USING NUTRITION MODELS FOR LACTATING DAIRY COWS ON PASTURE

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We are all familiar with the expression that grazing dairy cows is an art. This is in part due to the variability that comes with managing living forage, changing animal requirements, an outside environment, and trying to complement these factors with feed supplements for high efficiency production. The graziers (artists) that handle this variation and predict the changes over the grazing season have the most success. This is in part due to experience; what they have learned from grazing their cows on their pastures and what works best for them. In fact, you can say they are replacing art with science, or reducing the unknown factors of grazing.

Nutrition Models

Another means of gaining control over the grazing season is to use nutritional models to predict and evaluate your grazing program. One nutritional model that has been extensively used at Penn State is the Cornell Net Carbohydrate and Protein System (CNCPS). The CNCPS is a nutritional computer model that uses animal, environmental, management, and feed inputs to predict animal performance under differing nutritional situations. The model is based on a set of sub-models including intake, feed evaluation, environmental, ruminal fermentation, intestinal digestion, absorption, tissue utilization, and excretion. This type of model is considered to be biological in nature (mechanistic).

The most well-known nutrition model is the Nutrient Requirements of Dairy Cattle published by the National Research Council (NRC). The seventh edition was published in 2001. The NRC (2001) provides a summary of current reference information for dairy cattle nutrition. This information from the NRC (2001) has also been included in a ration evaluation program.

The objective of this paper is to discuss the CNCPS, how we have used it as a valuable tool at Penn State, and the strengths and weaknesses of using a computer model for grazing dairy cows. In addition, there is a brief discussion on the new NRC model.

Cornell Net Carbohydrate and Protein System

The CNCPS has been found to be a valuable tool in evaluating and predicting performance of cows fed in confinement. Research at Penn State (Kolver et al., 1998) tested the predictive ability and potential to use the model for diets based on pasture. Data were obtained from eight pasture studies in the United States and New Zealand in which DMI and animal performance provided reasonably good estimates of changes in body condition score (BCS), estimated energy balance, blood urea nitrogen, and milk production under grazing conditions. Kolver et al. (1998) found the model accurately predicted milk production, change in BCS, and protein status of grazing dairy cows. Based on this study, the CNCPS has been used to help evaluate pasture diets.

A study at Penn State (Kolver and Muller, 1998) compared cows fed all-pasture diets and cows on TMR. Cows fed TMR had higher DMI (42.0 vs. 51.5 lb/d), higher milk yield (65 vs. 97 lb/d) and BCS (2.0 vs. 2.5). To understand the differences in performance, the information was entered into the CNCPS. The CNCPS predicted that milk production was first limited by the supply of energy when only pasture was fed. It was determined that the difference in intake accounted for 61% of the difference between the pasture and TMR fed cows (Figure 1). Activity accounted for 24% of the difference in milk yield. Determining that energy intake and DMI were the most important reasons for the milk loss helped set the Penn State grazing research objectives for several years.

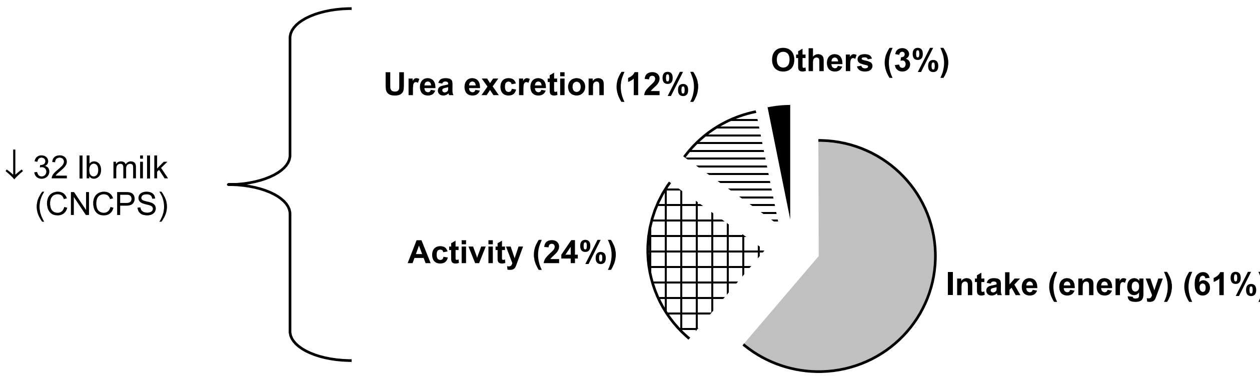

Figure 1. Accounting for differences between TMR and all-pasture diets with the CNCPS.

Using the CNCPS (and other programs)

Before the grazing season (WHAT IF…..?)

