THE USE OF CPM DAIRY AS A NUTRITION MANAGEMENT TOOL WITH A MID-SOUTH TWIST

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Introduction

The CPM Dairy 3.0 platform was developed by the University of Pennsylvania, using the Cornell Net Carbohydrate Protein System in collaboration with Cornell University and the Miner Institute.

In the development of the model, Chalupa realized that he did not have the only knowledge on how to design the platform. The final design included the collective input of many users that sought speed, accuracy, sensitivity, flexibility and performance from the software used to develop rations for the herds where they consult. This model evolved into not only a sophisticated nutrition model, because of the collaborative efforts of Cornell, University of Pennsylvania, and the Miner Institute; but also an excellent management tool, due to the suggestions from the many beta testers.

As each version was released, input from the beta testers has led to improvement in the model over time. However, beta testers in the southern states either did not realize or suggest a few modifications that could improve the model for use in heat stress climates.

Ration Building in Herds

To optimize milk components and milk volume in a herd while maintaining reproductive efficiency and animal health, requires incorporation of the total farm situation. CPM Dairy provides tools to assess environmental factors influencing a group of cows to facilitate development of rations that optimize production parameters desired by the dairy management.

However, problems have been experienced while working with the model in parts of Texas during periods of summer heat stress. Contributions of information and research-based knowledge are needed by model developers to fine tune the model to improve its capability to accurately predict production outcomes during periods of heat stress common to South and Central Texas.

Currently, CPM models do not accurately predict the dry matter intake (**DMI**) and resulting milk production during these periods. The model tends to over-predict DMI and milk production when the ambient temperature and the relative humidity rise to uncomfortable levels for lactating dairy cows. Table 1 shows the common Temperature Humidity Index (**THI**) chart for dairy cows, indicating that many conditions exist that are extremely stressful to dairy cows. Herds in Central and South Texas, as well as many areas in the Southern United States, experience these temperature and humidity extremes resulting in thermoregulatory problems for dairy cattle.

Mild to severe heat stress has been estimated (National Research Council, 1981) to increase maintenance requirements of a full grown cow by 7 to 25 %. This equates to 0.7 to 2.4 Mcal of NE_L per day; however, insufficient data are available to quantify these effects directly. Therefore, the model does not predict DMI reductions of this amount. The severity of the resultant decline in milk yield has been simulated in the laboratory for combinations of changes of temperature, humidity, and wind.

Herd Inputs for CPM

By providing relevant information the nutritionist can assist the model in more accurately predicting the depressed DMI and resulting loss of production. The areas of input include the environmental information, the animal information, and the herd management information. Additionally, feed ingredient input is vital to the model providing meaningful results for the nutritionist.

As with any other computer aided nutrition balancing program, the accuracy of the output depends on the accuracy of the input data. The CPM model requests a wide array of information on the environmental conditions and on the animal itself. In addition, management strategies and barn location are important considerations that CPM applies to the output dependent on the variables provided.

Table 1. Temperature Humdity Index (THI)[1] for dairy cows. Modified from Dr. Frank Wiersma (1990), Department of Agricultural Engineering, University of Arizona, Tuscon.

DEG	RELATIVE HUMIDITY																			
F	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
75														72	72	73	73	74	74	75	75
80							72	72	73	73	74	74	75	76	76	77	78	78	79	**79**	**80**
85			72	72	73	74	75	75	76	77	78	78	79	**80**	**81**	**81**	**82**	**83**	**84**	**84**	**85**
90	72	73	74	75	76	77	78	79	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**86**	**87**	**88**	**89**	*90*
95	75	76	77	78	79	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	*90*	*91*	*92*	*93*	*94*	*95*
100	77	78	79	**80**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	*90*	*91*	*92*	*93*	*94*	*95*	*97*	*98*	*99*	
105	79	**80**	**82**	**83**	**84**	**86**	**87**	**88**	*89*	*91*	*92*	*93*	*95*	*96*	*97*						
110	**81**	**83**	**84**	**86**	**87**	**89**	*90*	*91*	*93*	*94*	*96*	*97*					Mild Stress				
115	**84**	**85**	**87**	**88**	*90*	*91*	*93*	*95*	*96*	*97*							**Medium Stress**				
120	**88**	**88**	*89*	*91*	*93*	*94*	*96*	*98*									*Severe Stress*				

