An investigation into reduced milk production following dietary alteration on an Irish dairy farm

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ABSTRACT

A nutritional evaluation of an Irish dairy herd indicated gross overfeeding of late lactation cows, over-conditioning of cows at parturition and a high rate of body condition loss in early lactation. Metabolisable-energy based nutritional modelling software was used to guide recommended dietary changes to prevent excessive condition gain in late lactation. Immediately following the implementation of the changes there was an unexpected reduction in performance affecting both milk yield and protein concentration. An investigation into the poor performance revealed underestimation of peak milk yield; over-estimation of maize silage quality; a large difference in the concentrate being fed compared to the concentrate recommended, and failure of the blend of concentrate ingredients to maintain the intended proportions in the in-parlour feeding system. The estimated maximum cumulative effect of these errors was to cause undersupply of energy and protein in the recommended diet of 16% and 3% respectively to cows in early lactation. Use of a net-energy nutritional model would have indicated a requirement for a higher energy supply in this case. This report highlights the challenges in obtaining accurate on-farm data for use in dairy cow nutritional models.

KEYWORDS

Nutrition, dairy cow, protein, production

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INTRODUCTION

Nutritional management of the dairy cow has significant influence on health, production and reproduction particularly around parturition and early lactation (Roche, 2006, Mulligan et al., 2006). Monitoring nutritional status of the transition cow involves an assessment of nutritional inputs, body condition score changes, milk production performance, the incidence of production diseases, and blood parameters for mineral status and energy balance. A holistic preventative approach incorporating these elements has been outlined previously (Mulligan et al., 2006). Using this approach, if shortfalls (differences between farm targets and performance) in cow health or production are identified, an investigation into feeding management and dietary composition is indicated to assess nutritional status in greater detail. Several nutritional modelling software packages are available to aid advisors in designing appropriate diets for specific performance criteria (Chamberlain and Wilkinson, 2002, O'Mara, 1998). The accuracy of predictions made by such programmes depends on how accurately data entered by the advisor reflects the on-farm situation. There are a large number of on-farm variables that make accurate dietary evaluation and formulation challenging. This report describes an investigation into nutritional management of transition cows on an Irish dairy farm and an unexpected reduction in production performance following dietary alteration.

INITIAL NUTRITIONAL ASSESSMENT

A visit was conducted to an 80-cow dairy herd on January 29, 2010 to initiate nutritional monitoring. The 2009-2010 calving pattern and lactation status of each cow on the day of the visit is shown in **Figure 1**. Lactating cows (n=56) were housed together and fed a single total mixed ration (TMR) ad-libitum plus home blended concentrates in-parlour at two rates for early (n=26; average days in milk 44; range 3 – 110) and late lactation (n=30; average days in milk 318; range 150 – 704) cows respectively. Dry cows (n=20) were housed separately and fed a separate TMR. Details of all diets were gathered from farmer interview and farm records (**Table 1**).

Late lactation cows were dried off approximately 60 days before their due to calve date. All diets had remained unchanged since housing on November 15, 2009. Therefore, the late lactation group of cows had been fed the late lactation diet for 74 days on the 29th of January. The dry cow group had been fed the late lactation diet for

between 15 and 73 days and the dry cow diet for between one and 34 days. The early lactation cows had been fed the early lactation diet from between three and 73 days.

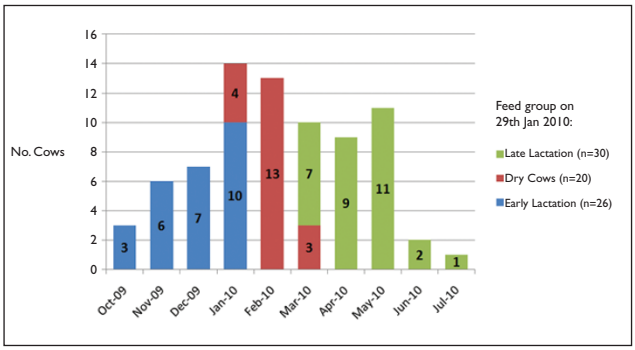

Figure 1 – The 2009/2010 calving pattern of the dairy farm investigated and corresponding feed group by stage of lactation (early, late or dry) as on the 29th of January 2010.

