# Using Models on Dairy Farms – How Well Do They Work?

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## INTRODUCTION

The use of computer models as a tool used by nutritionists to evaluate or formulate dairy rations is a routine and well accepted practice. Models have evolved from simple grain feeding charts through TI-59 programs, least cost formulation programs to a wide array of currently available computer programs. The available models differ greatly in cost, ease of use, and biology underlying the model. There are a number of ways that models can be used by nutritionists, faculty members, and Extension educators. These include:

1. Teaching –
    a. To gain a better understanding of nutrition principles.
    b. To assist in integrating feed, animal, environmental, and management components on animal performance results.
2. Extension – To help demonstrate the effects of changes in feed, animal, management, and environmental effects on animal performance, economic returns, and nutrient excretion.
3. To assist in designing and interpreting experiments.
4. As a tool to extend research results to on-farm nutrition programs.
5. To define areas of needed research information.
6. A diagnostic tool to evaluate feeding programs and to help in accounting for non-nutritional factors that impact ration performance.
7. To implement newer concepts, such as amino acid balancing and formulation for metabolizable protein.

A number of companies have models available for use by nutritionists. In addition, some feed companies have developed their own proprietary models. It is important to remember that none of the available models are perfect. They all have opportunities to improve the biological and nutritional concepts used as new research data becomes available. Each model has advantages and disadvantages. The user must have a thorough understanding of the specific model used to minimize risk of use.

An evaluation of the currently available models is outside the scope of this paper. This paper will focus only on the biological and nutritional concepts embodied in the Cornell Net Carbohydrate and Protein System (**CNCPS**) and CPM-Dairy models. This is not meant to imply that other models are not acceptable for use, but rather that the author's experience is with models using the CNCPS concepts. The software provided with the 2001 Dairy NRC incorporates some of the CNCPS concepts (NRC, 2001).

## MODEL DEVELOPMENT

The CNCPS model has been developed over a 30+ yr period by a large number of individuals. The goal was to develop a research based model that could be utilized on farms with readily available animal and feed inputs. A historical overview of this model development process is available (Sniffen, 2006). The biological and nutritional concepts contained in the CNCPS model have been described (Fox et al., 2004;

Tylutki et al., 2008; and Van Amburgh et al., 2010). Model development is a continuing process with the most recent peer reviewed paper providing information on nitrogen and urea recycling in dairy cattle (Recktenwald et al., 2014). The first on-farm application of an early version of the CNCPS model was in 1991. A number of revisions and updates have been made since that time. In 2006, a decision was made to license the biology in the CNCPS model to commercial firms. This let our group focus efforts on developing, refining, and verifying the biological and nutritional concepts in the model. Four companies have obtained a license at this point. Two companies are currently selling software in the U.S. under this license arrangement. These are Agricultural Modeling and Training System (**AMTS**; https://agmodelsystems.com) and Nutritional Dynamic System (**NDS**; www.rumen.it). Currently, the CNCPS biology is in use in more than 20 countries and about 3 million cows are fed rations formulated using these concepts. This includes users of CNCPS, CPM-Dairy, AMTS, and NDS. A number of consultants and feed companies use these programs as their primary ration evaluation and formulation tool.

## CASE STUDY OF CNCPS USE ON FARMS

The first on-farm use of CNCPS on a commercial dairy farm was reported in 1992 (Stone et al., 1992). An early version of the CNCPS model was used in a 300 cow herd producing 24,000 lb of milk/lactation. The model was used at least monthly over a one year period. Total feed costs were reduced, income over feed cost increased, and nitrogen excretion decreased as a result of implementing ration changes developed from model simulations. Herd milk production increased during this time, but was attributed to a trend of increasing herd milk production. A recent paper was published on the use of the CNCPS model in two New York dairy herds (Higgs et al., 2012a). This project was done in cooperation with the dairy farm managers and their herd nutritionists. The CNCPS model was used to formulate the high group ration in each herd over an 8 mo period. The goal was to maintain herd milk production while lowering feed cost, improving profitability, and decreasing nitrogen excretion to the environment. Table 1 contains the key results from this trial. Rations were adjusted at least monthly in each herd in cooperation with the herd nutritionist. Milk production, milk components, and milk urea nitrogen (**MUN**) data was available from dairy herd improvement (**DHI**) and the milk processor. Key points from Table 1 are:

1. Milk production was maintained in both herds, but milk true protein increased about 0.1 points. This was without tightly balancing amino acids.
2. Milk urea nitrogen was lowered by about 2 units in each herd. This indicates improved efficiency of nitrogen use in the cow.
3. Herd B had forage inventory problems so total ration forage feeding rate had to be decreased. This was due to the herd expanding in cow numbers during the trial.
4. Ration crude protein (**CP**) was lowered about 1 unit in each herd.
5. Ration starch was increased in both herds to provide rumen fermentable carbohydrates to stimulate microbial protein synthesis.
6. Metabolizable protein (**MP**) supply was lowered in herd A to bring it more in line with ration

metabolizable energy (**ME**). Metabolizable protein supply was increased slightly in herd B.
7. Manure and urinary N excretion was decreased.
8. Milk nitrogen (as % of N intake) increased 2 - 3 units. This is an index of improved efficiency of nitrogen use.
9. Total and purchased feed costs were reduced.
10. Income over feed cost (**IOFC**) and income over purchased feed cost (**IOPFC**) increased.
11. There are additional opportunities to further improve nitrogen utilization in these herds. Balancing for amino acids would be one step. However, there are some daily management considerations that need to be addressed before going to the next step in these herds to lower the risk of decreasing milk production by additional adjustments to ration N and MP.

We have used the CNCPS model in our undergraduate dairy nutrition course as part of a whole farm evaluation exercise by students. One component of this exercise is evaluating and adjusting rations. In one 450 cow herd, ration CP was lowered from 16.6 to 15.6 % in the mature cow group while maintaining a similar quantity of daily MP intake. Total feed cost was lowered by 60 ¢/cow/d while purchased feed costs went down by 57 ¢/cow/d. Milk production was maintained at 90 lb/cow. Thus, both IOFC and IOPFC increased after the ration was adjusted. In a second herd, ration CP was

**Table 1.** Commercial herd trial results

| Item | Herd A | | Herd B | |
|---|---|---|---|---|
| | Initial Ration | Final Ration | Initial Ration | Final Ration |
| Milk, lb/d | 79 | 80 | 82 | 80 |
| Milk fat, % | 3.58 | 3.63 | 3.56 | 3.63 |
| Milk true protein, % | 3.03 | 3.11 | 2.96 | 3.07 |
| MUN, mg/dl | 14.8 | 12.5 | 14.5 | 12 |
| Forage, % of ration | 54 | 57 | 60 | 48 |
| Corn silage, % of forage | 59 | 71 | 53 | 60 |
| Ration CP, % | 17.5 | 16.6 | 17.7 | 16.9 |
| Ration NDF, % | 32.5 | 33.6 | 31.3 | 33.2 |
| Ration starch, % | 23 | 27.6 | 23.6 | 26.3 |
| Ration fat, % | 4.3 | 3.8 | 5.4 | 4.2 |
| Total MP, g/d | 2950 | 2769 | 2646 | 2690 |
| N intake, g/d | 697 | 641 | 655 | 629 |
| Manure N, g/d | 500 | 441 | 469 | 441 |
| Fecal N, g/d | 250 | 237 | 233 | 231 |
| Urinary N, g/d | 250 | 204 | 236 | 210 |
| Milk N, % of N intake | 28 | 31 | 28 | 30 |
| Feed cost, $/cow/d | 5.88 | 5.43 | 6.14 | 5.97 |
| Purchased feed cost, $/cow/d | 3.55 | 2.96 | 3.73 | 3.42 |
| IOFC[a], $/cow/d | 3.08 | 3.83 | 3.01 | 3.22 |
| IOPFC, $/cow/d | 5.41 | 6.30 | 5.42 | 5.77 |

[a]IOFC = Income over feed cost, IOPFC = Income over purchased feed cost

lowered from16.1 to 15.1 % CP and milk production went from 84 to 86 lb/d, IOFC increased by 18 ¢/cow/d while IOPFC went up by 6 ¢/cow.

An evaluation comparing the predicted first nutrient limiting milk (ME or MP milk) with observed milk production using the CNCPS 6.1 model has been reported (Van Amburgh et al., 2010). The dataset used contained both research and commercial herd data. Ration CP varied between 12.7 and 17.4 %. Milk production ranged between 46 and 114 lb. The CNCPS model predictions accounted for 98 % of the variation observed in milk production with a mean prediction bias of less than 1 %.

As the field trial in Table 1 was being developed, there was also an opportunity to identify a group of herds feeding lower CP rations. These herds were fed by nutritionists utilizing CNCPS biology. This database currently contains data on about 35 herds averaging > 80 lb of milk with rations < 16 % CP. Table 2 contains example information from some of these herds.

These herds consistently have rations with < 16 % CP. Ration starch levels are on the high side to provide rumen fermentable carbohydrates to stimulate microbial protein production. The milk nitrogen efficiencies are also high at > 35 % for most of these herds. Many commercial herds have milk nitrogen efficiency (**MNE**) values < 30 %.