[1]THI=(Dry-Bulb Temp. C) + (0.36 dew point Temp. C) + 41.2

During the cooler seasons of late fall to early spring, the CPM model is very accurate in determining the DMI of lactating cattle and predicting the resulting milk production, provided care is taken to input the correct data on feeds available, the production parameters of the herd, and environmental conditions.

It is imperative that several correct measurements and analysis be added or adjusted in the model when inputting feed data. Particle size measurements of the silages need to be determined. Hay supplies must be sampled and analyzed in time for the data to be received prior to inclusion of the ingredient in the ration. Samples of any other feeds on the farm should be taken and analyzed as well, with the resulting inputs stored in a farm feed database. Taking samples of forages to be fed later saves time and increases accuracy of ration formulation when the feeds enter the ration compared to entering *book values* for forages not analyzed.

Environmental Input

Environmental data input into the CPM Model are extremely important. Environmental assessments need to be accurately made and include:

- Temperature
- Humidity
- Wind speed
- Hours in sunlight
- Minimum night temperature
- Mud depth

These parameters change with season and management on individual farms. During the evolution of the seasonal nutritional changes, many nutritionists may not have the time to accurately determine the correct data to input into the model. The model is sensitive to these inputs and success of this program dictates that they not be ignored.

An example of the inputs needed follows.

There are two **temperature** inputs:

current temperature: the temperature that is predicted for the next 30 days; and
previous temperature: the average daily temperature that has existed in the pen or location in the barn for the last 30 days.

The historical number allows the model to account for major temperature shifts that occur with the change in seasons. Too often they are held constant or remain at the default settings, which are not correct for areas of the South.

The same type of information is requested for the **relative humidity** (**RH**):

current RH % is the RH for the next 30 days and ***previous RH %*** is the RH for the previous 30 days.

Again, this is the average RH conditions in pens or sections of the barn for which the ration is being evaluated. In most herds, this number remains constant for all groups of cows in the lactating pens; however, it might be different for each pen depending upon the location in the barn.

Minimum night temperature input is also important. This is particularly important for the heat stress periods of the year when it is hot with high humidity even during the evening and night. Night cooling is critical for the cows, allowing them an opportunity to cool core body temperature. If the minimum night temperature is underestimated, the model will over predict DMI. Often, we rely on weather forecasts to obtain inputs; but in effect, some barns or pens do not cool off as quickly or as completely; therefore, the reported minimum night temperature is not attained. Adjustments based on each herd's unique condition's are required.

The **wind speed** input is critical. Measure wind speeds (natural or fan created) where the cows are lying down and where they are eating to more accurately predict the cow's environment.

Hours in sunlight become important where herds are kept in direct sunlight in the summer with limited access to shade. Cows that travel to a parlor may have more hours in the sunlight than other herds and could accumulate an additional heat load which must be accounted for in the model.

The **mud depth** input is for those farms that either do not scrape manure frequently enough or are in open lots that are deep in mud due to inclement weather. Shades in drylot operations that are not managed properly require alteration of this input. Mud depth can also reflect poor concrete floor management which makes it difficult for cows to move around.

Hair depth is a sensitive input only for cattle exposed to high wind flow coupled with high humidity and very cold temperatures. It is not an input that affects summer production predictions in this model.

