DEVELOPMENT OF THE CAMDAIRY NUTRITIONAL MANAGEMENT MODEL

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SUMMARY

The paper describes changes which have been made to the CamDairy computer model to improve accuracy of performance prediction and ration formulation. These include incorporation of a new metabolisable protein system. Possible residual benefits from current feeding strategies on future lactation performance are now considered. The range of available nutrients and their characteristics has been considerably expanded. The user interface has been simplified and extensive on-line help provided. Provision is now made for advanced users to view and edit equations in the model.
Keywords: dairy cattle, nutrition, model

INTRODUCTION

CamDairy (Hulme *et al.* 1986) is a computer programme which predicts milk production from a given ration, identifies limiting nutrients, and calculates a ration which maximises profit for a given set of constraints, eg herd size, milk quota (if applicable), stage of lactation, and available feed supply. The core programme predicts nutrient requirements, feed intake, substitution effects of concentrates, tissue mobilisation and partition of nutrients between liveweight gain and milk production.

The programme is widely used throughout Australia and New Zealand. Feedback from users and concurrent research, including validation, have been used to refine the programme, as described in this paper.

MODEL REFINEMENT

Energy

The original equation for predicting partition of nutrients between liveweight gain and milk production, given by Hulme *et al.* (1986), was based on analyses of the data of Jensen *et al.* (1942). These analyses showed that the response of milk production to energy intake was curvilinear, as suggested by Blaxter (1962). The average energy requirement for the first 75% of potential milk yield was 4.0 MJ ME per Litre of milk. At higher levels of milk production, energy requirement per Litre increased rapidly. This equation was used in CamDairy to determine, on the basis of feed and milk prices, the optimum level of feeding in order to maximise milk income above feed costs. A critical input was the potential peak milk yield, which was defined as the peak milk yield when cows in good body condition are fed the best possible diet. Potential yields at other stages of lactation were calculated according to one of the equations of Wood (1980).

Attempts to validate the relationship between actual milk yield and the milk yield predicted by the CamDairy model with data from large scale grazing experiments were inconclusive due to low precision in estimating forage intake (Jones *et al.* 1992), although they indicated that there was significant underprediction at low milk yields. Validation with data from controlled feeding experiments showed that the CamDairy model predicted milk yield with greater precision than the ARC (1980), NRC (1989) and AFRC (1993) systems (Jones *et al.* 1994b).

Data from controlled feeding experiments in the USA and UK were used to re-examine the relationship between metabolisable energy for production and milk yield (Jones *et al.* 1994a), and produced the following equation:

$$FCM = 0.025\ P\ (6.86\ (\pm 1.01) + 0.123\ (\pm 0.0076)\ ME_P)\ F \qquad r^2 = 0.75 \qquad (1)$$

where
- FCM = fat-corrected milk (kg)
- P = peak potential milk yield in Litres / day
- ME_P = metabolisable energy available for production (MJ)
- F = heifer liveweight / mature cow liveweight

Similar significant intercepts for this relationship were reported by Blaxter (1962) and Briceno *et al.* (1987). A substantial intercept in this linear relationship indicates either (a) maintenance requirements were overestimated by approximately 100%, which is unlikely, or (b) the relationship between FCM and ME_P

is not linear below the lowest range of ME_P values examined. To accommodate this, and to discount the high positive intercepts, milk production for cows with less than 30 MJ ME_P is predicted as:

$$FCM = 0.025\ P\ (\ 0.35\ ME_P\ )\ F \qquad (2)$$

The net effect of high positive intercepts in these linear relationships is a curvilinear increase in the average energetic cost of milk production per kg. However, within the range of the data set, that is from an average of 10 to 35 L/day of 4% fat corrected milk across the whole lactation, the relationship is linear, in contrast to the curvilinear relationship reported previously (Hulme *et al.* 1986).

We suggest that the reason for the fundamental difference between these 2 observations is the increase in genetic potential for milk production between the 1940s and the 1980s. In the earlier study (Hulme *et al.* 1986) we suggest that the intake capacity of the cows was greater than their capacity to produce milk. In contrast, contemporary dairy cows, which have been highly selected for milk production, have a greater capacity to produce milk than is possible from their intake capacity. Thus contemporary dairy cows exhibit linear responses to milk production within the constraints of their appetite (equation 1).

Protein supply

CamDairy has calculated protein requirements in terms of rumen-degradable protein (RDP) and undegraded dietary protein (UDP), based on SCA (1990). A detailed comparison was made between this system and 5 other protein systems (ARC 1980; NRC 1989; INRA 1989; Cornell net carbohydrate and protein system - Russell *et al.* 1992; Fox et *al.* 1992; Sniffen *et al.* 1992; AFRC 1993). The outcome was a modified metabolisable protein system, now incorporated into CamDairy, which incorporates some features of each system and modifies the way in which microbial protein synthesis is predicted (Jones *et al.* 1996).