Analyses of the first- and second-cut grass silage were available but no maize silage analysis had been performed and therefore these feed values were estimated (**Table 2**). Computer assessment of diet suitability was performed using the metabolisable energy (ME) and metabolisable protein (MP) modules of a nutritional modelling software package (RumNut V5.1a, Shedfield, Southampton, United Kingdom) (**Table 3**). All nutrient values of concentrate feedstuffs were taken from the same software package. Following discussion with the farmer early and late lactation cows were estimated to have an average daily yield of 32L and 16L respectively. For the purposes of the audit a target milk composition of 3.20% protein and 4.00% fat was used and all cows were assumed to weigh 650kg. The body condition score (BCS) of all of the lactating and dry cows was evaluated using a five-point scale (Edmonson et al., 1989) and compared to published targets (Mulligan et al., 2006). Farmer records of BCS at calving were used to assess condition loss in early lactation cows.

JUSTIFICATION FOR DIETARY CHANGE AND RECOMMENDED ACTIONS

The metabolisable energy based software model indicated that the milking cow diets were providing 129% and 155% of energy requirements to early and late lactation animals respectively and that the dry cow diet was providing 93% of energy requirements (**Table 1** and **Table 3**). Also, the early lactation cow diet was being provided at 115% of appetite (feed consumption as a proportion of maximum voluntary daily intake capacity). These results indicated that it would be unlikely that the milking cows could consume this diet in a 24-hour period. This was supported by farmer observations that the milking cow TMR (fed to both early and late lactation cows as a single group) was never finished within 24 hours. Analysis of the BCS results indicated that four of 14 late lactation cows and nine of 23 dry cows were above target and that five of seven recently calved cows (24-77 days calved) had lost half a unit of BCS. The farmer observed that over conditioned dry cows had gained condition primarily in late lactation rather than during the dry period which was consistent with the findings of the diet analysis.

The late lactation cow diet was found to supply up to 81MJ of excess energy daily (155% of requirement). This could support 2kg of body weight gain per day (Chamberlain and Wilkinson, 2002) and a gain of a single unit of body condition within 23 days. Although not every late lactation cow would gain condition this quickly (depending on variations in voluntary intake and milk yield) significant increase in condition when consuming this diet was considered very likely.

Table 1 – Summary of dietary investigation and recommended changes following review a nutritional assessment on an Irish dairy farm

Diet Details		Early lactation cows[1] (estimated yield 32L[2])	Late lactation cows[1] (estimated yield 16L[2])	Dry Cows[1]	
Diet in use up to nutritional assessment	Composition	TMR: 15kg 1st cut silage;15kg 2nd cut silage; 20kg maize silage; 2kg barley; 2kg wheat		TMR: 7.5kg 1st cut silage; 7.5kg 2nd cut silage; 10kg maize silage; dry cow mineral	
		In-Parlour: 8kg parlour blend 1 (table 5)	In-Parlour: 2kg parlour blend 1 (table 5)		
	Energy[3]	129%	155%	93%	
	Protein[3]	146%	155%	110%	
	Appetite[3]	115%	99%	56%	
Diet advised at nutritional assessment	Composition	TMR: 12.5kg 1st cut silage; 12.5kg 2nd cut silage; 18kg maize silage		TMR: 7.5kg 1st cut silage; 7.5kg 2nd cut silage; 10kg maize silage; dry cow mineral	Within two weeks of calving: TMR: Ad-lib 50:50 grass / maize silage
		In-Parlour: 8kg blend 2 (table 5)	In-Parlour: 1kg blend 2 (table 5)		
	Energy[3]	99.6%	101%	93%	NA
	Protein[3]	118%	97%	110%	NA
	Appetite[3]	97.6%	68%	56%	NA

[1]Body weight of all cows was evaluated at 650 kg. [2]All milk production was evaluated at 3.20 % protein and 4.00 % fat. [3]Percent of requirements supplied.

