CAMDAIRY RATION FORMULATION AND ANALYSIS MODEL

R.C. KELLAWAY* and D.J. HULME*

SUMMARY

CAMDAIRY is a package of computer programs which is designed to help advisers, farmers, students and research workers who are involved in the feeding management of dairy [illegible]. It can be used to predict performance and to explore the profitability of alternative management decisions relating to the nutrition of dairy cows. The core program is a mathematical model of a lactating cow, which incorporates functions to predict nutrient requirements, feed intake, substitution effects when feeding concentrates, tissue mobilisation and partition of nutrients between milk production and growth.

(Key Words: Computer model, dairy cow nutrition)

INTRODUCTION

There has always been a large gap in application between the information available on the nutrition of dairy cows and the practice of feeding management. Milk production is determined by a complex interaction of feed and animal factors. Whilst standard texts on feeding dairy cows (MAFF 1975;NRC 1978;ARC 1980) provide information on requirements for individual nutrients, they do not provide the means of integrating feed and animal factors to predict milk production. Similarly, these texts cannot be used to calculate rations which maximise profit. They assume that the relationship between energy intake and milk production is linear, whereas it is in fact a negative exponential relationship. When farmers wish to maximise profit, the optimum feeding level has to be determined by the shape of the response curve, feed costs and returns from milk sales. The computations involved are only feasible with a computer and this has severely restricted the application of current knowledge in the feeding management of dairy cows.

The recent availability of powerful and inexpensive micro-computers makes it possible to access and apply available information on dairy cow nutrition. The complex mathematics of ration formulation and analysis are no longer a problem. Micro-computers can do these calculations in a few seconds. The starting point for CAMDAIRY was the California model (Dean et al, 1972) from which we used data and file handling routines and screen layouts.* This saved about one man year of development time. Since then, we have spent in excess of three man years to develop the current model. In CAMDAIRY we have

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* M.C.Franklin Laboratory, Department of Animal Husbandry, University of Sydney, Camden, NSW 2570

used what we believe to be the most relevant; information available relating to nutrient intake and utilisation by lactating cows. The model is carefully designed to be "user friendly" so that it can be rapidly understood and applied by anyone with a basic knowledge of dairy cow nutrition.

CAMDAIRY STRUCTURE

The model is comprised of three modules:

1. Profit maximising
2. Performance prediction and ration analysis
3. Feed library

Profit Maximising

The object of this program is to determine the allocation of available feed resources which maximises profit from cows of specified potential and body condition. Feed resources are specified in terms of the types of pasture, hay, silage and concentrates available, constraints on their availability and their costs. Nutrient contents and edibilities of a wide range of feeds are given in the feed library, which can be edited or expanded,,

Cows are considered in two herds (usually early, and mid to late lactation) and are specified in terms of breed, age, liveweight, condition score, potential peak milk yield, milk fat level, stage of lactation and pregnancy.

Milk quotas for the farm are specified in terms of litres per day, cents per litre and production required above the quotas. Feed intake is predicted from liveweight, potential milk production, stage of lactation, edibility of roughages and substitution effects of concentrates. Partition of feed nutrients is predicted from stage of lactation, condition score and breed.

Energy requirements for maintenance are calculated according to Corbett (1987). Energy requirements for milk production are based on milk response curves derived from the data of Jensen et al. (1942). Energy contents of liveweight change are calculated from data on the chemical composition of cows with a wide range of body condition. Energy requirements for pregnancy are based on ARC (1980). Protein requirements are based on those of ARC (1980), with the addition of a requirement for metabolic faecal nitrogen and a reduction in efficiency of utilisation of absorbed amino acids. The net effect of these changes is that total protein requirements are more in accord with lactation trials and with NRC (1978). Mineral requirements -'are calculated according to NRC (1978).

Linear programming techniques are used to calculate the ration which maximises profit, whilst satisfying nutrient requirements, quota (or production) requirements, and constraints on feed and animal resources.

Detailed technical information, including data sources and equations used, is given by Hulme et al. (1986).

2. Performance Prediction and Ration Analysis

This program determines the milk production which is possible from defined resources of feeds and cows. Feed intakes have to be known or estimated. Nutritional requirements, substitution effects and nutrient partitioning are calculated in the same way as in the profit maximising program. This program is useful when first assessing feeding management practice on a dairy farm.

3. Feed Library

Because there has been so little application of information on feeding dairy cows, there has been no pressure to determine the nutrient content of pastures, conserved forages and concentrates. There is very little information on the nutrient content of pastures and conserved forages grown in Australia and information on concentrates is based largely on overseas data.

The feed library contains the nutrient analysis of a large range of feeds, which are classified as concentrates or roughages. In many cases interpolation of data were necessary to fill gaps in information available. The program allows you to change the data for a feed in the library, to replace a feed, to delete a feed or to add new feeds.

