Short Communication: Effects of Feeding Level on Energy Concentration in Grass Silage-Based Diets Offered to Dairy Cattle

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ABSTRACT

Twelve grass silages were offered to sheep as a sole diet at maintenance and to lactating dairy cows *ad libitum* as mixed silage and concentrates diets ($n = 13$ diets). Fecal and urinary energy outputs were measured for silages and mixed diets. Digestible energy (DE) and metabolizable energy (ME) concentrations for mixed diets with sheep at maintenance were estimated based on the silage dry matter (DM) proportion obtained in the cattle trials, the silage energy utilization values (methane energy-predicted) determined using sheep, and tabulated concentrate values. A comparison of dietary mean data ($n = 13$) indicated that concentrations of ME ($P < 0.01$) and DE ($P < 0.001$) in mixed diets were significantly lower for cows at production feeding level than for sheep at maintenance. The reductions were proportionately 0.015 and 0.020 with each unit increase in feeding level above maintenance, respectively. These ME and DE data were also used to evaluate the feeding level correction factors previously proposed by Van Es (1975) (ME, 0.018) and Yan et al. (2002) (ME, 0.016; DE, 0.025) using the mean square prediction error technique. The ME correction factor proposed by Yan et al. (2002) had a greater prediction accuracy than that proposed by Van Es (1975) for the prediction of ME concentration in mixed diets offered to dairy cattle at production feeding level.

(Key words: dairy cattle, feeding level, energy concentration, evaluation)

Abbreviation key: DE = digestible energy, ME = metabolizable energy, MSPE = mean square prediction error.

Van Es (1975) proposed a feeding level correction factor of 0.018 for metabolizable energy (ME) intake; this value has been adopted within the United Kingdom dairy cattle energy feeding system (Agricultural and Food Research Council, 1993). The feeding level is de-

fined as ME intake divided by ME requirement for maintenance. Thus, dietary ME concentration is reduced by 0.018 proportionately with each unit increase in feeding level above maintenance (Agricultural and Food Research Council, 1993). However, in view of the increased yield potential and intake capacity of dairy cows during the last 25 yr, the appropriateness of this feeding level correction factor needs to be re-examined. For example, regression techniques on recent data from 317 dairy and beef cattle (Yan et al., 2002) indicated the feeding level correction for ME to be lower (0.016). In addition, Yan et al. (2002) have developed 2 multiple regression equations to predict dietary ME and digestible energy (DE) concentration for cattle at any production feeding level using dietary ME and DE concentrations determined at maintenance. The objectives of the present study were to examine the effects of feeding level (3.03 to 3.99) on DE and ME concentrations in diets offered to high genetic merit cows and to evaluate the feeding level correction factors and equations proposed by Van Es (1975) and Yan et al. (2002).

Twelve grass silages, differing in harvest date, DM concentration, and digestibility, were produced from perennial ryegrass based swards. Mean silage analysis data are presented in Table 1. These silages were mixed with either high or medium protein concentrate supplements (silage DM proportion, 0.33 to 0.72) to produce 13 mixed diets. The high protein concentrate contained (kg/kg fresh weight) barley, 0.410; soybean meal (48% CP), 0.413; rapeseed meal, 0.112; molasses, 0.030; and a mineral and vitamin supplement, 0.035. The medium protein concentrate contained (kg/kg fresh weight) barley, 0.300; maize gluten meal, 0.218; molassed sugar beet pulp, 0.150; citrus pulp or soybean hull, 0.150; soybean meal (48% CP), 0.167; and a mineral and vitamin supplement, 0.015. Full details of each of the silages and mixed diets offered were reported by Ferris et al. (2003). The mixed diets were offered *ad libitum* to late lactation Holstein-Friesian cows (3 cows per diet) tied in individual stalls for 21 d. Fecal and urinary energy outputs were measured during the final 6 d. During the 6-d measurement periods, samples of each silage were taken daily, sealed in polythene bags, and stored at -20°C . These frozen samples were subse-

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Table 1. Silage composition and performance of lactating dairy cows offered mixed diets at production feeding levels.