Management Input

Assessments for the management of the herd that might directly affect the cow's ability to produce milk are also necessary. This is especially important in herds housed in dry lots, pastures, or other areas that are greater distances from the milking parlor. Assessments need to be accurately made and include:

- Activity
- Time standing
- Body position changes
- Distance Walked - flat
- Distance Walked - sloped

The **activity** input is provided in a drop down window format. There are defaults for each selection item which vary depending upon the type of dairy housing selected. After one of the options is selected the next 4 windows will automatically fill. However, it is much better to give more accurate assumptions for each dairy. For example, the number of trips to the milking parlor each day can drastically affect the energy expenditure of cattle for distances walked, time standing, or hours in sunlight.

The **number of hours standing** is a direct relationship to cow comfort. If the cow refuses to lay down in the freestall or if she cannot find a suitable location to lay down in the shade or in the lot, then she will stand for longer period of time. As would be expected, when the time spent each day in the holding area lengthens, the time spent standing increases.

There has not been a lot of information about the number of **position changes** a cow has in a day relative to environmental conditions of temperature and humidity, but this number also influence the number of hours standing. If a cow continues to stand in hot conditions in an attempt to cool her body, or if the free-stall is difficult to get up and down in then there can be a decrease in the number of position changes and an increase in time standing. Nutritionists simply cannot spend the amount of time needed to accurately predict body position changes for each dairy. Oftentimes, the default is the value used and one cannot argue that concept.

The distance walked:

distance walked -flat includes activity both within the pen and to the parlor in most situations and

distance walked –sloped may only be the incline into a parlor, which is the default value, but in the case of grazing herds, this input could be significantly different. In all cases, the number of trips to the parlor, or to a water source, may increase the distance walked. It is relatively easy to pace off distances; however it is difficult to know how much a cow walks within a pen in a 24 h period. The calculating nutritionist can easily estimate a minimum based on the known distances.

We need to observe cows in their daily behavior and modify these numbers because the maintenance cost for the different activities varies and CPM alters the nutritional requirements for energy based on the inputs. These maintenance cost calculations are based on the following:

- Every hour standing = 0.1 Mcal
- Every position change (going down and getting up) = 0.1 Mcal
- Every 100 meters walked flat = 0.1 Mcal
- Every 10 meters walked slope = 0.1 Mcal

These costs are based on very accurate research done many years ago. Intuitively it is agreed that the degree of slope has an impact for the same number of meters walked.

All of the inputs listed previously are used to describe the environmental conditions in which the cows exist and the behavior that might be used to adjust to that environment. Additional demands made that influence her comfort will affect nutrient expenditure. In many instances, the nutritionist can use this information to demonstrate the need to add cow comfort features to the dairy farm by simply showing the herd manager the difference that one input can make.

Feed Data

The importance of selecting the correct feed ingredient from the feed dictionary is of utmost importance in formulating the ration. If a representative feed is not in the dictionary, then, with an understanding of the feed analysis nutrients, an existing library feed can be modified to reflect the true nutrient density of the feed analyzed.

The reason for careful selection of the dictionary feeds is that not all of the composition values of the existing feeds were derived from direct analysis. This is especially true for forages and by-product feeds. The measurements that nutritionists are forced to use are *book values* for the rates of digestion, amino acid content, fatty acid content, and mineral bioavailabilities; to mention just four of the major categories.

It is critical to have a feedbank for each region, or each farm, upon which the model is being used. The best approach to building these feedbanks is the current download capability available from forage testing laboratories for feeds in the region. These data can then be reduced to a viable dataset which becomes the basis of the forage feedbank for farms or regions.

Some feed ingredients common to dairy farms in South or Central Texas are not available in the library feedbanks. For example, kleingrass hay and haylage, Coastal bermudagrass hays and silage, and some sorghum or sudan type hays and silages are not accurately represented in the feedbank due to minimal samples tested in laboratories further away from these sources. Differences in type of analysis also poses a problem for building a f*eel for the use of each forage*.

