGs depressing fibre digestion. When milk composition was included to calculate energy corrected milk production per day, the heifers on the control treatment produced more energy corrected milk. Despite this however, calves from the higher protein group maintained their weight difference and were heavier at weaning (1.34kg compared to 1.21kg average daily gain in pre-weaning phase). The author states that the mechanism(s), by which increased CP and/or fat content of the diet increases birth body weight, have not yet been elucidated. It was also speculated that increased follicular growth in the heifers that were on the higher protein ration could have been due to either increased dietary fat or excessive protein or a combination of both these components. Gunn et al (2013) found that excess dietary protein, which was rich in DUP, fed at 150% of NRC requirements increased ovulatory ovarian follicle growth in non-pregnant and non-lactating beef cows. This concurs with Bolze et al (1985) study which reported a shorter postpartum period for beef cows on 150% on NRC protein requirements when compared to cows fed 100%. However, this is an old study conducted before the review of NRC requirements in 2000.

Alderton et al looked at the effect of supplemental protein type on postpartum productivity of primiparous beef cows. There were 36 Gelbvieh cross Angus cows, fed a ration of native grass hay which had a crude protein of around 8.5%. The three treatments to supplement the hay were:

Treatment 1. corn and soyabean meal as a degradable intake protein (DIP)

Treatment 2 as above (DIP) with additional undegradable intake protein (UIP)

Treatment 3 replacing soyabean meal with blood meal and maize gluten meal so it is isonitrogenous (UIP IsoN)

The three treatments are summarised in Table 6 below.

Table 6 Summary of treatments (Alderton et al)

	Treatment 1 DIP	**Treatment 2 DIP + UIP**	**Treatment 3 UIP IsoN**
Native grass hay	Ad-lib	Ad-lib	Ad-lib
Maize kgDM/day	0.82	0.82	0.82
Soya kgDM/day	0.23	0.23	
Bloodmeal kgDM/day		0.12	0.07
Maize Gluten Meal kgDM/day		0.13	0.08
Crude protein (%) estimated (actual)*	10.9 (9.7)	12.4 (11,4)	10.9 (9.7)
DIP balance (g/d) estimated and (actual)*	-2.3 (-165.2)	40 (-123.1)	-35.8 (-189.8)
MP balance (g/d) estimated and (actual)*	6.0 (-82)	108.0 (22)	35.0 (-26)

*after chemical analysis of ration actual figures which were less than expected

At 30 days post calving they reported that all cows were in similar body condition, however 60 days after calving BCS loss was evident in all of the cows. From 30-90 days post calving the DIP+UIP treatment the BCS loss was less than on the DIP treatment and much less than the UIPIsoN treatment. At 90-120 days post calving the DIP+UIP treatment cows still had the highest condition score ($P<0.05$) but the DIP and UIP cows did not differ even though the UIP cows lost condition more rapidly between 30-60days post calving. Milk production in this study was highest for cows on the DIP+UIP ration but at 60 days post calving the milk production between the DIP+UIP and the DIP treatments did not differ, and they were both higher than the UIP IsoN treatment. By 90-120 days post-calving there were no differences between treatments. This study showed no differences in calf weight gains over the 120 day supplementary period. This is surprising given the difference in milk yields across the treatments and it is suggested that calves compensated by consuming more forage.

6.0 Effects of protein supply on cow productivity and calf growth

Van Saun et al (1993), Moorby et al (1996) and Murphy et al (1999) all found that feeding additional DUP during the dry period increased milk protein output whereas other studies have only shown minor effects (Wu et al, 1997; Huyler et al, 1999; Murphy, 1999; Putman et al 1999; Vandehaar et al, 1999; Dewhurst et al, 2000). The objective of the Moorby et al (2002) experiment was to investigate the consequences of altering energy and protein levels in the diets of dry dairy cows. It is acknowledged that dairy cows have a much shorter dry period and a higher nutrient demand for milk production than beef suckler cows, however as there is a lack of information in suckler studies it is worth looking at findings from dairy work. Moorby et al, in a UK trial, used 51 dairy cows 7 weeks prior to calving. They were fed grass silage and then 5 weeks prior to calving were allocated to 4 treatment groups summarised in table 7 below.