Table 2 – Feed values of silages and concentrate blends used on an Irish dairy farm during investigation of poor production performance.

Feedstuff	DM* (%)	ME*(MJ/kg)	FME*(MJ/Kg)	CP*(g/Kg)	NE*(UFL/kg)	PDIE*(g/Kg)	PDIN*(g/Kg)	STARCH(g/Kg)
1st Cut Grass Silage	28.6	10.4	8.1	131	0.76	71	77	NA
2nd Cut Grass Silage	34.9	9.9	8.0	126	0.72	70	74	NA
Maize silage (estimated)	30.4	11.5	9.0	88	0.8	68	50	290
Maize Silage (analysed)	22.7	10.6	NA	89	NA	NA	NA	169
Blend 1 (used before								
nutritional assessment)**	88.6	13.5	11.7	284	1.16	158	196	128
Blend 2 (advised at								
nutritional assessment)**	88.7	13.5	11.8	265	1.16	149	179	156
Blend 3 (actually used								
after								
nutritional assessment)**	88.6	131	1.6	211	1.10	120	139	254

*DM=Dry matter; ME=Metabolisable energy; FME=Fermentable metabolisable energy; CP=Crude Protein; NE=Net energy; PDIE=Protein digestible in the small intestine when rumen energy is the limiting factor; PDIN=Protein digestible in the small intestine when rumen nitrogen is limiting

**See table 5 for components of Blend 1, 2 and 3. NA=Not available.

Table 3 – Requirement and supply of energy and protein for different feed groups and diets either as calculated at a nutritional audit on the 29th of January (Metabolisable Energy and Protein) or as calculated during subsequent investigation of poor performance (Net Energy / Protein Digestible in the Small Intestine) on an Irish dairy farm.

		Metabolisable Energy / Protein[3]		Net Energy / Protein Digestible in the Small Intestine[4]		
Feed Group	Requirements / Diet	ME (MJ/day)	MP (g/day)	NE (UFL/day)	PDIE (g/day)	PDIN (g/day)
Early lactation cows[1] (estimated yield 32L[2])	Required	239	1849	19.38	1970	1970
	Used up to nutritional assessment	5306	2706	22.57	2543	2647
	Advised at nutritional assessment[5]	238	2177	17.13	1971	2123
Late lactation cows[1] (estimated yield 16L[2])	Required	153	1039	12.34	1195	1195
	Used up to nutritional assessment[5]	234	1609	17.43	1720	1625
	Advised at nutritional assessment[5]	154	1006	11.10	1028	1060
Dry cows[1] (more than two weeks from calving)	Required	88	436	NA	NA	NA
	Used up to nutritional assessment[5]	82	479	NA	NA	NA
	Advised at nutritional assessment[5]	82	479	NA	NA	NA
Dry cow[1] (within two weeks of calving)	Required	104	501	NA	NA	NA
	Used up to nutritional assessment[5]	82	479	NA	NA	NA
	Advised at nutritional assessment[5]	103	581	NA	NA	NA

[1]Body weight of all cows was evaluated at 650 kg. [2]All milk production was evaluated at 3.20 % protein and 4.00 % fat. [3]Calculated using RumNut V5.1a (Shedfield, Southampton, United Kingdom). [4]Calculated using INRAtion-PrevAlim v3.3 (2006). [5]See Tables 1 and 2 for diet composition and feedstuff nutrient values. NA=Not Applicable