Rumen digestible organic matter is estimated from degradability coefficients derived from *in sacco* incubation, according to Orskov and McDonald (1979). Microbial protein synthesis is calculated from fermentable organic matter (FOM), which is calculated from organic matter apparently digested in the whole tract less the dietary contents of fat, UDP and 50% of organic acids. INRA (1989) found no increase in accuracy of estimating efficiency of microbial protein synthesis when FOM intake was replaced by the measured amount of rumen degraded organic matter. This outcome is based on the premise that fat and UDP do not contribute ATP in the rumen. Some organic acids do provide a substrate for rumen microbes (Hobson 1976), the extent which has been estimated as 50% (Tamminga *et al.* 1994).

When animals are fed at low levels of energy intake rumen outflow rate is lower, and efficiency of microbial protein synthesis is reduced. The equation relating efficiency of microbial protein synthesis to feeding level (AFRC 1993) was adapted to use FOM rather than FME, by converting metabolisable energy to fermentable organic matter, and scaling the equation to adjust for the removal of UDP, based on the data of INRA (1989). The efficiency of microbial protein synthesis is then:

$$Y_{FOM} = 115 + 103\ (\ 1 - e^{(-0.35L)}\ ) \qquad (3)$$

Where Y_{FOM} = grams of microbial crude protein per kg FOM
L = level of feeding in multiples of maintenance

This equation yields microbial protein production of 145 g/kg FOM for animals fed at maintenance, 167 g/kg FOM at twice maintenance, and 182 g/kg FOM at 3 times maintenance. In accordance with the Dutch DVE system (Subnel *et al.* 1994) this relationship can also be adjusted for the proportion of undegraded starch. In this case, when the proportion of undegraded starch is known, FOM is defined as DOM less fat, UDP, 50% of silage fermentation products, and undegraded starch. Efficiency of microbial protein production is then calculated as:

$$Y_{FOM} = 119 + 107\ (1 - e^{(-0.35L)}\ ) \qquad (4)$$

The proportion of amino acids in rumen microbes is assumed to be 0.75, with a digestibility of 0.80. The proportion of amino acids in UDP is assumed to be 1 .0, and the digestibility of UDP in the intestines is assumed to be 0.90, reduced pro rata by the content of acid detergent insoluble protein in forages. For non-forage feeds, digestibility of UDP is reduced by 50% of the content of acid detergent insoluble protein (Nakamura *et al.* 1994).

Protein requirements

Jones *et al.* (1995) compared the protein requirement systems developed by ARC (1980), CamDairy (Hulme *et al.* 1986), NRC (1989), INRA (1989), Cornell University (Russell *et al.* 1992; Fox *et al.* 1992; Sniffen *et al.* 1992) and AFRC (1993) through a quantitative comparison of the respective requirements for maintenance and production. Differences in total metabolisable protein requirements were accounted for largely by the method used to calculate endogenous protein requirements. In CamDairy metabolic faecal protein is calculated as 30 g/kg dry matter intake. Total metabolisable protein requirements for lactating dairy cows in the new CamDairy model are slightly lower than those of the Cornell net carbohydrate and protein system (Sniffen *et al.* 1992) and NRC (1989) and higher than those of the other systems.

Feed database

The feed library incorporated with CamDairy has been extensively expanded. Provision has been made to enter data on the content of rumen degradable starch, and the rumen degradability of organic matter and protein, in order to predict amounts of organic matter and protein fermented in the rumen, from feeding level. Additional nutrients include non-structural carbohydrates, chlorine, selenium and vitamins A, D and E. There is provision to enter the estimated rumen degradability of fat and non-structural carbohydrates. Also there is provision to rate fibre effectiveness on a O-l scale, where fibre effectiveness is the capacity of fibre to stimulate rumen motility and rumination. Dietary cation-anion differences are calculated from Na, K, Cl and S.

Residual and recursive effects

When milk prices are low and feed prices are high, it may not be economic to feed cows well, even in early lactation. However if residual benefits of current feeding strategy are taken into account in terms of likely or possible increases in milk production, appetite, fertility and pasture growth it may well be economic to modify current feeding strategy. The new version of CamDairy provides guidance on possible residual benefits and allows the user to edit these before re-calculating rations.

User interface

The user interface has been changed to "point and click" operation, with extensive on-line help. There is provision for advanced users to view and edit equations in order to gain greater understanding of the relative importance of the many factors which affect intake and the conversion of feed energy to milk. All equations can easily be reset to the standard versions.

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