Evaluation of the German net energy system and estimation of the energy requirement of cows on the basis of an extensive data set from feeding trials

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Introduction

The maintenance energy requirement (NE_m) of the dairy cow is assumed to be 0.300 – 350 MJ net energy (NEL)/kg metabolic live weight ($LW^{0.75}$) in the systems established in Europe and USA (INRA 1989, AFRC 1993, GfE 2001, NRC 2001). The efficiency of utilisation of metabolizable energy (ME) for milk production (k_l) is in the range of 0.60 – 0.63 in these systems. Recent results of Agnew et al. (2003) indicate both a higher NE_m and a higher k_l.

Materials and Methods

A comprehensive data set (n = 24,583; means of two lactation weeks of individual cow measurements) obtained from long term feeding experiments with lactating dairy cows carried out in 9 research institutes in Germany, Austria and Switzerland (Gruber et al. 2005) was used to evaluate the current German feeding standards (GfE 2001). The experiments were carried out with Holstein Friesian, Brown Swiss and Simmental cows and the data showed a wide variation in animal parameters [(mean, ± SD, range); days in milk (138 ± 78, 2 – 459), milk yield (24.3 ± 8.1, 2.2 – 60.6 kg/d), feed intake (18.5 ± 3.5, 5.4 – 31.6 kg dry matter (DM)/d)] as well as nutritional factors [NEL content (5.9 ± 0.5, 4.1 – 7.4 MJ/kg DM), proportion of concentrate in the diet (25.6 ± 17.9, 0.0 – 81.1% of DM)]. The NEL system was validated by regressing NEL requirement, calculated on the basis of its assumptions [0.293 MJ NEL/kg $LW^{0.75}$ for maintenance, NE in milk = 0.38 × fat + 0.21 × protein + 0.95 (Tyrrell & Reid 1965), 25.5 MJ NEL for gain and 20.5 MJ NEL for loss of 1 kg LW, NEL pregnancy = (0.044 × exp(0.0165 × day of gestation/0.175 × 0.6)], on actual NEL intake (MJ), considering the decrease of dietary energy content with feeding level in the requirements (GfE 2001). ME requirement in this study was estimated using multiple regression analysis with $LW^{0.75}$ (kg), milk energy output (LE, MJ/d) and live weight change (LWC, kg/d) as independent variables.

Results and Discussion

The results of the validation of the NEL system are shown in Fig. 1A. The regression equation shows a bias of 3.7% of mean squared prediction error (MSPE) (mean NE requirement = 124.5 MJ, mean NE intake = 121.1 MJ) and an even higher error caused by a systematic deviation of the regression line from 1 (10.9% of MSPE). In addition, there was a high prediction error (MPE = 17.8 MJ NEL (= 14.7%), 85.4% of MSPE).

In order to find reasons for the relatively low correlation, a multiple regression analysis was carried out relating ME intake (MJ/d) to $LW^{0.75}$, LE and LWC. Requirement for pregnancy was calculated according to GfE (2001) and subtracted from total ME intake:

$$\text{ME intake} = 0.652 \times LW^{0.75} + 1.41 \times LE + 16.6 \times LWC \qquad (1)$$