**Table 2.** Herd data for herds feeding lower CP rations

| **Item** | **A** | **B** | **C** | **D** | **E** | **F** |
|---|---|---|---|---|---|---|
| Cows | 1550 | 920[a] | 140 | 180 | 100 | 700 |
| Milk, lb/cow | 88 | 116 | 89 | 95 | 89 | 89 |
| Milk fat,% | 3.6 | 3.2 | 3.65 | 3.6 | 3.5 | 4 |
| Milk TP, % | 3.05 | 3 | 3 | 3.1 | 3.1 | 3.1 |
| MUN, mg/dl | 10.6 | 8 | 8-10 | 8-9 | 7-9 | 9 |
| Ration CP,% | 15.9 | 15.9 | 14.3 | 15.8 | 15 | 16.3 |
| MP, g/d | 2625 | 2863 | 2600 | 2744 | 3016 | 2792 |
| Ration NDF, % | 29 | 31 | 31.4 | 32.3 | 31.5 | 32.2 |
| Ration Starch, % | 28.5 | 28.7 | 29.3 | 28.7 | 30 | 27.6 |
| Ration fat, % | 4.3 | 5.1 | 4.4 | 5.1 | 4.7 | 5.4 |
| Forage, % of ration DM | 57 | 60 | 59 | 51 | 59 | 53 |
| Milk N, % of N intake | 35 | 38 | 36 | 35 | 31 | 35 |

[a] High group ration

## NUTRIENT EXCRETION

An increasingly important issue for the dairy industry is nutrient excretion to the environment and gaseous emissions to the air. The current version of the CNCPS model provides nutrient excretion data for nitrogen and phosphorus. In addition, the manure nitrogen is partitioned into fecal and urinary fractions. The urinary nitrogen fraction is then used to estimate the potential ammonia release. The nitrogen excretion component of the model has been evaluated and validated (Higgs et al., 2012b). The current model also predicts methane emissions and has had an initial evaluation (Higgs et al., 2013). This component of the model will gain in importance as nutrient excretion and air emission regulations continue to increase.

## KEYS TO USING MODELS ON DAIRY FARMS

The appropriate use of models on dairy farms depends on a number of factors. The following are key points to keep in mind for successful use of models as part of your total nutrition programming:

1. Understand the biological and nutritional concepts contained in the specific model you are using. As an example, the CNCPS 6.1 model has some initial incorporation and accounting for urea-N recycling, while the 2001 Dairy NRC model does not.
2. Ration CP is poorly related to milk production. The 2001 Dairy NRC indicated that the industry should move to MP for formulating rations. This requires the use of models and most currently available models do use MP.
3. Identify the most important animal, feed, management, and environmental inputs. One of the most important input variables in all models is body weight. However, this is often an *estimated* value in many ration formulations. A 100 lb difference in body weight shifts predicted dry matter intake by about 2 lb and alters maintenance requirements. In some models, both mature cow and current body weights are needed as inputs. A change in daily distance walked can change predicted milk production by 1 to 5 lb or more. A simple exercise is to take a base ration and then change only one input value. How much did predicted milk change? How important is this input?
4. The quality of the inputs is directly related to the quality and usefulness of the results. If you estimate body weight and DMI, the model results will be less reliable and useful.
5. When using a model in a herd for the first time, make sure the model predicts the current herd or group milk production. There is little value in making adjustments if the base information is not correct.
6. Use actual herd DMI when possible. All models will provide a prediction of DMI based on the input information provided. However, herd factors can have an impact on actual DMI.
7. Models are only rapid calculators that can integrate a lot of variables in a relatively short time. This gives the user more time to think and consider alternative approaches.
8. Evaluate the results. Do they make sense relative to your experience? Models can generate mathematically correct results that may not be

nutritionally sound. The model is only a tool, but you still need to be in charge and use it correctly.

9. Use data from the herd to evaluate model results and changes. Look at milk, milk components, MUN, manure, chewing, rumination, and other parameters that you normally evaluate in herds.
10. Models are not perfect and will never be. By understanding the points above, you can use the current models in herds with a low risk of use.

## SUMMARY

Computer models are being routinely used in the evaluation and formulation of dairy cattle rations. There are a large number of these available to nutritionists. These models have the potential to improve profitability and efficiency of nutrient use. A key consideration is to understand the assumptions used in the specific model that you decide to use. A second consideration is to understand the importance of the various inputs needed in the various models. All of the available models have areas of opportunity for improvement in terms of biological and nutritional concepts as new information becomes available. The use of models can be a valuable asset in terms of providing information that can be used in the decision making process relative to nutrition programs in herds. However, this information should not be used to replace the knowledge and experience you have gained over the years.

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