Selecting the forages that most closely represent the forages from the Master Feed Dictionary and modifying the analyses to reflect the analysis array that is seen in the region is the best approach for simple ration analyses. For example, if the selection is grass silage, based on the downloaded data, choosing the coarse over the finely chopped forage in the feed dictionary might more accurately reflect the feed being fed on the farm.

Certain safeguards exist in the quick edit tab of feed ingredients. There are warning screens that appear if the feed values do not *make sense* to the model. There are some key values to watch especially in changing forage values: acid detergent fiber (**ADF**) is valuable in this model only as an evaluation tool for forages. Divide ADF by neutral detergent fiber (**NDF**) to estimate the amount of grass or legume in the forage. This is important because it has an impact on the lignin, available fiber, and the rates of digestion.

The mixture of legume and grass in forage has an impact on the composition of the non-fiber carbohydrates (**NFC**). If the ADF is less than 70 % of the NDF, it is probably an all grass forage. If ADF is in the mid 70's then it is a mixture of legume and grass. If the ADF is 80 % of the NDF or greater then the forage is mostly legume. This, along with mineral content and protein content will collectively identify the forage type to select from the dictionary or forage feedbank.

It is critical to select the appropriate forage, including a good estimate of the physical effective NDF (**peNDF**). The K_d of the fiber is an important issue. The K_d for the available fiber can be estimated by determining the 24 h disappearance of NDF along with measuring the lignin. Drs. Van Soest and Van Amburgh have developed strong mathematical relationships to provide equations to predict the K_d for the fiber.

Ether extract (**EE**) is important when formulating rations that will be consumed during periods of heat stress. Again for the feed being used, select the appropriate feed from the feedbank so that the right percentage of EE is estimated for total fatty acids (**FA**) with the correct FA profile. In the model there is a range in FA digestibility, further emphasizing the importance of the selection of the right feed.

The new mineral sub-model incorporated into CPM is from NRC (2001). Recent research refining the mineral and vitamin requirements made this the best model to select. The biggest change in CPM version 3.8 is a factorial calculation for each of the minerals and a new estimate of the bioavailability of each mineral, which is considered controversial. Assays for bioavailability are not yet available and there will not be one available very soon. However, the new sub-model is a step in the right direction. Again, be sure that the mineral-vitamin premixes make nutritional sense and the bioavailabilities seem reasonable.

Practical Use of CPM during Heat Stress

The composition of the diet is believed to be important in alleviating heat stress. There are, however, no reliable scientific guidelines for feeding cows in hot climates. Milk yields did not change significantly in earlier studies where animals were forced to eat diets containing various ratios of forage/concentrate or isocaloric diets in which the ratio of fiber was varied (El-Khohja, 1979) or fat was added (Moody et al., 1971). We do know that cattle under heat stress reach a hyperthermic state and refuse forage, but continue to eat concentrate. Regression equations for milk yield and feed intake at various THI conditions found in the Mid-South areas of dairy production have been developed.

The CNCPS Screen

When balancing a ration during heat stress, the first step would be to determine if the ME and MP balance are near 0.0 at the quantity of DMI being consumed. Observe the peNDF and the NDF. General guidelines are that the peNDF be around 23 % of DM; Forage NDF as % of DM be > 22% or 70 % of the total NDF; and the total NDF be close to 30 % of DM. The total NDF may be higher if there are fibrous by-products in the ration.

Next, evaluate the peptide and peptide + NH_3 balance in grams. The peptide + NH_3 balance should be larger than the peptide balance, and both of these values should be at least 110 % of requirements. If the ration is not meeting these major constraints, reformulation may be in order. In the stressful conditions of hot weather the NFC fraction may have to be higher than in non heat-stress conditions. If the herd is well managed, and the feeds are accurately analyzed, an allowance of the NFC to go to a maximum of 42 % DM could occur. A word of caution, a maximum of 38 % DM for most herds remains the highest value if management is not optimal.