$$R^2 = 0.717, \ RSD = 24.1 \text{ MJ}$$

The results reveal a considerably higher maintenance energy requirement (ME_m = 0.652 MJ/ kg $LW^{0.75}$) than in the other energy systems (ca. 0.500 MJ ME/kg $LW^{0.75}$; INRA 1989, AFRC 1993, GfE 2001, NRC 2001), but they are in line with recent observations in Northern Ireland (0.600 – 0.660 MJ ME/kg $LW^{0.75}$; Agnew & Yan 2000, Agnew et al. 2003, FiM 2004); k_l is also higher than in current systems (1/1.41 = 0.71). Agnew & Yan (2000) and Agnew et al. (2003) reported values of k_l of 0.64 – 0.69, based on literature data since 1976 and their own experimental results. The higher k_l value could be due to an increased proportion of ruminally undegraded nutrients in the actual diets, resulting in decreased microbial fermentation losses and a relatively lower chewing activity per kg DM (Susenbeth et al. 2004). Equation (1) gives a much lower estimate for the energy content for mobilisation/retention of body reserves (E_{LWC} = 16.6 × 0.71 = 11.8 MJ/kg) than usually expected. Further, the relationship between LWC and calculated net energy balance is not significant (Fig. 1B). Actually, LWC cannot be regarded as a useful predictor of energy balance. In their review, Agnew & Yan (2000) concluded that a fixed energy value for LWC as used in NRC and European systems is incorrect since it varies with body condition (BCS) and change of lactation (Tamminga et al. 1997). Unfortunately, BCS is not available in these data. Agnew & Yan (2000) assumed that both an increased internal organ mass associated with higher feed intake and a higher protein content of the body (lower body condition score) of high yielding dairy cows are possible reasons for the enhanced maintenance energy requirement. This is supported by the present results when considering an interaction term of [live weight × milk yield] in the following equation:

$$\text{ME intake} = (0.637 + (0.0088 \times \text{milk yield})) \times LW^{0.75} + 1.09 \times LE + 16.7 \times LWC \qquad (2)$$

$$R^2 = 0.722, \ RSD = 23.8 \text{ MJ}$$

It is concluded that recent data from feeding trials provide evidence that current NE systems for lactating dairy cows underestimate the energy requirement for maintenance and overestimate the requirement for lactation, leading to a higher total energy requirement at lower milk yields and a lower total requirement at higher yields (> 30 kg/d). These findings should lead to more accurate diet formulation for lactating dairy cows.

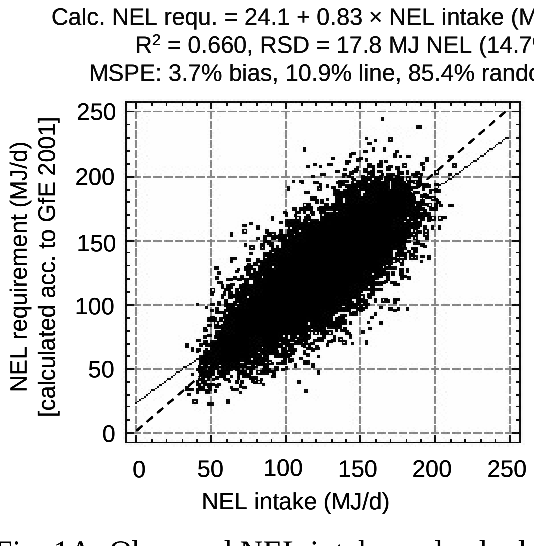

Fig. 1A: Observed NEL intake and calculated NEL requirement (based on GfE 2001)

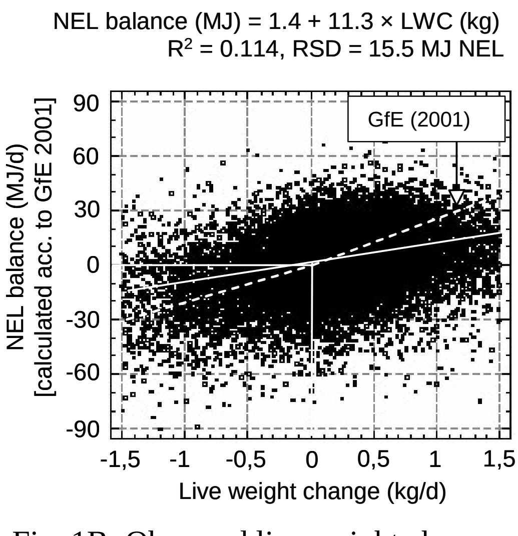

Fig. 1B: Observed live weight change and calculated NEL balance