A METHOD OF ESTIMATING TOTAL ENERGY REQUIREMENTS FOR GRAZING DAIRY COWS FROM MILK YIELD

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SUMMARY

A method of estimating the annual energy requirements for a dairy herd in Queensland was developed from nutritional standards and observed correlations of liveweight and milk production obtained from farm survey data. Maintenance energy requirements were calculated from liveweight estimated from milk yield, and together with energy requirements for milk yield, and allowances for walking and liveweight gain, the total energy requirements for the average cow were calculated. The method allows farmers and advisers to calculate herd energy requirements from easily obtainable milk production data and is useful in formulating rations.
Keywords: milk production, liveweight, energy requirements

INTRODUCTION

The development of a feeding plan for a dairy herd is an essential component of any dairy enterprise. It allows the farmer to allocate paddocks to various pasture and crop species and to estimate the resources required for the following year. The effectiveness of such a plan depends, in part, on the estimation of the future energy requirements of the dairy herd.

The National Research Council (NRC 1989) state in their nutrient requirements for dairy cattle that estimates of a cow’s nutritional requirements are based on the energy needed for maintenance, milk production and weight gain. Milk production is measured directly, and the energy requirements for this are readily estimated from known standards. However, liveweight of cows is often not known on dairy farms and estimates of maintenance requirements are more difficult to obtain.

This paper examines the use of milk production data to estimate liveweight and hence maintenance energy requirements of cows, and from this, the total energy requirements for the herd. The method uses data obtained from 14 dairy herds in Queensland to estimate the liveweight of herds from milk yield and subsequently the total energy requirements for a herd from milk yield.

MATERIALS AND METHODS

Liveweight and milk production data from each cow were obtained from 14 dairy farms in south-east Queensland. Milk production levels on these farms were obtained from monthly herd recording figures with the rolling herd average in December varying from 3,560 to 8,690 L per cow per lactation. The breed was predominantly Holstein-Friesian. Herd sizes varied from approximately 60 to 180 milkers and animals were weighed once after morning milking during a 3 week period in January 1995.

Linear regression techniques (SAS 1987) were used to estimate the liveweight of the average cow in the herd from average milk production per cow. The estimated maintenance energy requirements of the average cow were calculated from this liveweight estimate and NRC (1989) coefficients for metabolisable energy requirements. From the milk yield and estimated maintenance energy, total energy requirements of the average cow in the herd were predicted using standard energy values required for liveweight gain and milk production (NRC 1989).

RESULTS

Mean milk production and liveweight were calculated for each farm and relationships between liveweight and milk production were examined for both milking and dry cows (Figure 1). Two linear regression equations relating milk production to average dry cow weights and milking cow weights were developed with the highest correlation shown to be with the dry cows (Table 1).

Although the dry cow weight model was more precise, the milking cow weight model was used as it directly related to the average cow in the herd. This would provide a more realistic estimate of the energy requirements of the whole herd. The dry cow weight, minus estimated foetus and membranes weight, would still over-estimate herd energy requirements as it relates only to freshly calved animals.

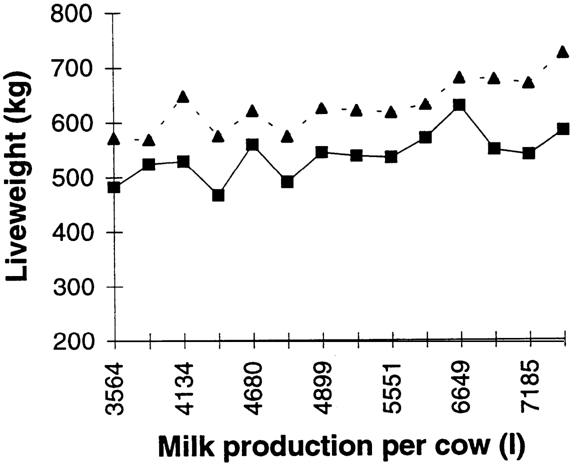

Figure 1. Relationship of mean milk production per cow and the liveweight of dry (-s-) and lactating (-n-) cows in 14 surveyed dairy herds in Queensland

Table 1. Parameters for the linear regression of milkers and dry cows liveweight (LW) versus average milk production per cow per lactation (L) for the mean of 14 herds in the study. Standard errors for the intercept and regression coefficient are shown in brackets

Class of stock	Intercept (kg LW)	Regression coefficient (kg LW/L milk)	Coefficient of determination	F value	Root mean squared error
Milker	433.0 (35.8)	0.019 (0.006)	0.44	9.3	32.5
Dry	471.3 (27.8)	0.028 (0.005)	0.74	34.1	25.3

Megajoules (MJ) of energy required for maintenance were then calculated using the liveweight formula for estimating maintenance energy (NRC 1989) as shown below:-

$$ME\ (MJ) = 0.55*LW^{0.75}$$

Where-

ME is Metabolisable Energy,
MJ is Megajoules, and
LW is the liveweight of the animal (kg).

