Summary report

A review of 11 applied dairy nutrition models used in Australia

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- Evaluators of user-friendliness:
  - Michael Lean (Camden, Australia); and
  - Dario Nandapi (Smart Cow Consulting, Australia).

Disclaimer

Contents

Section 1:

Introduction

Why this review was undertaken

A large number of computer-based dairy nutrition models have been developed and are available to help advisers and farmers make decisions about diets and feeding strategies.

Most of these models have been developed by 'champions' with a specific interest / focus as a tool to help them improve their understanding of nutrition and rumen physiology. They are then released for wider use.

In his review of dairy nutrition models and decision support tools for Dairy Australia in 2005, Dr John Black identified considerable overlap between many of the models being used. He also found that nutrition advisers:

- are often unaware of the existence of similar models, or of the strengths and weaknesses of these alternate models; and
- tend to use just one model and do not have enough time to become familiar with other models or to understand their potential value in decision making.

The relative accuracy and uniformity of predictions from nutrition models currently used by advisers was also unknown. As a result, a thorough comparison of the commonly used models and an evaluation of the accuracy of their predictions and sensitivity to their inputs was required.

Aims and methods

To address this need, Dairy Australia's Grains2Milk program commissioned SBS*cibus* to review and evaluate, in detail, a number of prominent tactical and strategic nutrition models used in the Australian dairy industry.

The objectives of this study were to address and explore the following:

- The purpose of each model.
- The underlying concepts / assumptions / algorithms / functions used in each model.
- The inputs that are essential / required for each model.
- The extent to which each model can be applied in practice to assist strategic or tactical decision making.
- The ability of each model to accurately predict the milk yield and composition responses to supplemental grains / concentrates under different circumstances.
- The ability of each model to estimate marginal milk yield response to supplemental grains / concentrates.
- The sensitivity of the models to errors in values, such as the nutrient composition of feeds, and animal and environmental factors.
- The production / feeding system(s) to which each model is most suited.
- The level of technical knowledge required to competently operate each model and its 'user friendliness'.
- Current costs and the level of technical support provided.
- Evidence of current development of the model.
- The level of commitment to future development.

Eight tactical nutrition models were reviewed and evaluated:

- AminoCow, CamDairy, CPM-Dairy, Diet Check, Feed into Milk (FiM), GrazFeed, RationCheck and Rumen8.

Three strategic nutrition models were also reviewed:

- Dairy Predict, FeedSmart and UDDER.

General and technical information was collected and documented for each of the models. Seven extensive, high-quality data sets from three nutritional studies (two University of Sydney studies – Westwood et al. 2000; Bramley 2005 – and one University of Melbourne study – J Hill, pers. comm.) were then provided to the 'champions' of each tactical model for evaluation.

The tactical models were evaluated using the seven datasets for their ability to predict the yield and composition of milk, supply of nutrients and nutrient requirements. In addition, the models were evaluated for their ability to predict the marginal response to grain and their sensitivity to changes in the nutrient composition of feeds, animal and environmental factors.

(Note: The strategic models were not evaluated with test data, as the required inputs for these programs varied significantly and comparing outputs was not appropriate.)

The user-friendliness of both the tactical and strategic models was evaluated by two users, one a dairy nutrition adviser experienced in the use of models, the other a Year 12 high school student with no prior experience in using nutrition models. Evaluation was conducted using installation processes, software compatibility, opening and viewing, parameter settings, the programs' menu, feed inventory, report viewing and printing, and help files.

Outcomes

The main outcomes from the study were a detailed description of each of the tactical and strategic nutrition models, and identification of the tactical nutrition models that better predicted the observed milk yield performance in experimental datasets.

How will this report help dairy nutrition advisers and farmers?

Dairy Australia's Grains2Milk program hopes that as a result of this study, dairy nutrition advisers will be more aware of the nutritional models available, and better able to use their preferred model to support their business with a greater understanding of its functionality, sensitivity to data inputs, and strengths and weaknesses.

We also hope that the information provided encourages dairy nutrition advisers to enhance their advisery capability by learning to use different models and better appreciate the strengths and limitations of these models.

Indirectly and longer term, dairy farmers will benefit from this study because there will be more nutrition advisers who have more knowledge about (and more confidence in) the nutritional models and who will be in a better position to select and use those nutrition models that are appropriate for their clients.

This study paves the way for more extensive evaluation of selected models in future using datasets collected as part of other Dairy Australia R&D projects. These datasets will require the direct measurement of pasture consumption and nutrient intake, and should cover a wide range of feeding systems including those that are predominately pasture based, those incorporating substantial supplement inputs, and TMR diets. These further evaluations will provide more information about the effectiveness of models to predict performance under a wide range of feeding systems and may identify which feeding systems each of these models can be applied more appropriately.

Finding the information you want

Section 2:

Profiles of the tactical and strategic models

Tactical models

Strategic models

AminoCow

Year first developed	1995
Where developed	USA
Used in	USA, S. America, Australia
Marketed by	Evonik
Latest version	Vn 3.52 (2007)
Retail price	Free
Technical support	Drs Patton, Brinkman and Heimbeck – phone, e-mail, web (no charge)
Phone	+1 570 966 4770 or +1 678 797 4311
Website	www.Makemilknotmanure.com
Downloadable from website	Yes
Updates available via web and cost	Yes. Free.

Stated objectives of the model

- To balance rations for all classes of dairy animals.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

Moderate.

Description

AminoCow was developed by the DeGussa company with input from Drs Ed Byers and Mike Hutjens. The program is a tool to investigate production limitations. A least-cost formulation or profit-maximising function is not provided and the program does not predict milk production. Rather, the outcomes provided are similar to those of RationCheck, expressed in terms of the capacity for the test diet to meet requirements for a given milk production.

The program provides a flexible approach to the calculation of requirements, as the user can opt to use the NRC (1989) energy system or the net energy system provided by the model.

The focus of AminoCow is on amino acid requirements, especially methionine and lysine. The model uses a factorial approach in setting amino acid requirements. For milking cows, the factors involved are: maintenance; milk production; body growth; and body condition repletion. Body growth is calculated if the animal is both less than 48 months of age and less than ideal body size. Body condition repletion is calculated from a desired body condition score of 3.5 at dry off (1-5 scale). Requirements for protein are based on NRC (1989) and do not allow for the effect of rumen outflow rates on degradation of protein.

Comparisons with other models

To compare star ratings for AminoCow and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using AminoCow and other nutrition models, see Table 2 on page 29.

To compare animal, environmental and ration inputs required for AminoCow and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in AminoCow and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of AminoCow and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how AminoCow works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆☆☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆☆☆☆
Ability to estimate milk yield accurately	☆☆☆
Ability to estimate nutrient requirements	☆☆☆
Level of technical expertise required to run software[1]	☆☆☆☆
Amount of inputs required to run software[1]	☆☆☆☆
Amount of feed analysis required	☆☆☆☆
Scope of feed library supplied	☆☆☆
Suitability of help file / manual	☆☆☆
Availability of extra features	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths	✘ Limitations
• Fairly easy to use. • Complete Help file and Nutritional Primer. • Is free.	• Pastures may not fit well with assumptions in protein module. • Lack of requirements for starch and sugar. • Difficulty in getting accurate forage information. • Does not have a least cost formulation or profit maximisation function, and does not predict milk production.

CamDairy

Year first developed	1984
Where developed	Australia
Used in	Australia and New Zealand
Marketed by	Cam Software
Latest version	V4.209 (2007)
Retail price	AU$660
Technical support	EpiCentre (Massey University) – face-to-face, phone, e-mail (no charge)
Phone	(02) 4651 2329
Website	http://epicentre.massey.ac.nz
Downloadable from website	Yes
Updates available and cost	Yes. Free with current service contract

Stated objectives of the model

- Predict animal performance.
- Identify possible limiting nutrients.
- Formulate diets to maximise gross profit.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

High. Tertiary training in ruminant nutrition recommended.

Description

The core program of the CamDairy model is a bio-mathematical model that incorporates functions to predict nutrient requirements, feed intake, substitution effects when feeding concentrates, tissue metabolism and partition of nutrients between milk production and growth. Nutrition partitioning is described by a series of asymptotic curves relating energy intake to milk production, such that energy requirements per litre increase progressively with level of milk production.

CamDairy allows for constraints to be applied relative to concentrations of energy, protein, crude fibre (CF), neutral detergent fibre (NDF), fat, calcium (Ca), phosphorus (P), Ca:P ratio and ash in the ration. A minimum constraint is set for roughage in the ration, to avoid problems of low milk fat, and this constraint can be edited.

This model incorporates an econometric model, 'Maximum Profit' that uses linear programming procedures to formulate rations for up to two groups of cows in a herd in a way that maximises income above feed costs, while meeting nutrient requirements and satisfying constraints on feed supply and milk production requirements.

Other programs in the CamDairy package are 'Least Cost', a program that calculates a least-cost ration using fixed energy requirements for milk production and 'Analysis', a program that predicts likely milk production given the characteristics of the cows, feed intake and feed composition.

Comparisons with other models

To compare star ratings for CamDairy and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using CamDairy and other nutrition models, see Table 2 on page 29.