	Minimum	Maximum	Mean	SD
Silage chemical analysis (n = 12)				
ACTDM, ¹ kg/kg	0.198	0.337	0.259	0.0490
Ash, kg/kg DM	0.073	0.113	0.091	0.0130
CP, kg/kg DM	0.120	0.203	0.162	0.0241
Acid detergent fiber, kg/kg DM	0.264	0.366	0.311	0.0363
Neutral detergent fiber, kg/kg DM	0.425	0.586	0.515	0.0524
Gross energy, MJ/kg DM	17.5	19.7	19.0	0.62
pH	4.05	4.56	4.18	0.142
Ammonia N/Total N	0.080	0.156	0.106	0.0226
Cow data (n = 13)				
Milk yield, kg/d	12.6	21.4	17.4	2.77
Live weight, kg	541	745	628	53.6
Silage proportion, kg/kg DM	0.33	0.72	0.57	0.157
DMI, kg/d	14.49	19.58	16.96	1.351
DE concentration, MJ/kg DM	12.97	14.94	14.04	0.604
Feeding level ²	3.03	3.99	3.42	0.302

¹ACTDM = Alcohol-corrected toluene DM.²As determined by Agricultural and Food Research Council (1993).

quently thawed and offered at maintenance feeding level to mature sheep (four sheep per silage) confined in digestibility crates. Silages were offered for 21 d, and fecal and urinary energy outputs were determined during the final 6 d. Methane production with the mixed diets offered to dairy cows and the unsupplemented silage diets given to sheep was estimated according to Yan et al. (2000) and Blaxter and Clapperson (1965), respectively. Using silage DM proportions in the mixed diets offered to dairy cows, the silage energy utilization data obtained using sheep, and tabulated concentrate data (Ministry of Agriculture, Fisheries and Food, 1990), DE and ME concentrations were estimated for mixed diets with sheep at maintenance feeding level.

A sensitivity analysis was used to examine the impact of using tabulated concentrate data. This analysis focused on barley, a major ingredient in each of the concentrate supplements offered. The impact of either increasing or decreasing the tabulated DE or ME concentration of barley (Ministry of Agriculture, Fisheries, and Food, 1990) by proportionately 0.05 and then recalculating the data for the mixed diets with sheep was examined. Increasing or decreasing the tabulated values by 0.05 had only a small and non-significant effect on the DE or ME concentration in the mixed diets with sheep at maintenance. This justifies the use of tabulated DE or ME values.

In a review of 72 comparisons from 17 comparative studies published since 1951, Yan et al. (2002) examined the impact of using OM digestibility derived from sheep for cattle at maintenance. The linear relationships in OM digestibility between the 2 species indicated no significant differences with concentrates, mixed diets, and good quality forages. This result was

similar to the conclusion of a review of early studies reported by Aerts et al. (1984) that at maintenance, sheep and cattle did not differ systematically in digesting good quality grassland products. The mixed diets used in the present study had an OM digestibility, measured in cattle, ranging from 0.69 to 0.75 (mean, 0.72; SD, 0.019). Therefore, at maintenance feeding level, ME or DE concentration of mixed diets estimated in the present study with sheep is unlikely to differ greatly from those that would be with cattle.

Results were determined using mean data for each diet (n = 13). Performance data for the lactating dairy cows are presented in Table 1. Feeding levels, calculated as ME intake divided by ME requirement for maintenance (Agricultural and Food Research Council, 1993), ranged from 3.03 to 3.99, with a mean of 3.42 (SD, 0.302). Concentrations of ME (11.93 vs. 12.37 MJ/kg DM; $P < 0.01$) and DE (14.04 vs. 14.74 MJ/kg DM; $P < 0.001$) in mixed diets determined in cows at production feeding level were significantly lower than those estimated in sheep at maintenance. Reduction rates ((maintenance – production)/maintenance) at the mean feeding level of 3.42 were 0.036 and 0.048, respectively. With each unit increase in feeding level above maintenance, ME and DE concentration in mixed diets decreased by, proportionately, 0.015 and 0.020 (reduction rate divided by feeding level above maintenance), respectively. Although the reduction (0.015) in dietary ME concentration is close to that (0.016) reported by Yan et al. (2002) using linear regression techniques, this value is lower than that (0.018) proposed by Van Es (1975) and currently adopted by the Agricultural and Food Research Council (1993).