A linear regression equation was again developed producing output in terms of energy requirements for maintenance for the average cow over a 300-day lactation (Table 2).

Table 2. Parameters for the linear regression for energy requirement for maintenance from average milk production per lactation for an average cow in each of 14 herds. Standard errors for the intercept and regression coefficient are shown in brackets

Intercept (MJ ME)	Regression coefficient (MJ/ L milk)	Coefficient of determination	F value	Root mean squared error
15728 (916.9)	0.49 (0.16)	0.44	9.3	832.8

The total energy requirement for the average cow was then calculated by adding energy required for maintenance to the milk production requirement. NRC (1989) have calculated the energy requirements for each litre of milk produced and these requirements vary according to the milk fat percentage (Table 3).

Table 3. Energy requirements for each litre of milk for different fat percentages (adapted from NRC 1989)

Fat percentage	3.0	3.5	4.0	4.5	5.0	5.5
ME (MJ /L)	4.34	4.67	5.03	5.36	5.68	6.01

These values can be multiplied by the average milk production per lactation according to the fat content of milk for the herd (obtained from herd recording summaries). The resultant value is then added to maintenance energy to obtain the energy requirements for maintenance and milk production for the average cow in the herd. The additional energy associated with pregnancy is estimated to be 30 per cent of the energy required for maintenance alone (NRC 1989). Assuming a 450 day inter calving interval (K. McGuigan, pers. comm.) this would mean that 60 per cent of the herd are pregnant at any given time thus allowing us to scale the 30 per cent down to 18 per cent to provide an average energy figure for pregnancy.

The final equation for predicting the energy requirements for maintenance, pregnancy and milking for the average cow over a lactation is:

$$\text{Total energy} = (15728 + 0.49*M)*P+E*M \quad \text{(equation 1)}$$

Where-

M=total milk for the lactation,

P=1.18 (a constant allowing for the extra energy required for pregnancy), and

E = the energy required to produce a litre of milk at a given fat percentage, taken from Table 3.

For example, an average cow in a herd producing 4,000 litres of milk at 4.0 per cent fat per lactation would require approximately 40,990 MJ of energy for the lactation.

Equation 1 does not allow for the weight gain or loss individual cows experience throughout a lactation and assumes that the weight gain for the herd is zero. This may not be the case in some herds as average liveweight may be increasing from year to year and additional energy requirements should be added to equation 1 to cater for estimated weight increases for the herd. Average herd weight gain could be estimated from 1 annual weighing of the whole herd. Other energy requirements include walking, and if these distances are large, allowances would have to be made for the extra energy required. This can only be done on an individual farm by farm basis. The values in Table 4 provide some estimated values for walking and weight gain and can be added to equation 1 depending on the circumstances of an individual farm. The values are based on a mean of 2 MJ per cow per walking kilometre and 50 MJ per kg liveweight gain (ARC 1980).

Table 4. Additional energy requirements during a lactation of 300 days for walking and weight gain

Distance walked (km/day)	ME (MJ/cow)	Average liveweight gain (kg/cow.year)	ME (MJ/cow)
1	600	10	500
2	1200	20	1000
3	1800	30	1500
4	2400	40	2000

DISCUSSION

This method provides an estimate of the maintenance energy requirements for cows in a herd. The addition of maintenance to the energy required for milk production, walking and average herd weight gain gives the farmer an estimate of the total energy requirements for an average cow in the herd. This predicted energy requirement allows farmers to estimate the amount of food the herd will require for the year, thus enabling them to plan their feeding schedules accordingly. For example, a 92 cow herd producing an average of 5269 litres of milk at 3.5 per cent butterfat and walking an average distance of 2 km/day with an expected average weight gain for the year of 20 kg would require 4.45×10^6 MJ of energy or 494 tonnes of dry matter per lactation (assuming an average value of 9 MJ per kg dry matter). For an annual feed plan this can be adjusted to 601 t to allow for 365 days. The maintenance proportion of this total is 221 t per lactation (269 t/year) or 45 per cent of the total requirement. It should be noted that the constant allowing for the extra energy for pregnancy of 1.18 is based on the average Queensland inter-calving interval of 450 days. This may need to be altered if the individual farm inter-calving interval is greatly different from that figure.

Other methods of predicting the liveweight of cows without weighing such as girth measurements have been developed (Davis *et al.* 1961) and good relationships between girth measurements and weight have been demonstrated (Heinrichs and Hargrove 1994; Heinrichs and Hargrove 1987). These measurements are inconvenient for farmers as every cow in the herd would have to be measured. On the other hand, 1 of the most easily obtainable measurements on a dairy farm is daily herd milk production as most farmers have daily milk tanker pick-ups.

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