CAMDAIRY APPLICATION

The following examples illustrate applications of CAMDAIRY.

1. Central Coast Dairy in Summer

Assumptions on the main resources and returns are as follows:

Cows: 100 Friesians with year-round calving

Feed supply: kikuyu grass ($17/t as fed) and a commercial concentrate ($150/t as fed)

Quota: 1000 litres/day @ 36 cents/l; surplus milk @ 14 cents/l

Question: In order to maximise profit, how much concentrate should be fed and to which cows?

Information on the cows, feeds and quota are entered into the computer, and when edited to the user's satisfaction, appear as shown in Tables 1 and 2.

Table 1
Screen display of herd characteristics and quota details

	Herd 1	Herd 2
Number of cows in group........	30	70
Average cow weight...........kg	550	510
Week of lactation..............	6	26
Week of conception.............	12	12
Breed..........................	Friesian	Friesian
Condition score (1-8)..........	5.0	5.0
Activity allowance % Maint.....	20	20
Average milk fat..............%	3.9	3.9
Potential peak milk yield l/day	35	35
1st lactation heifers.........%	20	20
2nd lactation heifers.........%	18	18

Quota 1 1000 l at 36.00 c/l Quota 2 0 l at 0.00 c/l
Surplus milk price 14.00 c/l

Table 2
Screen display of nutrient content of feeds available

CENTRAL COAST DAIRY February, 1987

THE FOLLOWING FEEDS WERE AVAILABLE FOR THIS RATION:

Nutrient Analysis 100% Dry Matter Basis (g/kg DM)

No.	FEED NAME	ME	CP	Fat	CF	NDF	Ash	Ca	P	NPN	DM
		MJ/kg	<----				g/kg				---->
6	Conc mix	12.0	180	46	69	210	126	12	6	0	870
75	Kikuyu	10 5	150	30	300	370	100	5	3	0	250

MINERAL ANALYSIS
100% DM

No.	FEED NAME	Mg	K	Na	S	Fe	Co	Cu	Mn	Zn
		<----	g/kg		---->	<----		mg/kg		---->
6	Conc mix	3	15	5	3	500	2	25	200	30
75	Kikuyu	2	7	3	2	100	0	5	40	20

It was assumed that 30 of the 100 cows (identified as herd 1) would be in early lactation (average week of lactation 6), and the other 70 (identified as herd 2) would be mid-late lactation (average week of lactation 26). Cows were assumed to be in calf by an average of 12 weeks after calving.

When the maximum-profit ration is formulated (this ration took 8 seconds on an Ariel AT computer), the following information is displayed:

Table 3
Screen display of predicted milk production, income and feed allowances

	HERD 1	HERD 2	TOTAL
NUMBER OF COWS MILKED..................	30	70	100
POTENTIAL MILK YIELD THIS WEEK l/cow/d	32.5	22.9	
PREDICTED MILK YIELD...........l/cow/d	23.0	18.2	
PREDICTED TOTAL MILK PRODUCTION..l/day	691	1276	1967
PREDICTED OVER QUOTA PRODUCTION..l/day			967
INCOME ABOVE FEED COSTS......$/cow/day	3.97	3.01	
INCOME ABOVE FEED COSTS......$/cow/day	119.13	210.38	329.51

Brief Ration Information on "as fed" basis

	HERD 1	HERD 2
AMOUNT OF CONCENTRATE PER COW.......kg	6.7	5.0
COST OF CONCENTRATE PER TONNE........$	150.00	150.00
COST OF CONCENTRATE PER COW..........$	1.01	0.75
AMOUNT OF ROUGHAGE PER COW..........kg	46.9	47.8
COST OF ROUGHAGE PER TONNE...........$	17.50	17.50
COST OF ROUGHAGE PER COW.............$	0.82	0.84
PREDICTED LIVEWEIGHT CHANGE PER WEEK kg	-0.3	1.7

Table 4
Screen display of nutrient content of ration components

ESTIMATED ANALYSIS OF RATION FOR HERD ONE

(100% DM)	CONCENTRATE	ROUGHAGE	TOTAL RATION	CONSTRAINTS MIN	MAX
DRY MATTER g/kg	870.00	250.00	327.89		
ME MJ/kg	12.00	10.50	11.00		
CRUDE PROT g/kg	180.00	150.00	160.00	160.00	
FAT g/kg	46.00	30.00	35.33		
CRUDE FIBRE g/kg	69.00	300.00	223.00	170.00	
NDF g/kg	210.00	370.00	316.67		
ASH g/kg	126.00	100.00	108.67		
CALCIUM g/kg	12.00	5.00	7.33	6.00	
PHOSPHORUS g/kg	6.00	3.00	4.00		
NPN g/kg	0.00	0.00	0.00		
Ca:Phos ratio	2.00	1.67	1.83		
SULPHUR g/kg	3.00	2.00	2.33		
COST AS FED	150.00	17.50	34.15	$/TONNE	
COST DRY MATTER	172.41	70.00	104.14	$/TONNE	