To compare the animal, environmental and ration inputs required for CamDairy and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in CamDairy and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of CamDairy and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how CamDairy works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	AU$660
Level of technical support available	☆☆☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆☆☆☆
Ability to estimate milk yield accurately	☆☆☆☆
Ability to estimate nutrient requirements	☆☆☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software	☆☆☆
Amount of feed analysis required	☆☆☆☆
Scope of feed library supplied	☆☆☆☆
Suitability of help file / manual	☆☆☆☆
Availability of extra features	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is not more suitable for use.

✔ Strengths

- Reasonably user-friendly.
- Good feed library based on Australian data.
- Offers a flexible modelling approach, provided by the 'genetic potential' function.
- Can model two herds simultaneously, allowing you to compare two strategies.
- Accuracy of performance predictions.
- Deals with impacts of supplements on feed intake, i.e. substitution.
- Economic value of ration formulations.
- Good educational tool on dairy cow nutrition.

✘ Limitations

- Mechanistic modules that would be valuable to research workers are lacking.
- Intermediary metabolism is not strongly addressed.

CPM-Dairy (CNCPS model)

Year first developed	1998
Where developed	USA
Used in	USA, Japan, Europe, South America, Australia, New Zealand, South Africa, China
Marketed by	University of Pennsylvania
Latest version	V3 Release (2006)
Retail price	US$550
Technical support	Cornell Miner Institute – face-to-face, phone, e-mail, web (no charge)
Phone	+1 610 316 0867
Website	http://cpmdairy.com/index.html
Downloadable from website	Yes
Updates available and cost	Yes. US$50/year

Stated objectives of the model

- Ration evaluation.
- Ration reformulation with auto-balancing.
- Maximise ruminal production of microbial protein.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

High. User requires extensive knowledge of dairy cow biology and management.

Description

CPM-Dairy was developed by the Universities of Cornell, Pennsylvania and the Miner Institute. It is an extension of the Cornell Net Carbohydrate and Protein System (CNCPS) and was developed with the aim of providing an applied platform for nutritional decision making and as a teaching tool.

The CNCPS in CPM-Dairy differs from traditional programs by accounting for dynamic attributes of feed ingredients, such as passage and digestion rates. Passage rate is the speed at which a feed ingredient leaves the rumen and therefore determines how long it is exposed to the resident microbial population. Digestion rates determine how quickly nutrients are assimilated from feed ingredients.

By using these attributes of feed ingredients, rumen function is modelled in a manner that allows for a better estimation of ruminal microbial yields from various feed combinations. The microbial population produced in the rumen is digested further down the gastrointestinal (GI) system and is a vital source of protein, often producing 50% of a cow's total protein requirement.

Linear and non-linear programming is used in the program to formulate least-cost rations and ensure that the nutrient requirements of the rumen microbes and cow are met. The CPM-Dairy program also provides the basis for developing dynamic programming approaches to ration formulation to investigate the economic effects of feeding specific sequences of rations to cows and can be used to capture further economic benefits in terms of seasonal feed prices and feed availability.

Comparisons with other models

To compare star ratings for CPM-Dairy and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using CPM-Dairy and other nutrition models, see Table 2 on page 29.

To compare the animal, environmental and ration inputs required for CPM-Dairy and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in CPM-Dairy and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems in CPM-Dairy and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how CPM-Dairy works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	US$550
Level of technical support available	☆☆☆☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆☆☆☆
Ability to estimate milk yield accurately	☆☆☆☆
Ability to estimate nutrient requirements	☆☆☆☆
Level of technical expertise required to run software[1]	☆☆☆☆
Amount of inputs required to run software[1]	☆☆☆☆
Amount of feed analysis required	☆☆☆☆
Scope of feed library supplied	☆☆☆☆☆
Suitability of help file / manual	☆☆☆☆
Availability of extra features	☆☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- User-friendly, with outstanding help section.
- Maximises ruminal production of microbial protein.
- Powerful ration optimisation function (this is more suited to TMR than pasture-based feeding systems).
- Contains many innovative elements, e.g. lipid sub-model.
- Can generate batch mixes, feed mixes and amounts of feed to be fed to groups of cattle.
- Multiple reports that can be sent in various formats.
- Useful teaching and research tool.

✘ Limitations

- Some of the nutritional concepts are advanced and the program assumes a high level of nutritional knowledge.
- Demands a high level of commitment to use well. For the less aware, it can give less satisfactory results.
- Areas of the program need upgrading, such as the predictions of rumen pH, aspects of the digesta flow rates and the consequent changes to protein sub-models.

Diet Check

Year first developed	2000
Where developed	Australia
Used in	Australia
Marketed by	DPI Victoria
Latest version	Web version (2003)
Retail price	Free
Technical support	DPI Victoria – phone, web (no charge)
Phone	(03) 5833 5222
Website	www.dpi.vic.gov.au/dpi/nrenfa.nsf/Home+page/DPI+Agriculture~Home+Page
Downloadable from website	Yes
Updates available and cost	N/A

Stated objectives of the model

- To help Victorian dairy farmers ensure grazing dairy cows are consuming sufficient metabolisable energy, crude protein and NDF for a target level of milk production. This is especially important when both pasture and supplements are fed to grazing cows.
- To help farmers to predict the likely production and economic benefits of supplementation.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

Basic.

Description

DPI Victoria developed 'Diet Check' as a simple tactical decision support tool to help dairy farmers in Northern Victoria estimate whether their cows are consuming sufficient ME, crude protein (CP) and NDF for a specific level of milk production.

The Diet Check program is a series of Microsoft Excel™ spreadsheets navigable using visual basic commands. The program estimates the requirement of grazing lactating cows for ME from Australian Feeding Standards – ruminants (SCA, 1990), and best estimates of both CP and NDF after herd and feed details have been entered by the user. These standards take into account the energy cost of grazing and of activity, as well as those for maintenance, lactation and pregnancy.

Diet Check estimates pasture mass, pasture intake, nutrient selection from pasture and substitution, and calculates whether metabolisable energy, crude protein or NDF is likely to be deficient for a particular level of milk production. It is designed for strip grazing or small paddock rotation systems where daily pasture allowance is between 15 and 70 kg DM/cow/day. It is not designed for use in grazing system outside this range in pasture allowance.

Comparisons with other models

To compare star ratings for Diet Check and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using Diet Check and other nutrition models, see Table 2 on page 29.

To compare animal, environmental and ration inputs required for Diet Check and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in Diet Check and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of Diet Check and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how Diet Check works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆☆☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆
Ability to estimate milk yield accurately	☆☆
Ability to estimate nutrient requirements	☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆
Amount of feed analysis required	☆☆
Scope of feed library supplied	☆
Suitability of help file / manual	N/A
Availability of extra features	☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- Easy to use, with useful drop down details.
- Estimates herbage intake by grazing cows from simple descriptors.
- Doesn't rely on pasture intake as an input.
- Models substitution effects.
- Excellent learning tool, and tactical decision support tool for farmers.
- Is free and available in downloadable form.

✘ Limitations

- Use is restricted to more than 50% grazed pasture in diet.
- Crude protein and NDF systems are rudimentary.
- Responses to supplements tend to be underestimated, as the model does not value intermediate and long term responses to supplements and does not permit adjustment of stocking rate to account for pasture made available through substitution.

Feed into Milk (FiM)

Year first developed	2004
Where developed	UK
Used in	UK, Europe, Japan, China, Australia
Marketed by	Consortium (UK dairy industry and government)
Latest version	Vn 1 (2004)
Retail price	FiM = AU$100. Ultramix Prof = AU$2500. Ultramix Lite = AU$2100.
Technical support (Aust.)	Pittolo Nutrition – face-to-face, phone, e-mail ($100/hr)
Phone	(02) 6492 0625; 0403 722 739
Website	www.ultramix.co.uk
Downloadable from website	No
Updates available and cost	No

Stated objectives of the model

- On-farm formulation and decision support.
- Improve feed additive design.
- Improve users' understanding of dairy cow nutrition.

Recommended for use by

- Dairy nutritionists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

At least intermediate nutritional knowledge.

Description

Feed into Milk (FiM) is used in conjunction with the Ultramix Professional Feed Formulation platform (UP) in 18 countries across a broad range of feed formulation applications. It was developed in the first instance as an on-farm application for advisers and service providers to provide feed formulations that combine linear and non-linear components.

FiM uses ATP yield as the energetic basis for rumen function. This approach includes the effect of raw material on intake. Nutrient flows are divided into nitrogen and dry matter with s, a, b and c descriptors.

There are three Decision Support Systems (DSS) in the FiM model. The first DSS allows the user to predict the likely effect of a given ration on milk yield and components, taking into account the stage of lactation, energy intake, CP, NDF, starch, sugar and the fatty acid profile of the ration, as well as the expected yield and components for the cow or herd. The second DSS predicts the supply and adequacy of amino acids and the third DSS is focused on rumen stability.

Within the UP platform, the user can choose to set these DSS values as formulation constraints, or the user can allow the ration to be solved without reference to the DSS and review the suitability of the formulated ration with reference to the requirement.