In summary, there was evidence to support excessive condition gain in late lactation cows driven by over-supply of required energy. This excess condition was being carried through the dry period and exacerbating subsequent negative energy balance and condition loss post calving. The negative health, productive and reproductive consequences of excess body condition loss at calving are well accepted (Roche, 2006, Mulligan et al., 2006). The milking cow diets were therefore adjusted with the aim of preventing excessive body condition gain in the remaining late lactation cows by reducing the energy content to match the calculated requirements. As a single TMR was fed to early and late lactation groups both milking cow diets had to be adjusted, with a new in parlour concentrate blend recommended. The new diets were indicated by the same software model to provide 99.6% and 101.0% of energy requirement respectively (**Tables 1** and **3**). As no excess energy supply was found in the dry cow group this diet remained unchanged other than to recommend that dry cows within two weeks of calving be allowed ad-libitum access to a TMR with increased maize silage. This was to provide a higher energy diet when dry matter intake was likely to reduce pre-calving, to allow a period for rumen conditioning to a higher energy diet and to account for an

increased energy requirement in this group (**Table 3**). Finally, it was advised that all over conditioned cows be given 250ml propylene glycol per os for seven days pre and post calving to reduce negative energy balance immediately post-calving.

Events following initial recommended actions

The agreed recommendations were implemented on January 30. Over the next five days the farmer observed reduced yields in early and late lactation groups. The average reduction was approximately 0.9L per cow per day (**Figure 2**). The milk composition was adversely affected over the same period with protein percentage in the bulk–tank reducing from 3.24% on January 29 to 2.96% on February 4 (**Figure 2**).

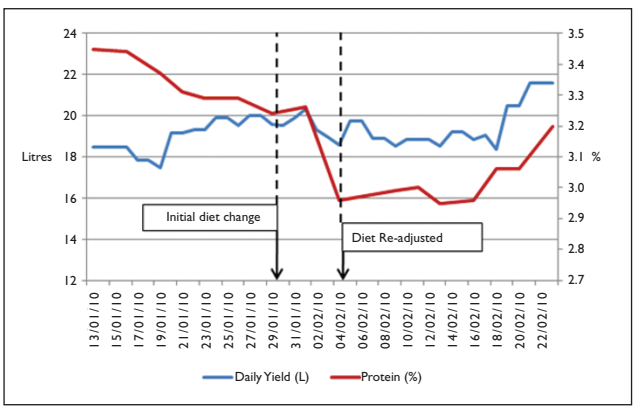

Figure 2 – Average milk yield per cow per day and bulk tank milk protein percentage changes following dietary alterations on an Irish dairy farm.

INVESTIGATION OF POOR PERFORMANCE

An investigation was initiated to identify possible causes for the unexpected reduced performance. The investigation focused on the following key areas: data in-putting errors in dietary computations; errors in dietary factual information collected from the farmer interview; errors in cow production estimations; errors arising from the assumptions of the quality of dietary components and differences in the diets recommended compared to those actually fed. Whenever possible the percentage difference in required energy and protein supplied to cows in early lactation compared to the previously advised diet was reported to quantify the effect of each inaccuracy identified.

FINDINGS FROM THE INVESTIGATION OF POOR PERFORMANCE

Data Input Errors

No data typing input errors were identified from the original assessment.

Milk Yield

The accuracy of the estimated 32L daily milk yield of early lactation cows was assessed by two methods. The herd average 305 day milk yield was calculated from all milk recording data from the previous 12 months (n=7) and average peak yield was estimated by division of the 305 day yield by 190 (Jarrige, 1989). In addition, the range and mean of early lactation cow milk yields (1-70 days in milk) were reviewed from available spring 2009 milk recordings. The average recorded 305 day milk yield from the previous 12 months was 6,850L giving a predicted average peak yield of 36L (Jarrige, 1989). Milk recordings were available from January and April 2009 and indicated average yields of 30 and 35L respectively and a range of early lactation yields from 15-48L. Thus an early lactation yield of 35 L was selected as a likely possible yield. The increased energy and protein requirement resulting from the inaccurately assumed milk yield amounted to 6.4% and 7.1% respectively (**Table 4**).