During hot environmental conditions or under any circumstances that stimulate cows to consume feed in a few meals in a slug fashion, allow an increase in the soluble fiber level in the ration to 7 to 8 % of DM. This means the starch needs to be reduced from 25 % of DM to 20 to 21 % of DM. This shifts the fermentable starch fraction down to 17-18 %, if it is 84 % fermentable in the rumen. If the farm is feeding low density, steam flaked corn combined with corn silage that is low in DM with kernels that are soft and extensively processed, increasing the soluble fiber should be considered.

There are two different sugar levels to monitor during heat stress. The first level is 5 % of DM as total sugar. Highly fermented rations will normally be 3 % of DM as sugar. If alfalfa and/or beet pulp is added, then sugar levels of 5 % of DM will easily be achieved. The enhanced sugar level is a number tentatively suggested by Hoover based on work with molasses and other sugars that result in a response in cattle. It is not unusual to see numbers this high in rations in the Northwest, but they are uncommon in the Mid-South area. It is suggested that this might be advantageous when there are considerable amounts of rumen degradable protein with over 50 % of that protein being in the soluble form.

Van Soest has suggested that the dairy cow might have a lignin requirement. The numbers are tentative and seem to fit best where more than half of the forage DM originates from corn silage and the remainder from a high legume forage. Monitor lignin levels to determine where they optimize.

Feeds high in unsaturated FA, usually vegetable in origin, are transformed in the rumen into more saturated FA though biohydrogenation. Most of the unsaturated FA is transformed into totally saturated FA. However, depending on rumen turnover, rumen pH, and other factors that are not totally understood, some of the FA leaving the rumen are only partially hydrogenated.

In most rations, most of the FA consumed are in the form of 18:2. These FA are assumed to be in the form of a triglyceride. Lipolysis is a rate limiting step. Most of the 18:2 is lypolysed to form FA, which are then biohydrogenated. Very little 18:2 arrives at the duodenum. However, if the quantity of 18:0 is large, there are 2 key points to consider. The first is when the 18:1T at the duodenum is > 120 g/d. It can lead to depressed milk fat. Secondly, when the 18:2 absorbed is over 70 to 80 g/d. A relationship to improved reproductive performance has been observed.

When formulating rations, exercise care when using ingredients high in 18:2 and 18:3 FA with high lipolysis rates. This means ingredients such as cottonseed and distillers grains, to mention two, have to be monitored and fit into the ration. These types of ingredients not only compromise the production of milk fat; but equally important milk protein, probably through a reduction in the production of microbial protein. There are now calcium salts of FA on the market which are high in 18:2 and 18:3 that have low lipolysis rates, providing higher amounts of 18:2 and 18:3 for absorption.

Balancing the amino acids (**AA**) to meet the factorial requirement has been beneficial in heat stress, provided nutritionists strive to obtain the ideal AA profile: lysine at or above 6.83 % and methionine at or above 2.15 % of metabolizable protein (**MP**). The approach is to meet the factorial requirements as well as the profile requirements. It is almost impossible to meet the profile requirements without a single source of rumen protected lysine or methionine. The higher lysine percentage can be achieved through optimizing the microbial yield.

Meeting the mineral requirements has become a new challenge with the bioavailability constants. There are some differences in the 2001 NRC requirements of which nutritionist must be cognizant. For example the P requirement has been reduced significantly. This is a result of some excellent work with high producing cows. Vitamin E recommendations have been increased; however nutritionists have been feeding higher amounts (over what NRC recommended) of vitamins for some time now with success.

Conclusions

The CPM model is a good platform for organizing nutritional management recommendations for clientele even in the Mid-South areas of dairy production. The CPM model forces nutritionists to approach feeding the whole herd in the most logical manner and in a way that should be safe to the cow's rumen health.

Careful input of data is required to achieve success in improving production and reproductive efficiency, especially during times of heat stress.

CPM can be used to determine areas that limit production on a farm, such as cow comfort compromises. The model is complex in that it requires careful input, correct analyses of feed ingredients, and more careful input of information on the animal and her environment.

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