Comparisons with other models

To compare star ratings for Feed into Milk and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using Feed into Milk and other nutrition models, see Table 2 on page 29.

To compare the animal, environmental and ration inputs required for Feed into Milk and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in Feed into Milk and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of Feed into Milk and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how Feed into Milk works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	AU$2100
Level of technical support available	☆☆
User-friendliness	☆☆
Applicability to various feeding systems	☆☆☆☆
Ability to estimate milk yield accurately	☆☆☆☆
Ability to estimate nutrient requirements	☆☆☆☆
Level of technical expertise required to run software[1]	☆☆☆☆
Amount of inputs required to run software[1]	☆☆☆☆
Amount of feed analysis required	☆☆☆☆
Scope of feed library supplied	☆☆☆
Suitability of help file / manual	☆☆
Availability of extra features	☆☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- Is the most flexible platform available.
- Includes feed-based intake factors.
- Includes assessment of the effect of meals, e.g. slug feeding.
- Realistic assessment of the likelihood of acidosis.
- Decision Support System on milk is very robust in the field.
- Provides opportunity cost for unused feeds and a value range for used feeds.
- Well suited to stockfeed company use.

✘ Limitations

- Ultramix platform that FiM runs on is not very user-friendly
- Not well suited to the farmer user.
- Analysis of Australian feed stuffs is still in development.
- High purchase price.

GrazFeed

Year first developed	1990
Where developed	Australia
Used in	Australia (plus limited use in NZ and S. America)
Marketed by	Horizon Agriculture
Latest version	Vn 4.2 (2007)
Retail price	AU$423.50
Technical support	CSIRO Plant Industry – face-to-face, phone, e-mail and web (no charge)
Phone	(02) 6246 5312
Website	www.pi.csiro.au/grazplan www.hzn.com.au/php
Downloadable from website	No
Updates available via web and cost	No

Stated objectives of the model

- To help farmers decide what level of animal production a particular pasture will support and how much of a specified supplement would be needed to meet a target production level.
- To formulate a way of achieving this aim that realistically simulates the interactions between selective grazing and substitution on feed intake by grazing animals.
- To develop a model that is generally applicable to all ruminant livestock and all types of pasture and is based on Australian feeding standards.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

Basic.

Description

GrazFeed is a component of the GRAZPLAN decision support project, developed by CSIRO Plant Industry. It has been designed for any breed of beef or dairy cattle or sheep, and for any pasture except the shrub vegetation of semi-arid rangelands.

GrazFeed predicts the intake of energy and protein and their use for maintenance and production according to the recommendations in SCA (1990), with some more recent modifications reflected in Nutrient Requirements of Domesticated Ruminants (2007).

GrazFeed takes into account the type of animal, the availability and quality of pasture, selective grazing and interaction with supplementary feeds (e.g. the substitution of supplement of pasture). GrazFeed can also predict the liveweight change of dairy cows after estimating, where appropriate, foetal growth and milk production. GrazFeed can also be used to test the effect of up to six feeding levels of the specified supplement.

Comparisons with other models

To compare star ratings for GrazFeed and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using GrazFeed and other nutrition models, see Table 2 on page 29.

To compare animal, environmental and ration inputs required for GrazFeed and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in GrazFeed and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of GrazFeed and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how GrazFeed works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	AU$423.50
Level of technical support available	☆☆☆☆
User-friendliness	☆☆
Applicability to various feeding systems	☆☆
Ability to estimate milk yield accurately	☆
Ability to estimate nutrient requirements	☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆☆
Amount of feed analysis required	☆☆☆
Scope of feed library supplied	☆
Suitability of help file / manual	☆☆☆☆
Availability of extra features	☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- Ability to predict the energy and protein intake by grazing animals under conditions of variable availability and quality of herbage and in the presence of supplementary feeds.
- Applicability of the model to all types of sheep and cattle and all types of pastures (particularly in temperate regions).

✘ Limitations

- Predicted intakes of pasture are relatively high compared to other models.
- Level of precision lower for tropical pastures.
- Not suitable for extensive grazing of semi-arid shrub lands.

RationCheck

Year first developed	2007
Where developed	Australia
Used in	Australia
Marketed by	NSW DPI
Latest version	Vn 1
Retail price	Free
Technical support	NSW DPI through dairy livestock officers (no charge)
Phone	(02) 6632 1900
Website	www.dpi.nsw.gov.au
Downloadable from website	No
Updates available and cost	No

Stated objectives of the model

- To assess if a ration is balanced for milking cows, dry cows and replacement heifers given their current level of production, stage of pregnancy or stage of growth.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

Basic.

Description

The NSW DPI developed RationCheck as a simple tactical program to help dairy farmers check if the formulated ration meets the requirements of lactating dairy cows for ME, CP and NDF for a specific level of milk production.

The function of RationCheck is to analyse the current ration for lactating cows, dry cows or replacement heifers. The program can then identify, which, if any, major feed components are not balanced to the herd's requirements given its current level of production, stage of pregnancy or stage of growth. The model has not been designed for milk production prediction, and cannot predict pasture and supplement intake of grazing dairy cows, nor the substitution rate.

It estimates the daily requirement of ME, MP, CP and fat for lactating and dry cows, and replacements based on NRC (1989, 2001) and AFRC (1992) recommendations. Changes in BCS are calculated based on NRC (1989) recommendations and Grifiths and Granzin unpublished data. Estimates on the NSC requirement are based on CPM-Dairy (1998) recommendations.

RationCheck also calculates average milk production/day/cow and the margin over feed from the input supplied on number of cows, and can be used to compare the price of various feeds either on a ¢/MJME or $/kg protein basis.

Comparisons with other models

To compare star ratings for RationCheck and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using RationCheck and other nutrition models, see Table 2 on page 29.

To compare animal, environmental and ration inputs required for RationCheck and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in RationCheck and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of RationCheck and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how RationCheck works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆☆☆
Ability to estimate milk yield accurately	☆☆☆
Ability to estimate nutrient requirements	☆☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆☆
Amount of feed analysis required	☆☆☆
Scope of feed library supplied	☆☆☆
Suitability of help file / manual	☆☆
Availability of extra features	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- Easy to use.
- Provides a simple quick check on whether a ration is balanced for major nutrients / minerals.
- Substantial feed library.
- Is free.

✘ Limitations

- Is not a ration formulation program.
- Limited level of technical support.
- No prediction of milk yield.
- Does not model substitution effects.

Rumen8

Year first developed	2003
Where developed	Australia
Used in	Australia, New Zealand and South Africa
Marketed by	Department of Agriculture and Food WA
Latest version	Vn 1.1 (2007)
Retail price	Nil
Technical support	Face-to face, phone, e-mail and web (no charge)
Phone	(08) 9753 0304
Website	www.agric.wa.gov.au
Downloadable from website	No
Updates available via web and cost	No

Stated objectives of the model

- To provide an easy-to-use interface.
- To allow production prediction with pasture-based diets.
- To allow easy estimation of pasture component of diet by subtraction.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Research scientists

Level of technical / nutritional knowledge required

Moderate.

Description

Rumen8 was developed by Department of Agriculture and Food WA as a tool for farmers and nutritionists to explore diets and make adjustments according to production and estimates of pasture utilisation and consumption. The program is based on AFRC (1993) equations, except for dry matter intake, which is estimated using NRC (2001) equations.

Rumen8 estimates requirements for feed intake, ME and MP. For these requirements the model uses warning lights that change colour. It has the ability to provide a least-cost diet from selected feed components, which permits the user to:

- select up to 10 different diet components;
- specify constraints under which the optimisation occurs; and
- store and compare two or three different optimised diets.

Rumen8 utilises the non-linear optimising function of Solver that is included in Microsoft Excel™ to provide least-cost diets. Information about the optimiser function is provided with the program as a separate file. Rumen8 also calculates a margin over feed cost for selected diets, expressed as $/cow.

Comparisons with other models

To compare star ratings for Rumen8 and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using Rumen8 and other nutrition models, see Table 2 on page 29.

To compare animal, environmental and ration inputs required for Rumen8 and other tactical models, see Table 3 on page 30.

To compare the scope and limits of the feed library in Rumen8 and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of Rumen8 and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how Rumen8 works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆☆☆
User-friendliness	☆☆☆☆
Applicability to various feeding systems	☆☆☆☆
Ability to estimate milk yield accurately	☆☆☆
Ability to estimate nutrient requirements	☆☆☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆☆
Amount of feed analysis required	☆☆☆
Scope of feed library supplied	☆☆
Suitability of help file / manual	☆☆☆
Availability of extra features	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths	✘ Limitations
• Easy to use. • Accuracy of predictions in pasture based systems. • Optimisation not limited to simplified linear equations.	• Narrow focus. • No predictions for young and dry stock. • Limited feed library for Australian forages. • Current manual and "rules of thumb" are rudimentary. • Optimiser requires Excel to function.