Maize Silage

A representative 5kg sample of maize silage was collected from the farm and placed in a sealed plastic bag and

Table 4: Results from an investigation into sources of inaccurate data entered into a nutritional modelling software package at a nutritional assessment on an Irish dairy farm

Area Investigated	Result	Change in energy requirements supplied compared to original model	Change in protein requirements supplied compared to original model
Data entry into computer model	No inaccuracy identified	0	0
Estimated average milk yield of early lactation cows	Average peak yield of 35L compared to previous estimate of 32L	-6.4%	-7.1%
Maize Silage Quality	Low quality of laboratory analysis results compared to estimated results (Table 2)	-8.0%	-4.0%
On farm production of TMR[1]	No difference between on farm TMR and original computer model identified	0	0
On farm production of in-parlour blended concentrate ration	Difference between ration included in original model and ration fed on farm (Table 4)	-2.0%	-9.9%
In-parlour feeder calibration	No inaccuracy identified	0	0
Settling of in-parlour blended concentrate feeds	Settling of feedstuffs identified	Variable	Variable
Potential Cumulative Effect	All above	-16.4%	-21.0%

[1]Total Mixed Ration

Table 5 – In-parlour concentrate blends utilised before and during an investigation into reduced performance following dietary changes on an Irish dairy farm

Concentrate blend	Soya %	Barley %	Wheat %	Maize Distillers %	Citrus %	Soya Hulls %	Rape seed %
1 In use before nutritional assessment	30.0	10.0	10.0	25.0	25.0	-	-
2 Advised for use at nutritional assessment	25.0	12.5	12.5	25.0	25.0	-	-
3 Actually used after nutritional assessment	-	20.0	20.0	21.0	-	18.0	21.0

submitted for laboratory evaluation of nutrient composition (Oldcastle Labs, Cogan St, Oldcastle, Co. Meath). The results from laboratory analysis of the maize silage indicated very low dry matter (22.7%), starch (16.9%) and ME (10.6 MJ/Kg) values (**Table 2**). These values were lower than the estimated values originally used and reduced the supply of energy and protein in the diet by 8.0% and 4.0% respectively (**Table 4**).

DIFFERENCES BETWEEN FEED COMPOSITION IN MODEL AND ON FARM

No differences were identified in the composition of the milking cow TMR being used on the farm compared to that entered into the original computer model however the in-parlour feed being used on farm differed from the one advised (**Table 2** and **5**). The effect of the different in-parlour feed used was to reduce the supply of energy and protein by 2.0% and 9.9% respectively (**Table 4**).

IN–PARLOUR FEEDING SYSTEM

Calibration of the in-parlour feeding system was checked by an independent milking machine technician to ensure that the correct weight of concentrate feed was being dispensed. Separation of blended concentrate feeds when fed in-parlour was assessed by collecting a representative 1kg sample 'as-fed' into a sealed plastic bag. This was submitted for laboratory evaluation of nutrient composition (Oldcastle Labs, Cogan St, Oldcastle, Co. Meath). Results were compared with the predicted values for that blend obtained from an Irish feed database (O'Mara, 1998). The in parlour feeding system was found to be accurately calibrated with each feeder dispensing the appropriate weight of feed. However, there were gross differences between the results of laboratory analysis for the blended concentrate feed collected in the parlour and the calculated figures from the feed database (**Table 6**). Separation of the dry concentrate feeds was taken to be the most likely cause of the gross differences observed.

Table 6: Composition of dry blended concentrate feeds fed in parlour as predicted by a computer software package and as analysed in a laboratory during investigation of poor production performance on an Irish dairy farm.

Item	Composition of blend predicted by a computer software package (%)	Composition of blend as analysed in a laboratory (%)
DM	87.3	87.2
Starch	28.9	61.1
Crude Protein	21.1	17.1
Ether Extract	3.6	3.4
Crude Fibre	13.9	8.7
Ash	4.6	3.9

METHODS OF CALCULATING NUTRIENT REQUIREMENTS

Results from the ME based model were compared to results from a net energy (NE) computer software package (INRAtion-PrevAlim v3.3 2006). Net energy nutrient values were obtained for the grass silages (Agri-food and Biosciences Institute, Newforge Lane, Belfast) and for the concentrate feed (O'Mara 1998). The NE model indicated that the advised diet was deficient in its supply of energy by 12% (Table 3).

