Feed Management

A Key Ingredient in Livestock and Poultry Nutrient Management

NRC Recommendations for Dairy Cows

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Disclaimer
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Introduction

This fact sheet has been developed to support the implementation of the Natural Resources Conservation Service Feed Management 592 Practice Standard. The Feed Management 592 Practice Standard was adopted by NRCS in 2003 as another tool to assist with addressing resource concerns on livestock and poultry operations. Feed management can assist with reducing the import of nutrients to the farm and reduce the excretion of nutrients in manure.

Feed Management is one of six components in a Comprehensive Nutrient Management Plan (**CNMP**). Feeds represent a costly fraction on a dairy farm budget and feed inputs are among the largest sources of nutrients imported to the operation. Feed management depends on adequate feed acquisition and allocation, in quantity and quality sufficient to supply the herd's nutrient demands for a given period of time. Knowledge of animal nutrient requirements is paramount for a successful Feed Management.

Nutrient requirement standards for most economically important farm animal species have been reported by the National Research Council (**NRC**) since the early 20th century (http://www.nap.edu/catalog/nrs/). NRC's seventh revised edition of the **Nutrient Requirements of Dairy Cattle**, issued in 2001, included significant alterations over its previous edition (1989). Calculations of nutrient requirements and their interactions are integrated by the 2001 Dairy NRC in a computer model that allows for estimates of nutrient requirements and dynamic ration evaluation.

Better comprehension of the processes used to determine a dairy cow's nutrient requirements in the NRC (2001) model is essential for the success of the nutrient management plan. A few aspects of nutrients that are relevant to **Nutrient Management** (nitrogen, phosphorus, and potassium) are discussed below.

Nitrogen (Protein)

Two aspects must be considered to evaluate a ration's adequacy: the nutrients supplied by the diet (nutrients contained in feeds) and the cows' nutrient demand for body maintenance, reproduction, production and growth in cows that have not reached mature body weight.

Protein content in feedstuffs is usually referred to as crude protein (**CP**). In the laboratory, feed samples are actually analyzed for nitrogen (**N**) content, and CP is calculated as:

$$CP = N \times 6.25$$

This equation is based on the assumption that dietary protein contains an average of 16% N.

In the 2001 dairy NRC, feed protein supply is divided into two fractions: rumen degraded protein (**RDP**) and rumen undegraded protein (**RUP**). Rumen degraded protein supplies microbial needs. However, rumen microbes require non-protein N (ammonia, amino acids, peptides,) as "building blocks" of microbial protein (**MCP**). The extent of MCP synthesis in the rumen depends on a number of factors including level of feed intake, digestion rate (**K_d**) of diet components in the rumen, and passage rate (**K_p**) of digesta from the rumen. In the absence of a analytical method to the NRC subcommittee chose to use three fractions (A, B, C) derived indirectly from rumen incubation of *in situ* bags to derive RDP and RUP supplied by feed ingredients (kg/d):.:

$$RDP = A + B \times [K_d/(K_d + K_p)]$$

$$RUP = B \times [K_p/(K_d + K_p)] + C$$

Where A is the amount (kg/d) of N presumably readily available to microbes, B is the amount of N that is available by degradation (at a rate = Kd) and C is the amount of N unavailable for microbial growth.

Ruminants also recycle N to the rumen as salivary urea that can be used by rumen microbes, especially with dietary N is below an optimal. That N source, along with enzymes and sloughed cells released in the gut are called endogenous CP because they come from within the body of the cow.

"Nitrogen is of primary environmental concern because of losses of ammonia in the air and because of nitrate contamination of surface water and groundwater."

NRC (2001)

Three sources of protein will reach the small intestine:

MCP;
RUP;
Endogenous CP.