Dairy Predict

Year first developed	2005
Where developed	Australia
Used in	Australia
Marketed by	DPI&F Queensland
Latest version	v1.1 (2009)
Retail price	Nil
Technical support	Queensland DPI&F – phone, e-mail (no charge)
Phone	(07) 5464 8736
Website	www.dairyinfo.biz
Downloadable from website	Yes
Updates available via web and cost	Yes. Free

Stated objectives of the model

- To enable dairy enterprise feed system planning, forage base x herd x supplement plans.
- To account for variable seasons (in the forage database).
- To explore different herd structure and supplementary feed plan options.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Agronomists
- Veterinarians
- Research scientists

Level of technical / nutritional knowledge required

Moderate.

Description

Dairy Predict is a dairy feedbase and enterprise planning model developed by Queensland DPI&F as a DSS tool for the subtropical dairy industry, but has application well beyond that environment. Dairy Predict resulted from the Dairy Australia and Subtropical Dairy Program project "Sustainable Dairy Farm Systems for Profit".

The model uses monthly dry matter production and ME available from the forage feedbase of a dairy enterprise in combination with different herd structures and supplementary feed plans to provide estimates of the adequacy of dry matter and ME intake. From the latter, milk production of the herd can be predicted. The model is based on a combination of NRC and ARC ruminant nutrition equations.

Forage data has been included. It has been derived from pasture analyses in the subtropical dairy areas of Queensland and NSW. The forage feedbases, QFEED and NSW FeedPlan, provide average DM production of pastures for each month of the year. A second type of forage feedbase has been developed using the pasture and forage growth rate simulation program 'DairyMod'. This makes Dairy Predict possibly unique, in that it can account for seasonal variation in pasture and forage production. DairyMod simulations use daily climate files from a locality to predict forage growth.

Comparisons with other models

To compare star ratings for Dairy Predict and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using Dairy Predict and other nutrition models, see Table 2 on page 29.

To compare the scope and limits of the feed library in Dairy Predict and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of Dairy Predict and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how Dairy Predict works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆☆☆☆
User-friendliness	☆☆☆
Applicability to various feeding systems	☆☆☆
Ability to estimate milk yield accurately	☆☆
Ability to estimate nutrient requirements	☆☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆
Amount of feed analysis required	☆☆
Scope of feed library supplied	☆☆☆
Suitability of help file / manual	☆☆☆
Availability of extra features	☆☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- Year-to-year variation can be seen; able to pick good or bad years.
- Single cut forages, such as maize and barley, can be grown, conserved and fed back within the farming system.
- Monthly surpluses of grazed forages can be either conserved and fed back at a later date or deferred and grazed in the next or later months.
- Can overlay different herd and supplement feed plans.
- All graphs and tables are exportable.
- Users can create their own forage and supplement databases which can be fully edited. Data can then be imported into Dairy Predict.
- Range of forages that can be modelled is being expanded.

✘ Limitations

- The DairyMod simulations used to develop the forage database (i.e. irrigation water availability in drought years is difficult to model).
- Financial analysis function is limited, and may not be able to adequately account for differences in costs between farming systems.

FeedSmart

Year first developed	1992
Where developed	Australia
Used in	Australia
Marketed by	Future Dairy
Latest version	Vn 3 (2007)
Retail price	Nil
Technical support	NSW DPI – face-to face, phone, e-mail and web (no charge)
Phone	(02) 9351 1635
Website	–
Downloadable from website	No
Updates available via web and cost	No

Stated objectives of the model

- Feed allocation for predominantly grazed pasture farmers.

Recommended for use by

- Dairy farmers
- Dairy nutritionists
- Veterinarians

Level of technical / nutritional knowledge required

Basic.

Description

FeedSmart was developed by the NSW Department of Primary Industries and Dairy Australia as part of the Future Dairy Project, to help dairy farmers efficiently allocate pasture and supplements on a daily basis.

FeedSmart is based on obtaining measurements of pasture on offer from weekly 'farm walks'. These data are then used in the central part of the program 'feed allocation', where the pasture available, herd requirements and feed deficit for each milking are calculated.

There are a number of supplementary feed options for filling the feed deficits. Options include concentrates, silage, hay or other, or a combination of these. The impact of these options on ration quality and costs of producing milk are estimated. The program provides several options for feed allocation, which describe where to graze the herd each milking, the supplements to be fed and paddock details. Pasture growth, pasture available and the pasture wedge, that is a graph of available pasture by paddock, can also be estimated with the situation on the farm. These outputs can be compared with previous seasons or to other farms.

Comparisons with other models

To compare star ratings for FeedSmart and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using FeedSmart and other nutrition models, see Table 2 on page 29.

To compare the scope and limits of the feed library in FeedSmart and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of FeedSmart and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how FeedSmart works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	Nil
Level of technical support available	☆
User-friendliness	☆☆
Applicability to various feeding systems	☆☆
Ability to estimate milk yield accurately	N/A
Ability to estimate nutrient requirements	☆☆☆
Level of technical expertise required to run software[1]	☆☆
Amount of inputs required to run software[1]	☆☆
Amount of feed analysis required	☆☆
Scope of feed library supplied	☆☆
Suitability of help file / manual	☆☆
Availability of extra features	☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths	✘ Limitations
• A practical tool for feed allocation on predominantly pasture-based system of farming.	• Ration formulation and calculation of cost of pasture are only approximate.

UDDER

Year first developed	1986
Where developed	Australia
Used in	Australia and New Zealand
Marketed by	WPC Computing
Latest version	Vn 2.10 (2002)
Retail price	AU$1950.00
Technical support	Michael Larcombe – phone, e-mail (no charge)
Phone	(03) 5147 1633
Website	www.udder4win.com
Downloadable from website	Yes
Updates available via web and cost	Yes

Stated objectives of the model

- Simulate a pasture-based dairy farm.
- Optimise management inputs on a pasture-based dairy farm.
- Farm systems model under pastoral management.
- An aid to increase productivity and profit.
- A learning tool to investigate the relationships of inputs to productive outputs (milk yield, BCS, APC, profit).

Recommended for use by

- Agronomists (possibly)
- Research scientists
- Farm system consultants

Level of technical / nutritional knowledge required

Very high.

Description

This program is a decision support model that predicts the expected milk production of dairy herds grazing pasture under different management systems and pasture growth. UDDER helps farmers make management decisions and has optimising routines that select management systems that are likely to increase farm profitability. It is a simulation model of a dairy farm where the major food supply is pasture. UDDER can also be used to calculate the feed requirements of a herd, provided the milk production and body condition of the cows are known.

UDDER can predict the milk production of herds with different calving patterns. Because many factors interact to determine milk production, UDDER accounts for the effect of variables, such as pasture growth, stocking rate, supplementary feeding, grazing management and fodder conservation. Milk production is predicted using a simulation of the utilisation of energy within the dairy cow, the estimated DMI of cows at pasture, and the predicted accumulation and quality of pasture on farms over a year.

UDDER consists of a 'Standard' module and a 'Professional' module capable of testing large numbers of management options. The Professional module enables UDDER to calculate the values of a variety of variables resulting in an optimum gross margin. It also provides the ability to conduct sensitivity factorial experiments using optimisations.

Comparisons with other models

To compare star ratings for UDDER and other nutrition models, see Table 1 on page 28.

To compare the parameters required to compile a ration using UDDER and other nutrition models, see Table 2 on page 29.

To compare the scope and limits of the feed library in UDDER and other nutrition models, see Table 4 on page 31.

To compare the predictive capabilities and suitability for different feeding systems of UDDER and other nutrition models, see Table 5 on page 32.

Further technical information

For further technical details on how UDDER works, including the information required to run a simulation, and the key concepts used to model rumen function, predict energy and protein requirements, feed intake, milk response, liveweight changes and pasture substitution, please visit www.dairyaustralia.com.au/nutritionmodels

Star ratings

Cost	AU$1950
Level of technical support available	☆☆☆
User-friendliness	☆☆
Applicability to various feeding systems	☆☆
Ability to estimate milk yield accurately	☆☆
Ability to estimate nutrient requirements	☆☆
Level of technical expertise required to run software[1]	☆☆☆
Amount of inputs required to run software[1]	☆☆
Amount of feed analysis required	☆☆
Scope of feed library supplied	☆
Suitability of help file / manual	N/A
Availability of extra features	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that the model is or is not more suitable for use.

✔ Strengths

- The only model to integrate stocking rate and calving patterns with supplementary feed analysis to determine optimum management scenario for a farm.
- A very powerful tool for investigating the interactions of inputs to produce outputs.
- Visually easy to follow for the farmer – intuitive display.
- Excellent as a management tool to plan a year's budget and feed inventory control excellent.
- Useful financial outputs but must be held in context of model, i.e. are a Gross Margin Analysis nothing more.
- Tracks actual performance against predictions very well.
- Provides yearly record of performance and strategies very well.
- Most complete pastoral farm systems model we have seen.
- Very powerful learning / teaching tool.

✘ Limitations

- Requires a high degree of skill, knowledge and experience to run the model effectively.
- Modelling of pasture quality changes.
- Uncertainty of substitution during supplementation under grazing conditions.
- ME based only and works well in pasture-based systems but once the percentage of pasture in the yearly ration gets below ~50% the predictions become less stable.
- Slow to adjust to rapid drops in pasture availability that sometimes occur in drought years. Best suited to areas with predictable pasture growth.
- At higher levels of production (>2.5 kg MS/cow/day) predictions can be less predictive.
- Does not have a PGR model included; it back calculates PGR from data sets.

