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Feeding Dairy Cows to Reduce Nitrogen, Phosphorus, and Potassium Excretion into the Environment

This NebGuide discusses feeding strategies to optimize dairy cow performance while minimizing negative environmental impacts.

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Reducing N, P and K Excretion--The Challenge

Increasingly, our society demands livestock production systems that not only produce economic, high-quality food products, but also minimize negative environmental impacts. Feeding management has improved continuously and helps explain increases in milk production averages. The future challenge for dairy producers and nutritionists will be to properly formulate rations for high production levels while simultaneously minimizing the environmental impact of excessive N, P and K excretion in the urine and manure. *A realistic approach will be to keep formulation of profitable, balanced rations as the primary goal, but to also give substantial consideration to adjusting formulations and feeding strategy to minimize any negative environmental impact*. In many cases, a properly formulated ration that precisely meets the cow's requirements for milk production will also minimize excessive N, P and K excretion in the manure and urine.

How Much N, P and K are Excreted under Typical Conditions?

When manure management systems are designed, standard excretion amounts for N, P and K are often used. These values have been tabulated by the American Society of Agricultural Engineers and estimate the daily and yearly excretion of N, P and K based on the cow's body weight and also provide reasonably good estimates of nutrient excretion. However, these standard values do not account for the large variation among dairy farms in feed intake levels, rations fed, feeding programs and consequently nutrient excretion levels. Research conducted at the University of Florida showed N and P excretion by dairy cows varies substantially with level of N and P fed. In fact, the amount of N and P excreted daily can be reasonably predicted based on daily intake of N and P, dry matter intake and milk production. *Table I* shows the daily and yearly excretion of N, P and K by 1,400 pound Holstein cows. It is clear that the amount of N, P and K in the diet has a dramatic effect on the yearly excretion of these nutrients. For instance, increasing the amount of P from .40 to .60 percent of the ration dry matter increased excretion of P from 40 to 69 pounds/cow yearly. *Table II* illustrates how to calculate the amount of N or P produced by your milking herd.

Table I. Daily and Yearly Excretion of N, P, and K by 1400 Pound Holstein Dairy Cow.

	ASAE[1] Standard	**0-30 DIM[2]**	**31-100 DIM**	**101-305 DIM**	**60-day Dry Period**	**Yearly Total**
Milk, pounds/cow		100	70	50	Dry	21750 pounds
DMI[3], pounds/cow		46.3	39.2	25.2	25.2	14462 pounds
Pounds N excreted/day						pounds/cow/year
--Total N (low degradability)	.63	.89	.73	.60	.36	223
--Total N (high degradability)	.63	1.03	.85	.70	.44	260
Pounds P excreted/day						pounds/cow/year
--.40% P in diet	.132	.123	.115	.107	.101	40
--.45% P in diet	.132	.151	.138	.126	.103	46
--.60% P in diet	.132	.235	.208	.185	.151	69
Pounds K excreted/day						pounds/cow/year
--.80% K in diet	.406	.296	.265	.239	.201	88
--1.2% K in diet	.406	.519	.450	.396	.302	146

Source: Recycling manure nutrients to avoid environmental pollution. H. H. Van Horn. 1992. Page 640 *in* Large Dairy Herd Management. ADSA. Champaign, IL.
[1]American Society of Agricultural Engineers.
[2]Days in milk.
[3]Dry matter intake.

Table II. Example of Estimating the Nutrients in Your Herd's Manure.

	Number of animals (A)	**N Production per animal (B)**	**Total N production (A x B)**	**P production per animal (C)**	**Total P production (A x C)**
Milking herd	__________				
Low degradability N diet		223	__________		
High degradability N diet		260	__________		
.40% P in diet				40	__________
.45% P in diet				46	__________
.60% P in diet				69	__________

Phosphorus Requirements and Excretion

Since the 1960's, several researchers have examined P metabolism in the lactating dairy cow. In the most recent National Research Council (NRC) publication, P requirements were increased by 10 to 22 percent to adjust for dietary P availability. Phosphorus can be supplemented by adding monocalcium or dicalcium phosphate, monosodium phosphate, ammonium phosphate (*high availability*); steamed bone meal, defluorinated phosphate, sodium tripolyphosphate (*medium availability*); or low fluorine rock phosphate, soft rock phosphate (*low availability*). Most commercial premixes contain phosphorus and must be properly incorporated into the diet. Phytate-P is readily available to ruminants such as dairy cattle. Over 99 percent of P bound to phytate was released from wheat middlings, hominy, soybean meal, corn distillers grains and cottonseed meal during rumen fermentation of the feedstuff. Therefore, do not over-supplement P above recommendations in a mistaken attempt to compensate for phytates.