Table 5
Screen display of mineral content of ration components

ESTIMATED MINERAL ANALYSIS - DM BASIS

MINERAL	CONCENTRATE	ROUGHAGE	TOTAL RATION	NRC MINIMUM
MAGNESIUM g/kg	2.50	1.50	1.83	2.00
POTASSIUM g/kg	15.00	7.00	9.67	8.00
SODIUM g/kg	5.00	3.00	3.67	1.80
SULPHUR g/kg	3.00	2.00	2.33	2.00
IRON mg/kg	500.00	100.00	233.33	50.00
COBALT mg/kg	2.00	0.10	0.73	0.10
COPPER mg/kg	25.00	5.00	11.67	10.00
MANGANESE mg/kg	200.00	40.00	93.33	40.00
ZINC mg/kg	30.00	20.00	23.33	40.00

Answer: Results in Table 3 show that, with the resources available, profit is maximised when concentrates are fed at rates of 6.7 and 5.0 kg/day to cows in herds 1 and 2 respectively. It is profitable to produce 967 litres/day in excess of the quota of 1000 litres/day. The nutrient analysis and constraints in Table 4 show that crude protein was the limiting nutrient. It may be more profitable to supply protein from a protein concentrate than from the commercial concentrate; this possibility could be examined. As well as crude protein (CP), the model has the facility to run with rumen-degradable protein (RDP) and undeqraded dietary protein (UDP) or with CP and UDP.

The mineral analyses in Table 5 indicate that magnesium, cobalt and zinc concentrations in the ration are lower than recommended. The accuracy of the ingredient analyses could be checked and mineral supplements made available if necessary.

The effect of potential peak milk yield on both requirements for concentrates and gross profit is illustrated in Table 6.

Table 6

Potential Peak Milk Yield l/day	kg concentrate/day Herd 1	Herd 2	Gross Profit* From 100 Cows $/day
35	6.7	5.0	330
30	6.7	2.2	318
25	5.0	2.2	303
20	2.2	2.0	277

* Milk returns less feed costs

2. Victorian Dairy Farm Without Quota

Assumptions on the main resources and returns are as follows:

Cows: 100 Friesian x Jersey; 500 kg liveweight
Pastures: Perennial ryegrass, late vegetative, costing $30/t DM
White clover costing $30, $36 or $42/t DM; assumed edibility 26% higher than that of ryegrass
Milk return: 14 cents/l

Question: What proportion of the pasture should be white clover in order to maximise profit?

At the present time there is a lot of interest in the role of white clover in pastures for dairy cows in Victoria. A unique characteristic of clover is its high relative edibility. This feed property is taken into account when predicting intake in CAMDAIRY. Effects on gross profit of increasing the white clover component of the pasture are determined by the relative cost of producing ryegrass and white clover, as illustrated in Table 7.

Table 7
Effects of pasture costs and stage of lactation on gross profit* ($/day) from 100 cow herd with seasonal calving

% white clover	Pasture cost $/t DM							
Ryegrass	30		30		30		30	
Clover	30		36		42		48	
Lactation wk	6	20	6	20	6	20	6	20
20	242	217	240	215	239	213	237	211
40	251	222	247	218	243	214	239	210
60	259	228	253	221	247	215	241	209
80	268	233	259	225	251	216	243	207

*Milk returns less pasture costs

Answer: Output from the model in Table 7 indicates that, on the basis of the assumptions made, gross profit decreases with increases with the amount of white clover in the pasture, when clover costs are 60% or more than ryegrass costs and cows are 20 weeks or later in lactation. To the feed costs must be added animal health costs associated with the use of clover, such as drugs used in bloat prevention and losses associated with cows succumbing to bloat. Without considering these costs, it appears that it would be useful to increase the percentage of white clover in the pasture, provided that costs of production are no more than 20-40% higher than those of producing perennial ryegrass.

3. Large Metropolitan Dairy With Quota

Assumptions on resources and returns are as follows:

Cows: 1000 Friesian with year-round calving

Feed supply: Limited grazing available - 10 ha/day of annual ryegrass, from which cows graze 2 tonnes dry matter/day; a contract supply of 6 tonnes/day brewers grain; a wide range of by-products and concentrates, with facilities for feed mixing.

Quota: 18,000 litres/day @ 36 cents/l; surplus milk @ 14 cents/l--

The nutrient composition of the feeds available was assumed to be as shown in Table 8.