Table 1: Star ratings (1 to 5) for tactical and strategic dairy nutrition models evaluated

All the information provided by developers and information independently obtained on each model during the study has been combined to rank the models using a star rating system.

Models	Tactical									Strategic	
	Amino Cow	Cam Dairy	CPM Dairy	Diet Check	Feed into Milk	Graz Feed	Ration Check	Rumen8	Dairy Predict	Feed Smart	UDDER
Cost	NIL	AU $660	US $550	NIL	AU $2100	AU $423.50	NIL	NIL	NIL	NIL	AU $1950
Level of technical support available	☆☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆☆☆	☆	☆☆☆	☆☆☆☆	☆	☆☆☆
User-friendliness	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆
Applicability to various feeding systems	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆☆
Ability to estimate milk yield accurately	☆☆☆	☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆	☆	☆☆☆	☆☆☆	☆☆	N/A	☆☆
Ability to estimate nutrient requirements	☆☆☆	☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆
Level of technical expertise required to run software[1]	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆☆☆
Amount of inputs required to run software	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆☆	☆☆
Amount of feed analysis required	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆	☆☆	☆☆
Scope of feed library supplied	☆☆☆	☆☆☆☆	☆☆☆☆	☆	☆☆☆	☆	☆☆☆	☆☆	☆☆☆	☆☆	☆
Suitability of help file/manual	☆☆☆	☆☆☆☆	☆☆☆☆	N/A	☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆	☆☆	N/A
Availability of extra features	☆☆☆	☆☆☆	☆☆☆☆	☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆	☆☆☆☆	☆☆	☆☆☆

Star rating: 1: low 2: low-medium 3: Average 4: High: 5: Very high

1. Where a higher level of technical expertise is required, the higher the star rating does not necessarily indicate that model is or is not more suitable for use.

Table 2: Essential/required parameters to compile a ration or a strategic feeding plan for tactical and strategic models.

Models	Breed	Body weight	Milk			DIM	BCS	Stage of lactation	Lactation no	Distance Walked	Terrain (hilly vs. flat)	Environmental factors	Days in calf	Price of ingredients
			Yield	Composition	Price									
Tactical														
AminoCow	Only for heifers	✔	✔	✔		✔	✔	✔	✔					
CamDairy	✔	✔	✔	✔	✔	✔	✔	✔			✔		✔	✔
CPM-Dairy		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Diet Check		✔	✔	✔		✔	✔	✔		✔	✔		✔	
Feed into Milk[1]		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
GrazFeed	✔	✔	✔	Given as 4% FCM		✔	✔	✔	✔	✔	✔	✔	✔	✔
RationCheck	✔	✔	✔	✔	MOFC option	✔	✔	✔		✔	✔			MOFC option
Rumen8		✔	✔	✔	(can be entered)	✔		✔		✔	✔		✔	(can be entered)
Strategic														
Dairy Predict		✔ pre-calving	✔	✔	✔	✔		✔		✔	✔			✔
FeedSmart	✔	✔	✔	✔		✔		✔						
UDDER[2]		✔		✔	✔	✔	✔	✔				✔ (only for seasons changes)		

1. FiM = Other parameters are used for FiM: Number of cows per group, number of meals per day.

2. UDDER = Other parameters for UDDER: Area of pasture offered; Quality/Quantity of pasture offered; Substitution by feeds other than pasture exists. Environmental factors considered in UDDER are based on strategic planning not daily basis.

Table 3: Animal, environmental and ration inputs required for tactical models.

	AminoCow	CamDairy	CPM-Dairy	Diet Check	Feed into Milk	GrazFeed	RationCheck	Rumen8
Animal and environmental inputs								
Animal status	✔		✔		✔	✔	✔	✔
Breed	✔	✔				✔	✔	
Lactation number	✔	✔	✔		✔			
Current age (months)	✔	✔	✔			✔		
Current weight (kg)	✔	✔	✔	✔	✔	✔	✔	✔
Mature weight (kg)	✔		✔			✔		
Days pregnant		✔	✔	✔	✔	✔		✔
Days in milk	✔	✔	✔	✔	✔	✔	✔	✔
Milk fat (%)	✔	✔	✔	✔	✔		✔	✔
Milk protein (%)	✔	✔	✔	✔	✔		✔	✔
Body condition score (1-5 scale)	✔		✔					
Body condition score (1-8 scale)		✔		✔	✔	✔		
Current temperature (°C)			✔			✔		
Current relative humidity (%)			✔					
Minimum night temperature (°C)			✔			✔		
Type of farming system	✔	✔	✔		✔			
Distance walked on flat terrain (meters/day)		✔	✔	✔	✔	✔	✔	✔
Distance walked on hilly terrain meters/day)			✔		✔			✔
Ration inputs								
DM intake (kg DM/day)	✔	✔	✔	✔	✔	✔	✔	✔
DM (%)	✔	✔	✔	✔	✔	✔	✔	✔
Energy (MJ ME/kg DM)		✔		✔	✔	✔	✔	✔
Crude protein (% DM)	✔	✔	✔	✔	✔	✔	✔	✔
DM digestibility (%)						✔		
Lignin (% DM)	✔		✔					
NDF (% DM)	✔	✔	✔	✔	✔		✔	✔
ADF (% DM)	✔		✔		✔			
EE (% DM)	✔	✔	✔		✔	✔	✔	✔
Ash (% DM)	✔		✔		✔		✔	✔
ADIP (% CP)	✔		✔		✔	✔		
NDIP (% CP)	✔		✔					
Soluble Protein (% CP)			✔					
Starch (% DM)			✔		✔		✔	✔
WSC (% DM)			✔		✔		✔	✔

Table 4: Feed bank, number of feeds in feed bank, cost of feed ingredients, limits on the number and amount of feed ingredients, margins over feed cost and marginal response to supplements.

Models	Feed library	Total no of feeds	Cost of feed ingredients	Limits on no of feed ingredients	Limit on the amount (kg) of feed ingredients	Margins over feed cost	Prediction of marginal response to supplements
Tactical							
AminoCow	✔	267	✔	✔ (Max 40 feeds)	None	✔	
CamDairy	✔	184	✔	None	None	✔	
CPM-Dairy	✔	500	✔	None	None	✔	✔ (only by comparing no supplement and supplement rations)
Diet Check	✔	51	✔	✔ Five feeds	✔ (concentrates should be < 50% of total diet)		✔ Marginal response to extra DMI
GrazFeed	✔	52	✔	None	✔ (user is warned if level of concentrate is more than 80% of diet)		✔ predicts marginal response through the effects of substitution of supplement for pasture
Feed into Milk	✔	194 (in basic feed library that was provided for this review). Library is expandable to 99999	✔ (essential)	240	99999.99 kg	✔ (for both expected and predicted from DSS)	✔ (comparative analysis and parametric analysis)
RationCheck	✔	152	✔	None	None	✔	
Rumen8	✔	42	✔	✔ (10 feeds)	99 kg	✔	
Strategic							
Dairy Predict	✔	138	✔	Unlimited forage, 15 supplements	None	✔	
FeedSmart	✔	75	✔	✔ Four feeds	None		
UDDER				✔ Six supplementary feeds. Five crop options	✔ (recommended limit of max. 6 kg of supplement/cow. Substitution predictions have not been tested above this level)	✔	✔ It simulates the outcome Immediate response in: - milk and pasture substitution - BCS gain Simple gross margin analysis - cost change - extra revenue from milk sales.

Table 5: Prediction of milk yield and composition, consideration of stage of lactation, ration formulation/strategic feeding plan for lactating, heifers and dry cows, environmental factors for the predictions and type of feeding systems.

Models	Milk production prediction and (individual vs. herd base)	Milk fat and protein (%) prediction	Is BCS used for milk yield prediction	Stage of lactation considered in ration formulation/ feed planning	Ration formulations/ feed planning	Ration formulation/ feed planning for heifers and dry cows	Environmental factors considered in ration formulation	Feeding system (PMR, TMR and Grazing)
Tactical	(cow vs. herd base)							
AminoCow[1]	✔[2] (Based on DMI)		✔ (using ME)	✔	✔[2]	✔		Best in TMR Can be used for all systems
CamDairy	✔ (either)		✔ (ME and CP calculated from tissue mobilization)	✔	✔	✔		PMR, TMR and Grazing
CPM-Dairy	✔ (cow within a herd)	✔ Protein	✔	✔	✔	✔	✔	PMR, TMR and Grazing
Diet Check					✔			Grazing Grazing + concentrate
Feed into Milk	✔ (cow)	✔	✔ (ME calculated from BCS component0	✔ (using DIM function)	✔	✔ (dry cows only)		PMR, TMR and Grazing
GrazFeed	✔ 4% FCM) (cow)		✔ (for potential feed intake and milk yield)	✔	✔	✔	✔	Grazing, TMR, PMR, Grazing + concentrate
RationCheck			✔ (Taken into account when calculating nutrient levels of ration)	✔	✔ (checks nutrient levels of ration)			All feeding systems
Rumen8[2]	(✔)[3] (individual cow)			✔	✔			All

Table 5: Prediction of milk yield and composition, consideration of stage of lactation, ration formulation/strategic feeding plan for actating, heifers and dry cows, environmental factors for the predictions and type of feeding systems (continued).