As we stated earlier, experience actually grazing cows is what makes us better graziers. However, with all the variation we encounter with grazing and the infinite number of possible solutions, it would take several lifetimes to gain the experience needed to be an expert in grazing. We gain experience through reading, attending meetings, and visiting other grazing farms. However, what will work on my farm can only be experienced by trial and error. One way to get trial and error experience quickly is through **What If Scenarios** using computer models. Although there is a lot of variation with grazing compared to feeding a TMR, there is some information we already know. We know a lot about the animals and supplements. Before the start of the grazing season, enter all the known information about your group of animals (body weight, BCS, milk yield, milk components, stage of lactation). At this point forage composition can be estimated based on species and time of year. Intake can be estimated based on computer model prediction.

We can also test amount and type of supplement fed. There has been a lot of discussion on marginal benefits to feeding energy supplements in Pennsylvania in these proceedings. One challenge stated by these proceedings is to evaluate the feasibility of energy supplementation on individual farms. The CNCPS may provide an opportunity to perform this type of evaluation. We entered a typical pasture composition into the CNCPS for early lactation cows and fed increasing levels of cracked and steam flaked corn (Table 1). If all the energy provided by the added supplement is partitioned toward milk, the yield on average is increased 1 to 1.5 lb/d and for the cracked corn and 1.5 to 2.0 lb/d for the steam flaked corn. Likely this extra energy would be partitioned to milk and body reserves, and average about 1 to 1.25 lb/d as stated in other papers in these proceedings. However, this type of modeling, when individual farm inputs are entered, may give an idea of the potential for an energy supplementation on their farm.

Table 1. Maximum theoretical increase in milk yield for increasing corn supplementation.

Pounds of Corn Fed	Pasture intake (lb/d)	Milk Yield for Cracked corn (lb/d)	Milk yield for Steam Flaked Corn (lb/d)
0	40	53.7	53.7
2[a]	39	57.4	58.7
4[a]	38	61.1	63.8
6[b]	36.4	63.6	67.6
8[b]	35.2	66.9	72.2
10[c]	33	68.3	74.8
12[c]	31.6	71.2	78.9

[abc]Substitution rate of 0.5, 0.6, and 0.7, respectively.

Using Models During the Grazing Season

We have our plan for grazing this spring and it will go off without any problems, right; wrong! One of the biggest mistakes made when using the CNCPS or any other computer program is formulating a ration once and not changing it over the grazing season. In general there are two types of grazing seasons; **the one we plan for** and **the one we get.** One of the real values of the CNCPS is its ability to evaluate a current feeding program. The predictions we make ahead of time are only one possible scenario, and it is unlikely that scenario will play out perfectly. The CNCPS can be used to evaluate the feeding program over the grazing season. To do this, it is important to continually test forages and adjust animal inputs to reflect changes over the grazing season. Modeling these changes to explain performance over the grazing season can also help the producer to make adjustments to the supplementation program.

A study conducted at Penn State demonstrates the importance of continued testing over the year. A pre-trial evaluation showed that feeding steam flaked corn can increase milk production 3 to 6 lb/day. However, animal milk yield with this trial was lower than modeled because the animals were in later lactation and energy demand was not great. Therefore adding a high-energy steam flaked corn had no effect on milk yield, but tended to increase body condition.

What Information do I Need and What Information do I Use?

Inputs

As with any computer program, the information we get out is only as good as the information we put in. For the CNCPS there are animal, environmental, and feed inputs totaling over 100 possible inputs to the model. Animal inputs range from production to hair and hide characteristics. Most of these inputs are easily obtained with DHIA records or available daily milk records. An important part of animal inputs includes recording animal activity including quality of pasture as related to the amount of energy needed to harvest pasture and the amount of energy required to walk from the pasture to the milking parlor. Environmental measures including temperature, wind, and relative humidity are used to determine maintenance energy lost due to heat and cold stress. Some of the more difficult information to obtain is the detailed feed characteristics required for the CNCPS. One of the most difficult characteristics to determine is dry matter intake.

Predicting pasture intake, especially when supplements are fed, is a weakness of the CNCPS. DMI for grazing cows is dependent on different variables than cows fed in confinement (refer to pages 17–22 in these proceedings). Pasture availability and sward density have a large impact. When adding supplements, the substitution rate cannot be predicted from the CNCPS. When supplemental grain and forage are fed, pasture intake is reduced. The level of reduction is called substitution rate. This is based on several factors that the CNCPS cannot predict. This will have to be estimated and ranges from 0.4 to 0.6 for most energy supplements and 0.9 to 1.1 for most forages. Therefore, if using the CNCPS to predict performance, it is important to consider a range of possible pasture intakes.

As far as feed composition, CNCPS requires some of the traditional feed measures such as dry matter, crude protein, mineral and vitamin measures, etc. Some of the more specific measures include fractional digestion of carbohydrates and proteins, as well as amino acid composition. It can be detrimental to try and estimate these more fractional measurements. The CNCPS has an extensive library and can be used to estimate these values. However, it is important to note that the more actual values used for input the better the output will be.