Table 7: Summary of treatments (Moorby et al (2000)

	Treatment			
	1 **GS**	**2** **GSPM**	**3** **GB**	**4** **GBPM**
First cut grass silage	Ad-lib	Adlib		
First cut grass silage and straw (60%:40% on DM basis)			Adlib	Adlib
Prairie Meal protein supplement		0.5kg		0.5kg
ME density of the ration	10.6	10.6	9.4	8.8

Note: All cows progressed on to the same lactation ration.

The metabolisable energy intake (ME) of the GB and GBPM fed cows was 35MJ/day lower than the GS and the GSPM fed cows. Forage DM intake was higher for grass silage based rations and total DM intake was significantly increased with protein supplementation, but forage intake was unaffected. Silage rations had a greater ME density than those containing straw (mean densities were 10.6MJ/kgDM vs 9.1MJ/kgDM) and this led to significant effects on body weight change 4-1 weeks pre-calving. BCS was unaffected by treatment. This was an experiment on dairy cows, if we assume a suckler cow would consume around 10kg of dry matter (adlib) this would be 106MJ, 106MJ, 94MJ and 88MJ of energy supplied for the treatments in the table above, which all nearly meet the energy requirements of a 650kg suckler cow 4 weeks pre-calving with no weight loss. The protein of the silage was 163g/kgDM and the protein of the straw was 25g/kgDM so even in the GB ration the overall crude protein was still 108g/kgDM.

The first month of lactation cows that were on the GSPM and GS had higher milk yields compared to others but this did not last over the first 4 weeks into lactation. This shows that there was a positive effect of the silage based rations in the last 5 weeks of the dry period but this didn’t last beyond the first 4 weeks into lactation. Inclusion of barley straw in the late dry ration actually led to a delay in milk production for the first month of lactation (this agreed with earlier work by Dewhurst et al., 2000). Moorby et al concluded that late dry period protein supplementation had no effects on forage intakes, BW or BCS. There was significant forage x protein supplementation interaction effect on milk protein concentration and BW change in early lactation. Milk protein concentrations were increased by provision of a protein supplement in the poorer quality forage ration and they decreased with the better quality forage. This finding is also supported by other work that Moorby et al (2002) cited.

Tuomo Kokkonen used regression analysis to evaluate the effects of prepartum protein supplementation on subsequent milk yield, milk composition, feed intake and tissue mobilisation of dairy cows using data from 15 peer-reviewed articles. These studies comprised pre-partum dietary crude protein levels ranging from 97g/kgDM to 206g/kgDM. To look at the various treatments he categorised them into the differing basal rations; grass silage-based, maize silage-soya bean meal (SBM) and other which included straw/hay/alfalfa. It was found that the composition of basal diet had a significant impact on how the cattle responded to protein supplementation. The maize silage based rations showed a negative effect of the addition of soyabean meal in the pre-partum diet on subsequent postpartum milk yield and dry matter intake, silage rations were variable and there was a response on poorer forages such as hay and straw. Tumno Kokkonen speculated that maize silage based rations may have provided more than enough DUP and microbial protein supply than the basal diets of silage, hay or straw during the late gestation period. The maize silage/SBM ration may have oversupplied MP and this may have had an energy cost to the cow.

During early lactation the dairy cow mobilises amino acids to support her lactation. Moorby et al (1996) and Van Saun et al (1993) reported that supplementing a dairy cow pre-partum with a rumen undegradable source of protein had a positive on milk protein content or protein yield. Greenfield et al (2000) and Hartwell et al (2000) reported that excess supplementation of a ruminal undegradable source had a negative effect on milk yield performance of the dairy cow.

Bolze et al (1985) looked at the effect of pre-partum protein level on calf birth weight, dystocia and reproductive performance of primiparous and multiparous beef females. Two trials were carried out to determine effects of dietary protein effects. Year one studied rations of 75%, 100% and 150% of NRC (1984) crude protein recommendations, and year two looked at using 100% and 150% of requirements. The trials used Simmental heifers and cows on all treatments, but they found no correlation between the treatments and the parity of the dam so all data was pooled across parities. Compared to some other trials there were reasonable numbers of animals in each group (28-30 Simmental females). It is not clear if the rations were of the same energy concentration, it is assumed they were. The differing protein rations were fed in the last trimester of pregnancy and then resumed to 100% of NRC (1984) recommendations post calving. Heifers on the trials were individually fed and cows were group fed during the last 112 days prior to their average expected calving date in the 60 day calving season. Although this mimicked a more practical “real life” scenario, there may have been differences in intakes due to social hierarchy effects. During the pre-partum period cows that were fed excess protein tended to put on more weight and lose more in the lactation phase in both trials. Pre-partum protein had no effect on birth weight or calving difficulty in these trials. The high pre-partum protein shortened the post partum interval to first oestrus, but there was no significant effect on first service or overall conception rate. There was more pre-partum weight gain in the cows that were fed the high protein ration on this trial which also agrees with earlier work. This could be an issue with already well conditioned cows and heifers and may increase incidence of calving difficulties in practice. Overall there was a lack of positive effects of feeding excess protein recorded in this trial. Effects were not that negative but just not convincing enough to add value to the farmer.