Model	Milk production prediction and (individual vs. herd base)	Milk fat and protein (%) prediction	Is BCS used for milk yield prediction	Stage of lactation considered in ration formulation/ feed planning	Ration formulations/ feed planning	Ration formulation/ feed planning for heifers and dry cows	Environmental factors considered in ration formulation	Feeding system (PMR, TMR and Grazing)
Strategic								
Dairy Predict	✔ based on forage and supplement plans)			✔ (from calving pattern)	✔			Grazing Grazing + conserved forage
FeedSmart					✔	✔		Grazing Grazing+ concentrate
UDDER[3]	✔ (on a calving group basis) Simulation model based on individual stage of lactation and age distribution (see footnotes)	✔ 1- Not based on metabolic process 2-Based on stage of lactation (see footnotes)	✔ Uses BCS throughout lactation	✔	✔ It is not a ration formulation package. UDDER can be used for strategic planning of feed management	✔ It is not a ration formulation package. UDDER can be used for strategic planning of feed management	No Although can adjust for this for strategic planning only by sophisticated manipulation	Grazing: excellent PMR: very good with some limitations on and quantity of feeds Grazing + concentrate: Very good within normal ranges of ingredients

1. AminoCow: Milk yield prediction: AminoCow predicts the nutrient requirements for the amount of milk production set by the user, but it doesn't directly predict milk production for a specific ration.

2. Rumen8: Milk yield prediction: The model does not predict milk yield directly but estimates if the diet can sustain current milk production. An estimation of milk yield can be predicted by changing the milk production level to match energy and protein requirements.

3. UDDER: Milk yield prediction: The prediction of milk production is based on individual stage of lactation and also age distribution.

Milk composition prediction: The prediction is not based on metabolic processes. Prediction= Predicted fat test for a standard cow (predicted fat test for standard cow at stage of 150 days x 150 day fat test predictor for simulated cows). This is also based on stage of lactation with two input variables entered by operator: i) average fat test for 150 days and ii) fat test curve for lactation defaults. UDDER does not predict fluctuations in response to feeding.

Section 3:

Evaluation of the eight tactical models

As explained in Section 1, after general and technical information had been obtained on each model, the 'champions' of each tactical model were provided with seven extensive, high-quality data sets.

Each model's ability to predict yield of milk, supply of nutrients, and nutrient requirements and marginal response, to grain was then evaluated.

Each model's sensitivity to changes in nutrient composition of feeds, animal and environmental factors was also evaluated.

This section summarises the findings from this evaluation and enables the eight tactical models performance to be compared.

Prediction of milk yield

The outputs (milk production, milk fat percentage and milk protein percentage) generated using the tactical models from the experimental diets are presented in Table 6 and Figure 1. The actual milk production and milk components recorded at the trials are also presented for these diets.

The good news was that there were very high levels of concordance achieved between actual milk yields and those estimated by application of the various tactical nutrition models to the seven experimental datasets. See Tables 7-8 and Figure 2.

Regression analysis of predicted responses against the actual indicate that almost all models closely predicted the actual milk production from the diets provided, giving good confidence in the performance of these. The most appropriate responses were provided by CamDairy and CPM Dairy which showed highly significant regression with intercepts close to zero and coefficients that closely approximated unity. The intercepts provided from RationCheck, Rumen8 and FIM were least satisfactory and had coefficients also that varied from unity.

Table 6: Estimated outputs of tactical nutrition models using experimental diets.

Models	AminoCow	Cam-Dairy	CPM-Dairy[1]	Diet Check[2]	Feed into Milk	GrazFeed[3]	RationCheck	Rumen8	ACTUAL
Test diet 1									
Milk production (L/d)	41.0	39.5	MP:37.1 (ME:45.0)	N/A	42.6	39.0	49.0	39.4	37.09
Milk fat (%)	2.9	N/A	N/A	N/A	3.55	4.0	N/A	N/A	4.0
Milk protein (True protein %)	2.9	N/A	2.69	N/A	3.2	N/A	N/A	N/A	3.3
ME supplied from diet (MJ)	277.30	292.0	293.0	N/A	287.2	237.0	293.4	292.0	
CP supplied from diet (%)	23.69	23.9	23.7	N/A	20.3	23.0	23.4	24.3	
NDF supplied from diet (%)	26.2	27.0	27.0	N/A	26.7	N/A	27.7	27.6	
MP requirement (% of DM)	10.06	N/A	12.5	N/A	10.97	16.0 (RDP+UDP)	N/A	11.23	
NDF requirement (% of DM)	27.73	30.0	N/A	N/A	N/A	N/A	33.2 (Max)	N/A	
Test diet 2									
Milk production (L/d)	49.0	39.5	ME:44.5 (MP:48.0)	N/A	42.4	38.0	42.0	37.7	40.89
Milk fat (%)	2.9	N/A	N/A	N/A	3.68	4.0	N/A	N/A	4.0
Milk protein (True protein %)	2.9	N/A	3.48	N/A	3.08	N/A	N/A	N/A	3.3
ME supplied from diet (MJ)	275.65	286.0	287.0	N/A	285.8	224.0	285.9	286.0	
CP supplied from diet (%)	22.49	22.5	22.5	N/A	26.5	22.0	22.6	22.5	
NDF supplied from diet (%)	28.82	32.6	32.6	N/A	32.6	N/A	32.7	32.6	
MP requirement (% of DM)	9.04	N/A	12.7	N/A	10.77	15.0 (RDP+UDP)	N/A	10.82	
NDF requirement (% of DM)	27.73	30.0	N/A	N/A	N/A	N/A	36.3 (Max)	N/A	
Test diet 3									
Milk production (L/d)	22.5	29.0	ME:28.0 (MP:28.6)	30.6	28.9	23.0	29.0	27.9	33.4
Milk fat (%)	4.28	N/A	N/A	N/A	4.08	4.0	N/A	N/A	4.28
Milk protein (True protein %)	3.0	N/A	3.33	N/A	3.31	N/A	N/A	N/A	3.32
ME supplied from diet (MJ)	192.42	232.0	205.0	234.0	231.6	202.0	229.7	232.0	
CP supplied from diet (%)	14.77	14.7	14.8	14.8	14.8	13.0	14.7	14.8	
NDF supplied from diet (%)	35.51	37.5	34.4	35.0	37.5	N/A	37.5	37.5	
MP requirement (% of DM)	7.01	N/A	11.20	N/A (18.5% CP)	10.19	18.0 (RDP+UDP)	N/A	10.89	
NDF requirement (% of DM)	26.67	30.0	N/A	30.0	N/A	N/A	34.9 (Max)	N/A	

Table 6: Estimated outputs of tactical nutrition models using experimental diets (continued).

Models	AminoCow	Cam-Dairy	CPM-Dairy[1]	Diet Check[2]	Feed into Milk	GrazFeed[3]	RationCheck	Rumen8	ACTUAL
Test diet 4									
Milk production (L/d)	19.0	23.6	MP:26.2 (ME:27.9)	18.2	22.5	18.0	20.0	21.5	25.4
Milk fat (%)	4.37	N/A	N/A	N/A	4.24	4.0	N/A	N/A	4.37
Milk protein (True protein %)	3.40	N/A	2.99	N/A	3.48	N/A	N/A	N/A	3.51
ME supplied from diet (MJ)	203.93	212.0	209.0	176.0	211.7	186.0	201.0	212.0	
CP supplied from diet (%)	16.05	16.1	16.1	14.0	16.1	19.0	15.9	16.1	
NDF supplied from diet (%)	38.9	41.3	36.9	39.0	39.1	N/A	41.0	41.3	
MP requirement (% of DM)	7.28	N/A	11.90	N/A (15.0%CP)	9.30	20.0 (RDP+UDP)	N/A	9.22	
NDF requirement (% of DM)	22.50	30.0	N/A	34.0	N/A	N/A	41.1 (Max)	N/A	
Test diet 5									
Milk production (L/d)	23.8	25.8	MP:30.4 (ME:32.0)	N/A	26.4	19.0	20.0	24.5	24.0
Milk fat (%)	4.50	N/A	N/A	N/A	4.15	4.0	N/A	N/A	4.37
Milk protein (True protein %)	3.0	N/A	2.92	N/A	3.49	N/A	N/A	N/A	3.51
ME supplied from diet (MJ)	206.82	236.0	231.0	N/A	236.5	199.0	225.2	237.0	
CP supplied from diet (%)	14.5	14.5	14.5	N/A	14.5	15.0	14.5	14.5	
NDF supplied from diet (%)	35.6	37.8	33.8	N/A	36.3	N/A	37.4	37.8	
MP requirement (% of DM)	7.38	N/A	12.60	N/A	9.63	19.0 (RDP+UDP)	N/A	9.57	
NDF requirement (% of DM)	24.82	30.0	N/A	N/A	N/A	N/A	40.9 (Max)	N/A	
Test diet 6									
Milk production (L/d)	26.2	15.3	ME:17.7 (MP:24.1)	15.0	13.7	18.0	18.0	13.3	19.1
Milk fat (%)	4.15	N/A	N/A	N/A	4.11	4.0	N/A	N/A	4.15
Milk protein (True protein %)	3.0	N/A	3.93	N/A	3.34	N/A	N/A	N/A	3.43
ME supplied from diet (MJ)	204.03	154.0	154.0	154.0	153.9	127.0	157.4	154.0	
CP supplied from diet (%)	16.05	20.0	20.0	20.0	20.0	12.0	20.0	20.0	
NDF supplied from diet (%)	38.09	42.5	42.4	42.0	42.5	N/A	42.5	42.4	
MP requirement (% of DM)	7.16	N/A	11.20	N/A (16.5%CP)	7.97	15.0 (RDP+UDP)	N/A	7.47	
NDF requirement (% of DM)	26.08	30.0	N/A	31.0	N/A	N/A	41.2 (max)	N/A	

Table 6: Estimated outputs of tactical nutrition models using experimental diets (continued).