SUMMARY AND RECOMMENDATIONS FROM THE INVESTIGATION

Results from this investigation revealed several inaccuracies existed in the data collected for use in nutritional modelling software used to direct the initial nutritional changes. Errors in evaluation of average daily milk yield, maize silage quality and concentrates fed in the parlour were estimated to reduce required energy and protein supply by 15.4% and 21.0% respectively compared to the advised diet. These inaccuracies meant that the diet used may only have supplied 84% of required energy and 97% of required protein to cows in early lactation (using the metabolisable energy/protein system).

Only some of the results of this investigation were used to inform alterations during the period of poor performance as there was a significant time-lag in receiving laboratory results. The diet was re-adjusted following the reduced production to increase energy content with poor maize silage quality suspected. The milk yields and composition improved slowly over a period of several weeks during and after the investigation (**Figure 1**).

DISCUSSION

In this case there were several challenges in obtaining accurate data to assess nutritional requirements and dietary supply on a commercial dairy herd. It is the authors experience that underestimation of average milk yield occurs commonly in dairy herds. If available, milk recording data should be used to validate estimated yields for the purposes of dietary evaluation. It should be noted that feeding cows with a range in daily yields from 15L to 48L as a single group will always risk under/over-feeding cows at either end of the spectrum. Failing to have ensiled feeds analysed for nutrient content and altering concentrate feeds according to availability and cost is also common practice amongst dairy farmers. The maize silage in this case had been visually inspected and did not appear to be of poor

quality. It is the authors' opinion that estimating silage quality in this way introduces an uncontrolled risk into nutritional assessment. The difference between the advised concentrate blend and the one actually fed resulted from substitution of constituents by the farmer when some of the advised constituents were not available (Table 5). The cumulative effect of all these factors contributed significantly to the reduced performance in this case.

Some degree of difference between the analysis of the dry blended concentrate feeds 'as fed' and the calculated figures from standard texts was expected. However the magnitude of the difference observed is considered only possible if settling out of component feeds was occurring in the in-parlour feeding system. This would have the effect of inconsistent supply of nutrients to the cow. Feeding dry blended concentrates reduces costs but when settling out occurs it may increase the risk of negative energy balance, ruminal acidosis and mineral deficiencies in individual animals.

The results of this investigation indicated that there was a sudden reduction of energy content of the early lactation cow ration to approximately 16% below requirement. The observed consequences were reduction in volume and protein content of the milk produced. The sudden dietary change described is likely to have reduced both the yield of microbial protein and volatile fatty acids from the rumen (DePeters and Cant, 1992) with subsequent effects on milk production. Insulin and insulin-like growth factor are hormonal regulators of milk protein production and are known to reduce within hours of energy restriction in lactating dairy animals (Chelikani et al., 2004, Griinari et al., 1997). Changes in protein composition of over 0.3% have been observed within four days of changes in circulating insulin (Griinari et al., 1997). The rate and extent of the protein alteration described in this case (approximately 0.28% within five days) were therefore considered as plausible consequences to the marked energy restriction caused by the dietary change.

When the NE system was used to evaluate the advised diet in this case it indicated an important energy deficit in the advised diets. The NE system used in this case accounts for losses in energy from associative effects and therefore is more generous to the cow by assuming greater actual energy requirements. Had this NE system been used at the initial visit it would have offset some of the deficits in energy caused by the errors discussed above. Differences between dairy cow nutritional models have been presented previously (Vermorel and Coulon, 1998).

CONCLUSION

The results of this investigation highlight several areas where error can occur when estimating data for entry into nutritional modelling software packages. In this case, for each error identified the effect was to either over-estimate feedstuff nutrient values or underestimate cow requirements. The cumulative effects of these errors ultimately caused under-feeding of the dairy herd that was likely to be sufficient to cause the observed reduction in performance.

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