Technical Note 1

Energy requirements and ration planning for low-input dairy cows

Introduction

With milk prices expected to remain volatile in the future, it is important that farmers look for options to reduce the costs of milk production. Feed costs represent one of the most significant costs of milk production on most farms, and as such it is important that cows are rationed correctly.

When rationing dairy cows we need to take account of their energy requirements for milk production, the energy required to maintain the cows' basal body activity ('maintenance'), energy required for pregnancy, and energy required (or released by) body weight change. Research over many years has provided information on the energy required for each of these activities, with energy requirements for milk production the largest of these energy demands. Energy required for milk production is estimated from energy output in milk, which is then divided by the efficiency with which metabolisable energy (ME) is used for milk production (k_l). This 'efficiency factor' (k_l) is required as the process of milk production is not 100% efficient, i.e., some energy is wasted during the process. The second major energy demand is for maintenance of basal body activity, which is quantified as metabolisable energy requirement for maintenance (ME_m). The metabolisable energy requirement for maintenance is normally expressed on a 'metabolic liveweight' basis, i.e., liveweight (kg) to the power 0.75 (liveweight $kg^{0.75}$) – this takes account of cows with different body sizes.

Most energy rationing systems currently adopted across Europe have been developed for the 'average' cow (normally a Holstein cow) offered a 'typical' diet. However, within organic and low input systems the use of breeds other than the Holstein (including crossbred cows) is common, and it is uncertain if existing rationing systems are fully applicable to cows of other breeds. In addition, most existing rationing systems have been developed for cows offered moderate or high levels of concentrates. However, it is unclear if these rationing systems are appropriate for cows offered diets containing very high levels of forages, as is normal within organic and low input systems.

Thus important objectives within the SOLID project were firstly, to examine if there are differences in energy utilisation between Holstein-Friesian cows and cows of other breeds, and secondly, to examine if cows offered diets containing very high levels of forage utilised their energy differently from cows offered diets containing moderate or high levels of concentrates.

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How do we measure the efficiency with which cows utilise their energy?

The energy intake of a cow is calculated by multiplying her feed intake by the energy content of her food. On average, approximately 35% to 40% of energy consumed is lost in faeces, urine and methane gas. The remaining energy (i.e. the metabolisable energy) is then available to support milk production, to maintain the cow's body (maintenance), for pregnancy, and for body weight gain. The energy lost in methane, and the energy lost while maintaining the cow's body, can be determined using respiration calorimeters.

Respiration calorimeters (see photo) are really just small 'rooms' where cows remain for a number of days to allow methane production and heat production to be measured. The Agri-Food and Biosciences Institute (AFBI) in Northern Ireland has two of these chambers, and over the last 20 years these have been used to measure the energy utilisation efficiency of over 1000 dairy cows in over 50 studies. A number of different breeds of cow have been used in these studies, and in addition, cows have been offered a wide range of diets, including diets containing high levels of forage and high levels of concentrate. Data collected from these studies were examined within the SOLID project to identify if cows of different breeds have different energy requirements for maintenance, or if the efficiency of energy use for milk production (k_l) was affected by breed. In addition, the data were used to identify if cows offered diets containing high levels of forage have different energy utilisation efficiencies compared to cows offered diets containing medium or high levels of concentrates.

Respiration calorimeter at AFBI-Hillsborough in Northern Ireland – used to measure energy utilisation in cattle

Do cows of different breeds utilise energy with different efficiencies?

In this part of the project energy utilisation data from a number of 'adapted' dairy cow breeds (Norwegian Red, Norwegian Red × Holstein crossbreds and Jersey × Holstein crossbred cows) were compared with data for the Holstein breed. More details on testing the suitability of these breeds for organic and low-input farming can be found in Technical note 8. An initial test demonstrated that the three alternative breeds did not differ from each other in energy utilisation, and this allowed us to combine their data (categorised as 'non-Holstein' cows), and compare it with data for the pure Holstein cows (see Table 1).

Table 1. Breed of cow has no effect on energy utilisation efficiency

	Holstein	Non-Holstein
Metabolisable energy required for maintenance (ME_m, MJ/kg $LWT^{0.75}$)	0.69	0.68
Efficiency with which metabolisable energy is used for milk production (k_l)	0.64	0.64
Feed required to maintain a 600 kg cow (kg DM/day)	6.9	6.8
Feed required to produce 30 kg milk (kg DM/day)	12.1	12.1

There were no significant differences between Holstein cows and non-Holstein cows in the metabolisable energy required to maintain the cows' basal body activities (ME_m, expressed on a 'metabolic liveweight' basis) or in the efficiency of use of metabolisable energy for producing milk. This result demonstrates that there were no differences between Holstein cows and the 'adapted breeds' in terms of their energy requirements for maintenance or milk production. For example, a 600 kg Holstein cow producing 30 kg milk/day will need to consume a similar amount of dry matter (DM) for maintenance and milk production as a 600 kg cow of an alternative breed producing the same quantity of milk (Table 1). In summary, this research confirms that feed rationing systems which have been developed for Holstein cows are also appropriate for cows of other breeds. However, it should be remembered that some alternative breeds of cows are lighter than Holstein cows, and as such they will have a lower energy requirement for maintenance (MJ/day). In addition, some breeds (such as Jersey crossbred cows) produce milk with a higher fat content, and this will increase their energy requirement for milk production.