Models	AminoCow	Cam-Dairy	CPM-Dairy[1]	Diet Check[2]	Feed into Milk	GrazFeed[3]	RationCheck	Rumen8	ACTUAL
Test diet 7									
Milk production (L/d)	20.3	21.7	ME:23.1 (MP:34.2)	21.8	20.6	19.0	20.0	19.6	22.3
Milk fat (%)	4.39	N/A	N/A	N/A	4.05	4.0	N/A	N/A	4.39
Milk protein (True protein %)	3.71	N/A	4.57	N/A	3.48	N/A	N/A	N/A	3.71
ME supplied from diet (MJ)	194.59	199.0	199.0	199.0	199.1	148.0	197.2	199.0	
CP supplied from diet (%)	26.53	26.5	26.5	26.5	26.5	12.0	26.5	24.7	
NDF supplied from diet (%)	31.36	31.4	31.4	31.0	31.4	N/A	31.3	28.9	
MP requirement (% of DM)	7.39	N/A	12.50	N/A (16.5%CP)	9.74	16.0 (RDP+UDP)	N/A	9.39	
NDF requirement (% of DM)	25.78	30.0	N/A	31.0	N/A	N/A	38.9 (Max)	N/A	

1 CPM-Dairy predicts milk production both as ME available milk and MP available milk. Both estimates have been presented here but the lowest value has been used in the analysis of the predictions.

2 Diet Check does not estimate the MP requirement. The program estimates the CP requirement. No prediction is generated for diets 1, 2 and 5, because Diet Check is not suitable for rations with < 50% pasture, .

3 GrazFeed does not estimate the MP requirement. The program only estimates the RDP and UDP requirements. GrazFeed does not predict milk components, but milk production is predicted at 4% FCM. The milk fat values have not been used in the analysis.

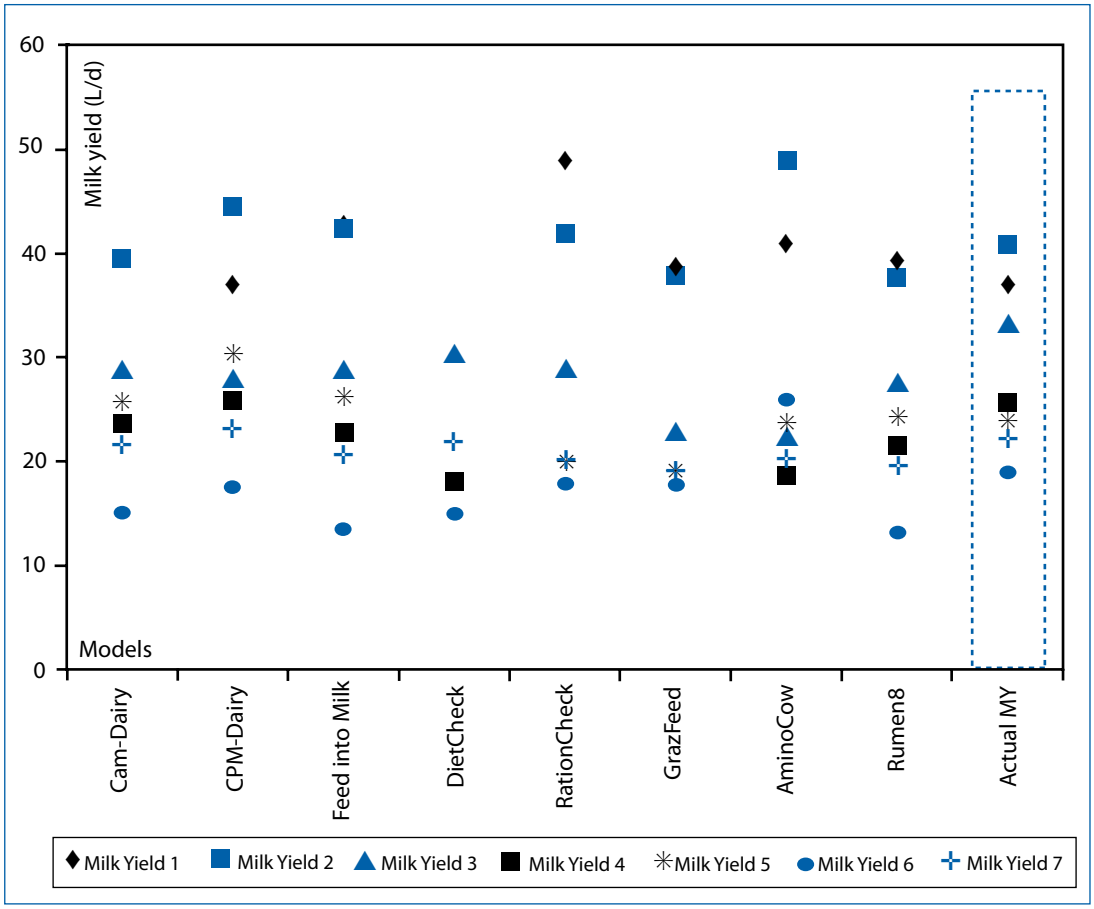

Figure 1: Actual and estimated milk production for the test diets.

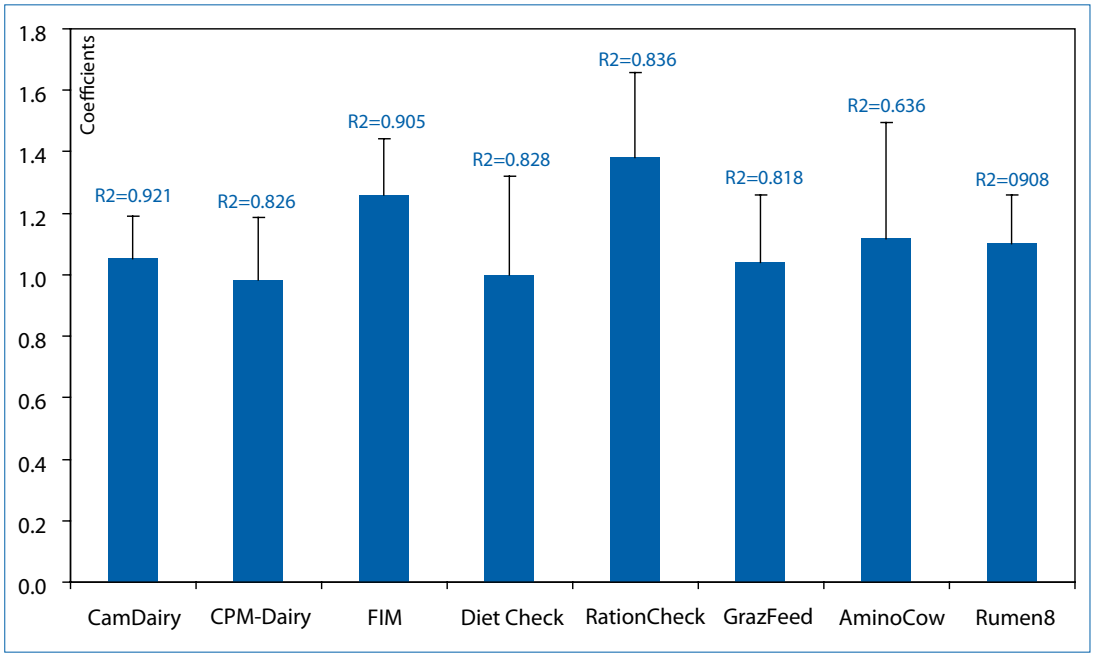

Figure 2: Coefficient ± SE and R2 of actual milk yield using seven different diets vs. predicted milk yield generated by eight tactical dairy nutrition models.

Table 7: Spearman's rank correlation of predicted and actual milk production (Friedman concordance = 40.2; $p<0.0001$) .

Models	RationCheck	Rumen8	Feed Into Milk	CPM-Dairy	Cam-Dairy	AminoCow	GrazFeed
RationCheck							
Rumen8	0.964*						
Feed Into Milk	0.964*	1.000*					
CPM-Dairy	0.852*	0.929*	0.929*				
CamDairy	0.954*	0.991*	0.991*	0.955*			
AminoCow	0.484	0.536	0.536	0.607	0.559		
GrazFeed	0.944*	0.909*	0.909*	0.818*	0.899*	0.618	
Actual Milk	0.927*	0.929*	0.929*	0.893*	0.955*	0.464	0.800*

** p value <0.05*

Note: DietCheck did not provide sufficient data to be evaluated statistically and similarly, data on estimates of milk fat and protein content were provided by too few programs to evaluate statistically.