Digestible protein will be hydrolyzed in the small intestine essentially into amino acids, which can be absorbed and used for body maintenance, growth, reproduction, and lactation. The absorbable amino acids, defined in NRC

(2001) as metabolizable protein (**MP**), can be converted into milk protein with an average efficiency of 67%. Considering an average intestinal digestibility of 0.65, one can estimate the theoretical maximum milk N efficiency of utilization as:

$$0.67 \times 0.65 = 0.44 \text{ or } 44\ \%$$

"Of all dietary essential mineral elements for dairy animals, phosphorus represents the greatest potential risk if excess is released into the environment contaminating surface waters and causing eutrophication."
NRC (2001)

After more than half a decade of its publication, the NRC (2001) model withstood a number of comparisons and validations against measured data and other models. Some criticism has been observed. Those include a need for accurate feedstuff characterization, extent and complexity of inputs required by the model, over-prediction of milk response to RUP supplementation, and over-evaluated energy value of proteins. However, if default values are replaced by more accurate feed and animal characterization, the NRC (2001) model accurately predicts milk and protein production.

Finally, because the NRC (2001) is a dynamic model that incorporates animal-feed interactions, and feed - feed interactions. Thus, the model should be used rather than the tabulated values Overall, the NRC (2001) predicts that dietary CP contents between 16.5 and 17.5 % of the DM supply the protein requirements of early-lactation dairy cows under most conditions. Dietary CP should be equal to or below 16.5% as cows advance into the second half of the lactation.

Phosphorus

In the NRC (2001) phosphorus (**P**) in feed and microbes were given absorption coefficients (**AC**).

Phosphorus AC is the efficiency with which P from a source is absorbed in the cow's small intestine. The AC is variable, depending on a number of animal and feed characteristics. In general, decreasing P content of the diet increases the AC and P efficiency of utilization from feed to milk. The NRC (2001) adopted fixed absorption coefficients for forages (0.64) and concentrates (0.70). Only mineral sources were given specific ACs. For instance, dicalcium phosphate AC is 0.75, while higher ACs were applied to monosodium phosphate and phosphoric acid (0.90). These AC values –were higher than the 0.5 value used previously (NRC, 1989). Endogenous P sources, a major recycling route in ruminants, have an AC above 0.70.

Phosphorus available for absorption is defined as absorbable P and is calculated as feed P (in grams) multiplied by its AC and summed for all feeds in the diet:

$$\text{Absorbable P} = \sum(\text{feed P} \times \text{feed P AC})$$

The NRC (2001) estimates dairy cows' demand for absorbed P based on a factorial approach. The factorial determination of requirements consists of accounting for the absorbed P necessary for maintenance, growth, reproduction and lactation

Milk contains only 0.09% P, but may range from 0.083% to 0.100. Given milk volume produced by the modern dairy cow, milk P is however the largest requirements for a lactating dairy cow followed by body maintenance, with only a small fraction needed for growth and reproduction. Phosphorus demand for fetal growth is relevant only in the last third of gestation.

Phosphorus supply adequacy is estimated as dietary absorbable P minus the sum of requirements (maintenance + growth + reproduction + lactation).

Current NRC P recommendations for lactating dairy cows range from 0.30 to 0.40 % of the diet DM, depending particularly on milk production. A number of studies have shown no production or reproduction benefits from feeding P above NRC dietary recommendations, and that most excess P is excreted in feces.

Using dicalcium phosphate ($400/ton = $0.82/lb P, discounted Ca value), one can estimate that it costs $1.50/cow/year for every one hundredth of a percentage unit (0.01) P increased above NRC recommended level for a cow eating 50 lb/d of dry matter. Overfeeding P to lactating dairy cows is uneconomical, wasteful and may harm the environment.

Potassium

The NRC subcommittee adopted a single AC of 0.90 for potassium (**K**) in all feeds. Potassium requirements are calculated similarly to P requirements.

Lactating dairy cows have high demand for K. As much as an ounce of K will be secreted with every 42 lbs of milk, but even larger quantities are lost with sweat, feces and particularly in urine. Those requirements must be supplied on a daily basis because K is not stored in the body.