Table 2. The evaluation of feeding level correction factors and equations proposed by Van Es (1975) and Yan et al. (2002) using treatment mean data (n = 13) and mean square prediction error (MSPE) techniques.

References	Factors	Energy ¹			MSPE	Proportion of MSPE		
		Predicted	Actual	Bias		Bias	Line	Random
ME concentration								
Yan et al. (2002)	Eq. [1] ²	11.9	11.9	−0.04	0.10	0.02	0.03	0.95
	0.016	11.9		−0.04	0.09	0.01	0.01	0.98
Van Es (1975)	0.018	11.8		−0.09	0.10	0.09	0.01	0.90
DE concentration								
Yan et al. (2002)	Eq. [2] ³	14.0	14.0	−0.04	0.09	0.02	0.07	0.91
	0.025	13.9		−0.19	0.15	0.23	0.03	0.74

¹Measured in MJ/kg DM.

²ME_{prod} = [1.068 - 0.019 * (FL-1)] * ME_{maint} - 0.755, where ME_{prod} = metabolizable energy (ME) concentration at production feeding level, FL-1 = feeding level above maintenance, and ME_{maint} = ME concentration using data obtained from sheep at maintenance.

³DE_{prod} = [0.891 + (-0.027 + 0.018 * S/T) * (FL-1)] * DE_{maint} + 1.355, where DE_{prod} = digestible energy (DE) concentration at production feeding level, S/T = silage DM as a proportion of total diet, FL-1 = feeding level above maintenance, and DE_{maint} = DE concentration using data obtained from sheep at maintenance.

The present data set was also used to evaluate the feeding level correction factors of Van Es (1975) (ME, 0.018) and Yan et al. (2002) (ME, 0.016; DE, 0.025) and the prediction equations (Eq. [1] and [2]) developed by Yan et al. (2002). These equations were developed to calculate dietary ME or DE concentration for cattle at production feeding level (ME_{prod} or DE_{prod}) using data obtained from sheep at maintenance (ME_{maint} and DE_{maint}), feeding levels above maintenance (FL-1; Agricultural and Food Research Council, 1993), and silage DM as a proportion of total diet (S/T):

$$\text{ME}_{\text{prod}} = [1.068 - 0.019 * (\text{FL}-1)] * \text{ME}_{\text{maint}} - 0.755; \quad [1]$$

$$\text{DE}_{\text{prod}} = [0.891 + (-0.027 + 0.018 * \text{S/T}) * (\text{FL}-1)] * \text{DE}_{\text{maint}} + 1.355. \quad [2]$$

This evaluation (Table 2) was undertaken using mean square prediction error (MSPE) analysis (Rook et al., 1990). Equation [1] and the ME correction factor (0.016) of Yan et al. (2002) predicted dietary ME concentration at production feeding level with a smaller bias than the ME correction factor (0.018) of Van Es (1975) (0.04 and 0.04 vs. 0.09 MJ/kg DM). The latter had a greater bias error and a smaller error of random variation as a proportion of MSPE than the former 2 approaches. For dietary DE concentration at production feeding level, Eq. [2] produced a smaller bias (0.04 vs. 0.19 MJ/kg DM), a smaller MSPE, and a greater proportion of error from random variation than the correction factor of 0.025 proposed by Yan et al. (2002). This result may reflect the latter not taking into account the dietary

forage proportion and the rate of depression of energy digestibility associated with increasing feeding level being reduced with increasing dietary forage proportion (Yan et al., 2002). In conclusion, Eq. [1] and [2] and the ME correction factor of 0.016, reported by Yan et al. (2002), provide good predictions of DE and ME concentrations in mixed diets for cattle at production feeding level, using DE and ME data obtained from sheep at maintenance feeding level.

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