Do dairy cows utilise predominantly forage based diets less efficiently?

This part of the project examined the effects of concentrate level in dairy cow diets on metabolisable energy requirements for maintenance, and on the efficiency of utilisation of metabolisable energy for milk production. To facilitate this evaluation, the whole AFBI dataset from the calorimeter chambers was divided into four categories according to the proportion of forage in the diet (on a DM basis), namely cows offered diets containing less than 30% forage, 30-59% forage, 60-99% forage and 100% forage. The efficiency of energy utilisation of cows within each of these four groups was examined, and the results are presented in Table 2.

Table 2: Increasing dietary forage proportion increases maintenance energy requirement of dairy cows

	Forage proportion in the diet (DM basis)			
	Less than 30%	30%–59%	60%–99%	100%
Efficiency with which metabolisable energy is used for milk production (k_l)	0.64	0.64	0.63	0.63
Metabolisable energy required for maintenance (ME_m, MJ/kg $LWT^{0.75}$)	0.61	0.65	0.67	0.68
% increase in metabolisable energy required for maintenance, compared to a diet with less than 30% forage		7%	10%	11%

The proportion of forage in the diet did not alter the efficiency with which diet energy was used for milk production, i.e., k_l was similar for all diets. However, increasing the proportion of forage in the diet significantly increased the metabolisable energy requirement for maintenance (MJ per kg metabolic body weight). When compared with diets containing less than 30% forage, the metabolisable energy requirement for maintenance of cows offered diets containing 30-59% forage, 60-99% forage and 100% forage was increased by 7%, 10% and 11%, respectively. This result indicates that a 600 kg cow consuming a high forage diet (rather than a high concentrate diet), will need to eat approximately 0.7 kg more DM per day to supply its energy requirement for maintenance. The increase in feed intake required would be greater than 0.7 kg DM/day for cows offered diets containing poor quality forages. This is because cows offered high forage diets may require more time and a greater effort to eat, ruminate and digest these bulky forage based diets. This action can increase the basal metabolic rate of their body activities, and this in return requires additional energy (MJ per kg body weight). Thus, when designing rations for cows within low-input and organic systems, the higher maintenance energy requirements of these cows need to be taken into account.

Conclusions and recommendations

The results of this work suggests that cows of adapted breeds (e.g., Norwegian Red and crossbred cows) have similar maintenance energy requirements as Holstein cows, and utilise energy for lactation with a similar efficiency as Holstein cows. Thus existing rationing systems are appropriate for a range of dairy cow breeds. However, the metabolisable energy requirement for maintenance (MJ per kg metabolic body weight) obtained within the SOLID project is much higher than currently adopted in the feed rationing systems used in Germany and France, while similar to the current UK feed rationing system (Feed into Milk models). These differences are illustrated in Figure 1 for a 600 kg cow. Using the data obtained from the SOLID project, this cow would need to consume 7.1 kg DM/day for maintenance, compared to 6.9 kg DM/day in UK, 5.1 kg DM/day in France and 5.0 kg DM/day in Germany.

The results also demonstrate that dairy cows managed under low input or organic farming regimes may require more feed energy for maintenance of their basal body activity than those managed within higher concentrate input systems. Cows offered high forage diets may require more time and a greater effort to eat, ruminate and digest these bulky forage based diets. This issue has not been considered within energy feeding systems for dairy cows in many European countries. Thus many existing systems may underestimate the feed requirements of dairy cows managed within low concentrate input systems.

In summary, in order to improve the economic and environmental sustainability of dairy farming in Europe, there is an urgent need to upgrade current energy rationing systems for low input and organic dairy farming, taking account of the findings of the current work.

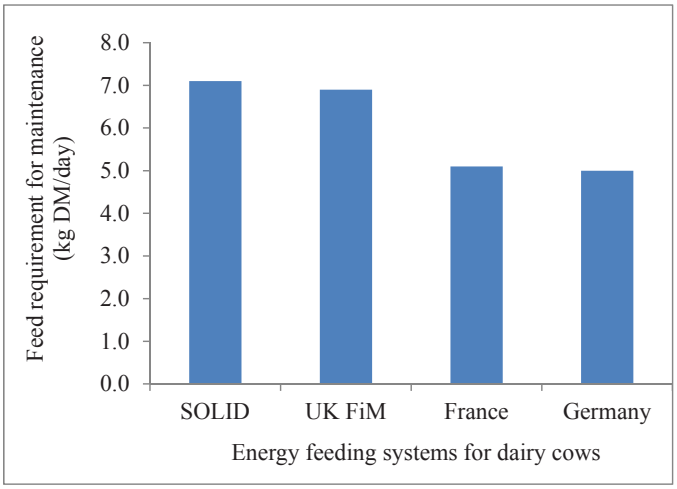

Figure 1: Comparison of feed required (kg DM/day) to maintain a 600 kg dairy cow, when calculated using information from the SOLID project and energy feeding systems currently used in UK, France and Germany.

Cows of different breeds and genotypes were found to utilise energy for milk production with similar efficiencies. However, cows managed on predominantly forage diets have a greater energy requirement for maintenance. This finding should be incorporated into dairy cow rationing systems within Europe.

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