Despite recognition that the requirement increases with higher temperatures (sweating), NRC (2001) K model does not take into consideration ambient temperature to calculate K requirements. Furthermore, K is an important element influencing the DCAD (**Dietary Cation-Anion Difference**) of a ration(in addition to sodium (**Na**) and chloride (**Cl**)). There has been increased interest in how DCAD affects acid-base balance of dairy cows. Whereas a low DCAD (in general lower dietary K and Na, high Cl) has been recommended for periparturient cows to prevent milk fever, higher postpartum DCAD (~+200 meq/kg) is suggested to maximize milk production. This dichotomy raises concerns and complicates K balance in a nutrient management plan.

NRC (2001) recommended dietary K levels ranging from 1.0 to 1.2% of the dry matter.

"Application of manures of fertilizers rich in potassium to crop land can result in excess potassium in the environment and very high potassium content of forages. This can cause problems with calcium and magnesium metabolism particularly for periparturient cows, and may cause udder edema."

NRC (2001)

Table. Nutrient requirements of lactating dairy cows estimated with the NRC (2001) model using sample diets varying feeds, stages of the lactation and milk production levels.[1]

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Animal description:					
Age, months	52	55	53	55	59
Parity	3	3	3	3	3
Body weight, lb	1432	1432	1432	1432	1432
Body weight change, lb/d	-0.88	0.00	-1.10	-1.10	1.50
Days in milk	45	120	60	120	250
Days pregnant	0	50	0	50	170
Body condition score	2.75	2.75	2.75	2.75	3.50
Production inputs:					
Milk production, lb/d	98.0	98.0	130	130	45.0
Milk fat, %	3.50	3.50	3.50	3.50	3.70
Milk true protein, %	3.00	3.00	3.00	3.00	3.00
Milk lactose, %	4.78	4.78	4.78	4.78	4.78
Intake estimated by NRC (2001) model:					
Dry matter intake, lb/d	51.8	59.5	64.7	70.3	42.7
Sample diet used in the NRC (2001) model, lb dry matter/d:					
Corn silage, normal	23.50	28.20	24.07	32.00	19.40
Legume forage hay, mid-mat.	4.25	7.25	8.41	5.48	6.60
Bermudagrass hay, Tifton-85	---	2.38	---	---	4.40
Grass hay, C-3, mid-mat.	1.98	---	---	2.69	6.60
Whole cottonseed	---	---	4.54	---	---
Soybean, meal, solv. 48% CP	6.72	6.41	3.68	9.49	0.46
Soybean, meal, expellers	2.33	1.01	---	1.83	---
Corn gluten meal	---	---	4.21	---	---
Urea	---	---	---	---	0.18
Corn grain, steam-flaked	---	---	---	---	4.10
Corn grain, ground, hi moist.	10.37	---	17.80	15.46	---
Corn grain, ground, dry	---	12.78	---	---	---
Tallow	0.99	---	---	1.37	---
Calcium soaps of fatty acids	0.26	---	0.26	0.35	---
Calcium carbonate	0.20	0.20	0.29	0.22	0.10
Monosodium phosphate (1 H2O)	0.11	0.09	0.18	0.15	0.04
Salt	0.30	0.29	0.32	0.25	0.20
Vitamin and mineral premix	0.77	0.90	0.95	1.00	0.62
Diet nutrient contents:					
% RDP	10.2	9.7	9.7	9.6	9.6
% RUP	6.9	6.1	7.8	7	3.8
% CP (% RDP + % RUP)	17.1	15.8	17.5	16.6	13.4
% phosphorus (P)	0.38	0.36	0.40	0.38	0.29
% potassium (K)	1.32	1.31	1.13	1.29	1.46

[1] Feeds were chosen from NRC (2001) feed library for example purposes. For accurate diet evaluation, the NRC (2001) model requires animal description and feed analyses for every specific situation.

References

National Research Council. 1989. Nutrient Requirements of Dairy Cattle. 6th rev. ed. Natl. Acad. Sci., Washington, D.C.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Sci., Washington, D.C.

Project Information

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