Table 8

Screen display of nutrient content of feeds available

Nutrient Analysis 100% Dry Matter Basis (g/kg DM)

No.	FEED NAME	ME	CP	Fat	CF	NDF	Ash	Ca	P	NPN	DM
		MJ/kg	<------------------				g/kg				------------------>
2	Barley	12.9	107	21	70	90	29	1	4	0	890
5	Brewers grain	10.1	260	72	160	230	41	3	5	0	250
8	Corn gluten meal	13.0	471	25	44	70	26	2	4	0	910
10	Cottonseed meal	11.6	448	23	130	200	69	2	13	0	920
11	Cottonseed whole	15.6	249	211	180	290	39	2	7	0	930
12	Limestone	0.0	0	0	0	0	958	361	0	0	1000
13	Dicalcium phos	0.0	0	0	0	0	868	237	188	0	960
42	Wheat	13.9	120	22	30	40	21	1	4	0	860
44	Mill mix	11.3	178	45	98	112	57	1	12	0	900
71	Cottonseed hulls	5.3	43	10	500	710	29	2	1	0	900
74	Lucerne hay	8.7	195	27	260	330	93	14	3	0	900
89	Ryegrass, early	12.0	222	33	200	280	127	6	4	0	180

Question: In order to maximise profit, which concentrates should be fed and how much of each?

As in the first example, it was assumed that 30% of cows would be in early lactation and 70% would be in mid-late lactation. Also, it was assumed that cows would be in calf by an average of 12 weeks after calving.

When the maximum-profit ration is formulated (this ration took 32 seconds on an Ariel AT computer), the following information is displayed:

Table 9
Screen display of predicted milk production, income and feed allowances

	HERD 1	HERD 2	TOTAL
NUMBER OF COWS MILKED.................	300	700	1000
POTENTIAL MILK YIELD THIS WEEK l/cow/d	31.3	21.1	
PREDICTED MILK YIELD...........l/cow/d	24.3	15.8	
PREDICTED TOTAL MILK PRODUCTION..l/day	7289	11071	18360
PREDICTED OVER QUOTA PRODUCTION..l/day			360
INCOME ABOVE FEED COSTS......$/cow/day	7.10	3.96	
INCOME ABOVE FEED COSTS.....$/herd/day	2130.64	2770.69	4901

Bried Ration Information on "as fed" basis

	HERD 1	HERD 2
AMOUNT OF CONCENTRATE PER COW.......kg	23.8	17.3
COST OF CONCENTRATE PER TONNE.........$	48.36	57.13
COST OF CONCENTRATE PER COW...........$	1.15	0.99
AMOUNT OF ROUGHAGE PER COW..........kg	34.2	9.2
COST OF ROUGHAGE PER TONNE............$	11.31	73.40
COST OF ROUGHAGE PER COW..............$	0.39	0.68
PREDICTED LIVEWEIGHT CHANGE PER WEEK kg	1.4	0.6

Table 10
Screen display of ration composition and opportunity prices

RATION FOR HERD ONE

FEED USED IN RATION	kg/ COW DAY	g FEED /kg* ROUGH AF	g FEED /kg ROUGH DM	$/ TONNE AF	OPPORTUNITY RANGE $/TONNE AF LOWER	OPPORTUNITY RANGE $/TONNE AF UPPER	CONSTRAINTS g FEED /kg ROUGH DM MIN	CONSTRAINTS g FEED /kg ROUGH DM MAX
Ryegrass, early	32.47	949	788	9	8	9		
Cottonseed hulls	1.76	52	213	54	52	61		
TOTAL ROUGHAGE	34.23	(7.42 kg DM)						
Brewers grain	16.58	696	390	26	26	26		
Barley 1	6.93	291	581	100	99	102		
Mill mix	0.17	8	15	95	93	98		
Limestone, ground	0.16	7	16	78	2	142		
TOTAL CONCENTRATE	23.84	(10.63 kg DM)						
TOTAL RATION	58.07	(18.05 kg DM)						

*as fed

FEEDS NOT USED IN RATION:	$/TONNE AS FED AT FORMULATION	OPPORTUNITY
Corn gluten meal	400	103.17
Cottonseed meal sol	300	107.65
Cottonseed, whole	180	159.82
Dicalcium phosphate	150	73.70
Wheat 1	130	112.07
Lucerne hay, mid	120	FEED USED IN OTHER GROUP

Answer: Output from the model in Tables 9 and 10 gives the ration which maximises profit, together with opportunity costs. When the cost of feeds in the ration move outside the opportunity range, the ration should be re-formulated. When the cost of feeds not in the ration fall to or below the opportunity price, they would be included in the ration when re-formulated. In practice, the opportunity prices are a very effective bargaining tool in negotiations with feed suppliers.

The model used cottonseed hulls as the cheapest source of fibre to meet the constraint of 170 g crude fibre/kg which is usually used (Table 4) to reduce the chance of low fat concentrations in milk.

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