Martin et al (2007) found an increased pregnancy rate of heifer calves from dams that had been supplemented with additional protein in the last trimester of pregnancy. The percentage of heifers that calved in the first 21 days was 77% compared to 49% from unsupplemented heifers. However, this paper is in Nebraska where cows are grazed on dormant Sandhills which is a region of mixed-grass prairie on grass stabilised sand dunes in north central Nebraska and is often of poor quality. Although the paper doesn’t state the nutritional value of the pasture it is assumed that the cows requirements in late gestation far exceed that supplied from the grazed forage.

Funston et al’s (2010) review on effects of maternal nutrition on conceptus growth and offspring performance reported higher protein levels in the in the dam’s diet (in the last trimester of pregnancy),   increased intramuscular fat in the carcass of the steers resulting in a more valuable carcass on the US market. Larson et al (2009) suggested that late gestation protein supplementation may affect carcass quality through improving calf health. Calves did not show a response in health from birth until weaning but more calves from dams that were not supplemented had health issues from weaning until slaughter. Underwood (2008) found that steers from cows that had grazed improved pastures gained more body weight in the finishing period and were fatter and heavier at slaughter.

7.0 Conclusions

It can be concluded that literature sources have not been able to give a clear picture of the need for, or responses to, higher levels of metabolisable protein during the dry period than are currently used by many suckler cow ration programs employed in England. Better calf survival outcomes or enhanced weaning weights from the average cow in adequate condition are unlikely to be found given the literature reviewed, the most likely effect of protein supplementation is increased weight of cow at calving.

There are legitimate concerns that the current recommendations for protein based on AFRC (1993) are too low and do not take into account changes in the genetics that have occurred since they were formulated or colostrum production in the last two weeks of pregnancy. However, many organisations already recognise this and have amended their advice in regard to protein supply.

Table 6 below summarises results from suckler cow and dairy experimental data where metabolisable protein supply in the late pregnancy/dry period diets has been enhanced either by increased microbial protein supply from energy and rumen degradable protein sources or from supplementary DUP in relation to components of cow and calf survival.

Table 8: Effects of increasing MP supply and enhanced DUP supply on calving outcomes

Outcome	Effects of increasing MP supply	Specific effects of enhanced DUP
Calf survival traits		
Immunoglobulin content of colostrum	Generally no effect Blecha (1981), Fishwick (1975), Hough (1990) Hook (1989) (dairy cows)	Quigley (1998) (dairy) – no clear effects
Immunoglobulin levels in calf sera	Positive effects Blecha (1981) McGee (1996) (cows and heifers) Negative effect Hough (1990)	Quigley (1998) (dairy) – no clear effects
Calf birth weight	Increased birth weights (dystocia) Gunn (2013) No effect on birth weight Bolze (1985)	
Calf weight gain or protein supply from milk produced by cow	No effect Wu (1997) (dairy) Huyler (1999) (dairy) Murphy (1999) (dairy) Tesfa Vandehaar (1999) (dairy) Positive effect Van Saun Moorby (dairy) Murphy Funston (weaning weight)	No effect Alderton (2000)) Greenfield (2000) (dairy) Hartwell (2000) (dairy)
Cow survival and reproduction traits		

Factors affecting getting cow back in calf		Positive effects Gunn (2013) (non-pregnant heifers) Bolze (1985) (shorter post partum interval)
Cow weight change pre-calving	Increase in LW Bolze (1985)	
Cow weight/CS change post calving	No effect Gunn (2013) Cows lost more weight Bolze (1985)	
Generational effects	Positive effect increased pregnancy rate of the heifer calves born to supplemented dams. They were also more likely to calve in the 1st cycle of their 1st calving season. Martin (2007)	

There are severe limitations to the data, most of the information gathered has come from North America. Some of the trial work was in similar systems to the UK and some was not, for example extreme winter grazing systems which are not applicable in the UK.