Outputs

The output for the CNCPS provides hundreds of parameters from crude protein content of the diet to predicted pH of the rumen. For grazing cows, protein status of the animal and energy balance have been shown to be reliable and should be the main outputs used.

- DMI: Dry matter intake is complicated and is based on many different physical, physiological, management, and behavioral constraints and is difficult to predict. In confinement feeding it is possible to measure DMI for a group and these numbers should be used in ration regulation and evaluation. However, this is more difficult with pasture and model predictions can be used as a guide to DMI, keeping in mind that substitution rates may vary.
- Energy: In the CNCPS the energy status of the cow can be determined by the energy available for milk (ME allowable milk) and the changes in body reserves. The important factor to evaluate the energy status of the cow is to know if she is losing or gaining condition. Computer models cannot predict energy partitioning, and knowing the body condition of the cows can help us determine, confirm, and make sense of our outputs and help make changes in the ration.
- Protein: The metabolizable protein (MP) available for milk, found in the CNCPS, can evaluate the protein status of the cow. Further there are predictions of CP% of the diet, MP from rumen undegradable feed, and MP from rumen bacterial protein. It is often said that as ruminant nutritionists our job is to feed "bugs" not the cow. This may not be entirely true but maximizing microbial protein is the most efficient way to provide nutrients to the cow. Therefore the measures of MP from feed and bacteria are a valuable tool in determining how well we are feeding the "bugs," and in general you want 50% from bacteria and 50% from feed.

Other measures

Evaluating DMI, energy and protein status of the cow on pasture should evaluate the pasture diet and provide insight into the value of various supplements to the diet. Other measures found in the CNCPS can help support these conclusions. However, caution must be taken in relying on any one number in any computer program. It is important to look at all predictions and see if they are telling the same story and that they all make sense compared to what the cow is telling you; because the cow is always right.

NRC Nutrition Model

The NRC model has not been extensively tested for lactating dairy cows on pasture. Although not a scientific test, we used the NRC computer program to evaluate some recent research pasture diets (Table 2). A study at Penn State (Bargo et al., 2002) was conducted feeding all-pasture diets and pasture with 19 lb of a corn-based supplement. Information from this study was entered into the NRC model and the results are compared with the actual measurements taken from the experiment (Table 2).

Table 2. NRC evaluation of pasture diets and grazing activity.

	All pasture diet		Pasture and grain	
	Actual	NRC Predicted	Actual Pasture/grain	NRC Predicted
DMI	40	***(40.9)***[a]	49.3	***(45.0)***[a]
Pasture	40	40	31.5	31.5
Grain	0	0	17.8	17.8

Milk yield	49	48.9	66.0	70.4
Energy for milk	---	48.9	---	74.8
Protein for milk	---	51.5	---	70.7

Sources of added maintenance costs	Energy Cost	Potential Milk Loss
Activity	1.52 Mcal	4.6 lb
Walking activity	0.65 Mcal	2.0 lb
Eating	0.71 Mcal	2.15 lb
Total	2.88 Mcal	8.75 lb

[a]Predicted intake, but not used in the model because actual intake was measured.

From this exercise we can see that cows fed all-pasture diets consumed 40 lb of pasture dry matter. Milk yield averaged 49 lb/d with a milk fat of 3.73%. The information for this study was entered into the NRC model. The NRC predicted that the cows should consume about 41 lb of pasture, however, since actual DMI was known, it was entered into the program. The NRC predicted the milk yield would be limited by energy intake and would average about 49 lb/d, which is the production level achieved on the trial. Although not a scientific test, this is evidence that the NRC did a good job of predicting milk yield. In this study, there were also grazing cows receiving an energy supplement. When these cows were entered into the NRC program, it predicted that they may produce 70 lb of milk. This was about 4 lb higher than actual milk yield, but may have been accounted for in weight gain. Therefore the NRC model seemed to do a reasonably good job of accounting for milk yield for this situation.

There has been some interest in how the NRC predicts maintenance energy needs for dairy cows grazing pasture. In the NRC model, there is a box that you select to indicate you are grazing these cows. Doing this automatically increases maintenance requirements 10%. There is a further energy cost based on distance traveled and grazing (eating) activity. In this example (Table 2), activity added 1.52 Mcal/d onto the maintenance cost. This represents about 4.6 lb of potential milk yield. In the actual study, cows walked about 8000 ft/d and were predicted to expend about 0.65 Mcal/d, which translates into 2.0 lb of potential milk yield. Lastly, 0.71 Mcal/d are predicted to be expended in eating activity, or about 2.15 lb of potential milk/d. In total, it is predicted that cows in this study spent an extra 2.88 Mcal/d or 8.75 lb of milk due to increased maintenance energy for all grazing activity.

References

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