O11 Energy requirements for maintenance and lactation in Holstein Friesian dairy cattle

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Introduction

The current energy evaluation system for dairy cattle in the Netherlands and Belgium already dates from the seventies (Van Es, 1975). As production potential of Holstein Friesian (HF) cows has increased a lot in the past decades, an update of the energy evaluation system is desirable. A recent study from Spek and Šebek (2019) indeed indicated increased maintenance energy requirements in modern HF cows. The aim of the current study was to derive the energy requirements for maintenance and the efficiency factors of metabolizable energy (ME) utilization in modern HF dairy cattle, based on a large database with energy balance studies in climate-controlled respiration chambers.

Material and Methods

A database was composed with 324 individual animal observations from 11 climate respiration studies that were performed from 2004 till 2018 at Wageningen University & Research, the Netherlands. The average values (mean ± SD) for metabolic bodyweight ($BW^{0.75}$), dry matter (DM) intake and milk production in the dataset were 122.3 ± 9.11 kg, 17.3 ± 3.21 kg/day, and 27.1 ± 8.35 kg/day, respectively. The average diet characteristics (per kg DM) were 173 ± 33.1 g crude protein, 383 ± 46.8 g NDF, 133 ± 80.4 g starch, 36 ± 10.7 g crude fat, and 78 ± 11.8 g crude ash. A number of linear and non-linear models was tested to estimate the energy requirement for maintenance (ME_M) as well as the efficiency factors to convert ME intake (MEI) into milk (k_l), MEI into growth (k_g), for body energy reserves into milk (k_t), and for MEI into milk fat, milk protein, and milk lactose. We considered either MEI or energy excreted in milk (E_L) as dependent variable. Further, it was tested whether relating k_l to the ratio ME/gross energy (GE) of the diet (q) could improve the model fit. It appeared that MEI models resulted in better predictions than E_L models and models that included separate utilization efficiencies of ME into milk fat, milk protein, and milk lactose showed a better fit (lower AIC value) than one conversion factor for milk, but the improvement was considered too small to adopt this complex model in practice. Hence, the following final model was chosen:

$$MEI = ME_M + (E_L - k_t \times MOB)/(\beta 1 + \beta 2 \times q) + RET/kg + study + error$$

With MEI, ME_M, E_L, MOB and RET expressed in kJ/day/kg $BW^{0.75}$; MOB = energy mobilized from body tissues; RET = energy retained in body tissues; β1, β2 = regression coefficients; q=ME/GE of the diet; study = random effect of study; error = residual error term
The NLMIXED procedure of SAS 9.4 was used to fit the model to the dataset.

Results and Discussion

Based on the most complex model eight observations with studentized residuals larger than |2.5| were considered as outliers. The resulting ME_M was 562 kJ/day/kg $BW^{0.75}$, which is 15% higher than the ME_M of 488 kJ/day/kg $BW^{0.75}$ in Van Es (1975). Even higher ME_M was found by Agnew and Yan (2000) and Moraes et al. (2015) (582 and 570 kJ/day/kg $BW^{0.75}$, respectively). The efficiency factor k_l is dependent on q and equals $0.405 + 0.418 \times q$, and with the average dataset value for q of 0.636 the value for k_l is 0.671. The efficiency factors k_g and k_t are 0.851 and 0.807, respectively. In the current Dutch energy evaluation system (Van Es, 1975) k_l is also dependent on q as follows: $0.463 + 0.24 \times q$; a q-value of 0.636 results in a k_l value of 0.616, which is 8% less efficient than the value of 0.671 using the established relationship from this study. Agnew and Yan (2000) reported a value of 0.637 for k_l and Moraes et al. (2015) reported 0.62, 0.81 and 0.79 for k_l, k_t and k_g, respectively.

Conclusion and Implications

The results of this study confirm the higher maintenance energy requirements of modern HF cows and gives evidence for increased efficiencies of utilization of ME for milk production as well as for body weight gain and for utilization of body reserves for milk production. All of this underlines the need to update the current Dutch energy evaluation system.

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