Table 8: Intercept, coefficient ± SE and R^2 of actual milk yield using seven different diets vs predicted milk yield generated by eight tactical dairy nutrition models.

Models	No. of diets	Intercept ± SE	Coefficient ± SE	R^2	Significance of coefficients (*p* value)
AminoCow	7	-3.405 ± 11.273	1.116 ± 0.378	0.636	0.032
CamDairy	7	-2.660 ± 4.112	1.054 ± 0.138	0.921	0.001
CPM-Dairy	7	1.155 ± 6.032	0.984 ± 0.202	0.826	0.005
DietCheck	4	-3.621 ± 8.255	0.999 ± 0.322	0.828	0.090
Feed Into Milk	7	-8.208 ± 5.465	1.259 ± 0.183	0.905	0.001
GrazFeed	7	-5.209 ± 6.552	1.041 ± 0.219	0.818	0.005
RationCheck	7	-11.630 ± 8.171	1.382 ± 0.274	0.836	0.004
Rumen8	7	-5.555 ± 4.692	1.102 ± .157	0.908	0.001

Marginal response to grain

Almost all models provided consistent responses from 11 to 14 additional litres for the extra 5 kg of grain (triticale) that was simulated, with the exception of GrazFeed that predicted only an extra one litre response (see Table 9).

The consistent and high responses observed with most models all exceed observed marginal responses to grain supplementation of up to 1.5 litre/kg grain in older Australian studies. Differences between the simulation and actual response are likely to be related to the partition of the extra nutrients into body weight rather than milk and/or substitution of pasture intake at increased levels of grain intake.

Some of the models can accommodate increased partitioning of nutrients towards growth including Cam-Dairy, CPM-Dairy, RationCheck, Feed into Milk, GrazFeed, and Rumen8 can allow for increased weight gain, as specified. Consequently, predictions of milk response may be moderated if it is considered that either growth or partitioning to body condition is likely. None of the models has incorporated anti-nutritional or palatability concepts.

Table 9: Estimated marginal milk response to additional concentrate (5 kg of triticale grain) to "test diet 6".

Models	Milk Production (L/day)		Marginal response (L/day)	Note
	Control diet	Response diet (5 kg of triticale)		
AminoCow	14.8	28.3	13.5	Milk yield is predicted where ME requirement is equivalent supplied ME
Cam-Dairy	15.3	27.2	11.9	Optimum milk yield was set at 40 L/day (0.1 kg of live weight change)
CPM-Dairy	17.7	31.7	14.0	Target milk yield was set to match the DMI of the model
DietCheck	15.0	26.5	11.5	
Feed into Milk	13.7	25.2	11.5	Target milk yield was set at a level where ME requirement is equivalent supplied ME
GrazFeed	18.0	19.0	1.0	Substitution effect is predicted (pasture intake was reduced by 3 kg DM)
RationCheck	18.0	31.0	13.0	Target milk yield set to match the DMI of the model
Rumen8	13.3	24.3	11.0	Milk yield is predicted where ME requirement is equivalent supplied ME

Sensitivity to changes in inputs

The tactical models appeared to differ quite significantly in their sensitivity to changes in the inputs such as nutrient composition and animal and environmental factors. See Tables 10 and 11.

Two models, GrazFeed and Rumen8, provide much lower responses to a change in diet quality. Of the others, three, CPM-Dairy, DietCheck and AminoCow, provide warnings that the NDF supplied may exceed the capacity of cows to eat this.

Estimates for milk production loss from supporting additional maintenance were quite consistent. Surprisingly, GrazFeed predicted an increase in milk production which was the result of increased intake. The responses for AminoCow were also inconsistent with other models, indicating a higher estimate of the maintenance requirement. The estimated cost of decreasing exercise was consistent across models, although Cam-Dairy and CPM-Dairy had higher estimates than those in Feed into Milk, RationCheck, DietCheck and GrazFeed. It is somewhat surprising to see differences in these estimates as the standards for exercise are well-defined and similar standards are accepted internationally.

Table 10: Sensitivity of tactical models to varying nutrient composition using high-quality pasture in "test diet 6".

Models	Milk Production (L/day)		Difference	Note
	Control diet (test diet 6)	Diet with high-quality pasture		
AminoCow	14.8	23.2	8.4	2.04 kg's excess NDF supplied, 1.94 kg's excess CP supplied
Cam-Dairy	15.3	23.9	8.6	
CPM-Dairy	17.7	23.5	5.8	Excess NDF (peNDF above capacity)
DietCheck	15.0	26.4	11.4	Diet supplies 13% excess NDF
Feed into Milk	13.7	21.4	7.7	
GrazFeed	18.0	19.8	1.8	
RationCheck	18.0	26.0	8.0	
Rumen8	13.3	16.0	2.7	Limiting factor is DMI (excess NDF)

Table 11: Sensitivity analysis of tactical dairy nutrition programs to additional bodyweight (100kg) and level of exercise (2km less/day) in "test diet 6".

Models	Control diet	Milk production responses to changes in body weight and level of daily exercise ((L/day)			
		Sensitivity analysis of additional 100 kg body weight	Difference	Sensitivity analysis of level of exercise (2 km less /day)	Difference
AminoCow	14.8	11.8	3.0	N/A	
Cam-Dairy	15.3	14.7	0.6	17.1	1.8
CPM-Dairy	17.7	16.1	1.6	18.6	1.1
DietCheck	15.0	13.0	2.0	15.6	0.6
Feed into Milk	13.7	12.6	0.9	14.2	0.5
GrazFeed[1]	18.0	18.6 (due to increased pasture consumption)	+0.6	18.5	0.5
RationCheck	18.0	16.0	2.0	18.5	0.5
Rumen8	13.3	11.8	1.5	14.2	0.9

1. In all models except GrazFeed, pasture intake was assumed to be the same as the control diet. In GrazFeed, the pasture intake increases with increasing bodyweight and it is not possible to set the pasture intake as the same as the control diet.

Section 4:

Conclusions

This study is the most comprehensive review and evaluation of the range of prominent computer-based nutrition models used in the Australian dairy industry.

It has highlighted how different the tactical and strategic nutrition models used by advisers and farmers are in terms of:

- their stated objectives;
- the recommended target audience;
- who they are recommended for use by;
- the level of technical / nutritional knowledge required to use them;
- the underlying concepts / assumptions / algorithms / functions used in each model;
- the animal, environmental and ration inputs required to perform a simulation; and
- their predictive capabilities and suitability for different feeding systems.

This should not be surprising, given that the models have been developed often by individuals or 'champions', who each have their own specific interests and focus, as tools to help them improve their understanding of nutrition and rumen physiology, and which have then been released for wider industry use as decision-support tools.

Each model reviewed has a number of strengths and limitations, which are important for users to be aware of. These have been identified and listed in Section 2 under the individual profile for each model.

The star ratings based on all the information provided by the developers and information independently obtained on each model during the study also highlight how different the models are for key factors, including:

- level of technical support available;
- user friendliness;
- level of technical expertise required of the operator to run the software;
- amount of inputs and feed analysis required to run the software;
- scope of the feed library supplied; and
- help files / manual and extra features available.

A summary of the star ratings for each model is presented in Table 1 on page 28.

The eight tactical models were evaluated for their ability to predict milk yield response and their sensitivity to inputs using the seven extensive, high-quality data sets that were provided to the 'champions'.

Almost all of the models evaluated closely predicted the actual milk production from the diets provided, which should give users of the models some deal of confidence in using these nutrition models.

Almost all models also predicted consistent responses to grain supplementation when simulated, although these were consistently higher than the marginal responses observed in actual data derived from previous Australian studies. Users of models need to acknowledge the limitations of given models to partition extra nutrients into growth or body condition, and/or account for substitution of pasture intake at increased levels of grain intake.

Users of models should also be aware of the differing sensitivities of the models to changes in inputs, such as the nutrient composition of feeds, and other inputs, such as bodyweight and level of exercise, that were also identified in the evaluation.

As stated in the introduction, Dairy Australia's Grains2Milk program hopes that as a result of this study, dairy nutrition advisers are more aware of the nutritional models available, and better able to use their preferred model to support their business with a greater understanding of its functionality, sensitivity to data inputs, strengths and limitations. We also hope that the information provided encourages some dairy nutrition advisers to enhance their advisery capability by learning to use different models.

Indirectly and longer term, dairy farmers will benefit from this study because there will be more nutrition advisers who have more knowledge about (and more confidence in) the nutrition models and who will be in a better position to select and use those nutrition models that are appropriate for their clients.

This study also paves the way for more extensive evaluation of selected models in the future using datasets collected as part of other Dairy Australia R&D projects.

We wish to acknowledge the many people who contributed their expertise and experience to this challenging project.

Dairy Australia Your Levy at Work

GRAINS 2 MILK From grains to profit

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