In relation to colostrum production and quality, experimental data sets were often too small to produce significant results and overall there was little statistically significant evidence for responses to protein supplementation of cows pre-calving. Similar lack of response from sheep experiments where ewes were in good condition have recently been presented at BSAS (Houdijk, 2016 and Wilkinson, 2016). Given that suckler cows with a single calf produce much less birth weight in relation to maternal bodyweight than sheep, and are thus under less nutritional pressure, such a result is not unexpected. There is clearly a danger of overfeeding suckler cows resulting in dystocia which is a common problem, especially in autumn calving herds. Also, compared to sheep, cows tend to calve over longer periods of time thus there are cost issues and potential dystocia risks from potentially long periods of supplementary soya feeding for colostrum. As Wright and Russell's work showed, it is likely cow size, condition and protein reserves will determine the effect of supplementary feeding on cow condition, milk production and weaning weight of calves. With increasing mature size of suckler cows in the UK common place - for example up to 900kg LW at calving - such cows have huge body reserves to potentially mobilise, and consequently may be even less likely to show responses to supplementary feeding of protein. However, large cows that are in good body condition which are mobilising body tissue are likely to be out of balance between protein and energy as the tissue contains a relatively low amount of protein to energy and they may be deficient in MP as a result (Wright and Russell). In these situations additional DUP might be beneficial. Knowing the quality and quantity of the forage to be fed is an absolutely vital part of managing the cow and the ration.

8.0 Farmer Messages

- It is essential to analyse your forage, if the basal forage is poor and there is not enough energy and protein for the cow to make enough microbial protein, then supplementing with a high protein source may be advisable to make better use of the forage given. The main source of protein to the cow should first come from protein made by the rumen bugs so ensuring adequate energy and rumen available protein to feed the rumen is essential.
- If cows are thin and have lack of their own reserves they may benefit from additional protein, but it does depend on the quality of the forage available to them. Feed according to condition and start planning in plenty time before calving.
- Heifers, especially those calving at two, need to have adequate protein and energy for growth as well as pregnancy. Heifers tend to have lower quantity and quality of colostrum. There is an argument to supplement heifers that are under nutritional strain with additional protein and look after them as a separate group
- Cows that are in good condition have reserves to use and need to have feed restricted to avoid them becoming too fat. Adequate rumen available protein should always be fed - research shows that severely undersupplying protein by feeding straw alone in the last few weeks pre-calving reduces colostrum immunoglobulins and thus preventing the calf getting sufficient immunity via colostrum. Also there could be an issue with cows' rumens not being able to function adequately.
- Getting rations worked out based on your forage quality and the condition of your cows will not only utilise your forage efficiently but it will ensure cows are in the correct condition to calve down well and prevent problems with dysotocia or lack of colostrum.

9.0 What Next?

There is a lot of uninformed comment amongst farmers and advisors on how to feed suckler cows approaching calving for best performance. With margins extremely tight money should only be spent on supplements where benefits are seen, but so far we only have anecdotal information with little or no evidence to back it up. Every system in the UK is different; different breeds, bulls and management set up and clear guidelines on requirements for sucklers together with education on feed management is required to keep costs under control without compromising production.

Potential trials

The experimental data give a guide to situations where responses to supplementary protein are most likely to give a return. These are where the cow is in poor condition and under ‘protein pressure’ e.g. heifers or thin second calvers in a herd situation which could be separated off for supplementary soya. Cows with twins or cattle that have accidentally got in calf at too young an age may also show responses but the latter could not be trialled under current UK welfare legislation. Smaller genotypes from native breeds with fewer body reserves of protein may be more likely to respond. The specific problem of neonatal calves that have low IgG levels in blood despite apparent good nutrition and stockmanship deserves attention, perhaps targeting such herds for on farm trials with supplementary soya. Also it may be useful to look at the effect of different rations on cows’ (of differing size and condition) protein status via blood sampling prior to calving and what the outcomes are in terms of colostrum production and calf growth rates to weaning. There are so many factors that need to be considered in a trial examining pre-calving suckler cows including age, body condition score, breed, dietary factors and also how to monitor the protein efftects whether based on overall CP or on DUP or MP content. Measurements of dry matter intake, BCS (and weights), bloods and calving information would be required as well as measurements of health and performance of the calf. To run a scientific trial would require home office licencing and a good number of cows (100+) to give meaningful scientific information.

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