Phosphorus is the most expensive nutrient in typical mineral-vitamin formulations for dairy cattle. For example, feeding a ration containing .45 percent P versus one containing .55 percent P would save about $.05/cow/day. For 100 cows over a year's time, it would save about $1,825.

Dry cows require only .25 percent P in the ration dry matter. A 1,300 pound milk cow, however, requires about 17 grams of P daily for maintenance plus .90 grams per every one pound of daily milk production. For example, a 1,300-pound cow producing 85 pounds of milk requires about 94 grams of P daily. Signs of P deficiency include inactive ovaries and lack of estrus behavior. Cows may eat wood or dirt or drink urine. Over-supplementation of P generally will not impair performance--the maximum tolerable level is 1.0 percent of the ration dry matter. However, dry cow health may be impaired when excessive P is fed during the dry period. Over supplementation of P also leads to increased environmental risks.

Excretion estimates of P in *Table I* show a dietary P of .40, .45 or .60 percent results in estimated annual excretion of P of 40 to 46 to 69 pounds per cow. Clearly, a dairy producer has considerable control over mineral excretion in the manure by manipulating the amount of mineral in the feed. Feeding adequate P is important for cow performance and health, but .40 to .45 percent of the dietary dry matter may be near to optimal levels for lactating dairy cows. For a cow producing 100 to 120 pounds of milk daily, a diet containing .45 percent P meets the NRC recommendation. However, the same dietary P level provides about 140 percent of the daily P requirements for a cow only producing 40 to 50 pounds of milk. *From this, we can determine that multiple rations must be formulated over the complete lactation cycle to minimize P excretion into the environment.* This is hardly an earth-shattering statement. **Remember: the goal is to keep excretion of N, P and K as low as possible while maintaining optimum dairy cow performance**.

Potassium Requirements and Excretion

The dairy cow's minimum requirement for K is .90 to 1.0 percent of the ration dry matter. The maximum tolerable level is about 3.0 percent. In the late 1970's, Michigan researchers found 1.2 percent K was associated with optimum feed intake, milk yield and normal blood K levels. Because more K is lost through sweat and saliva, supplemental K can help to alleviate symptoms of heat stress. Research results have been variable, but increasing dietary K levels to 1.5 or 1.6 percent of ration dry matter during periods of heat stress may be beneficial to the cow. Signs of K deficiency include poor response to heat stress, crampiness when rising from free stalls, poor growth in young animals and drinking of urine. Excessive K intake can lead to udder edema in fresh cows, greater incidence of retained placenta and greater risk of displaced abomasum (DA).

Potassium supplementation is seldom needed because most forages contain high concentrations of K. For example, in Nebraska, alfalfa routinely tests over 3.0 percent K on a dry basis! The NRC lists the K content of alfalfa at 2.2 percent, so relying on book values can result in substantial overfeeding of K. In some instances, however, high corn silage diets will need some K supplementation. Good sources of K include potassium chloride and commercial premixes. High K rations may increase the need for Mg supplementation. Excessive K intake decreases Mg absorption, decreases feed intake and milk production, increases water intake and increases urine output. *High levels of dietary K during the dry period can predispose the fresh cow to milk fever, DAs, uterine problems and other metabolic disorders*. Try to keep K levels during the dry period to less than .65 to .70 percent. If the ration is high in K due to high forage content, there is little the producer can do in the short term. The only long-term solution would be to lower the K level in the forages. In the case of K, forages take up far more than needed for maximum dry matter yields per acre. Plant levels of 2.0 to 3.0 percent are adequate for plant growth, but 6.0 percent K in grass silage has been reported. **Excessive feeding of K puts substantially more K into the environment than necessary. As shown in *Table I,* increasing K content of the diet from .80 to 1.2 percent of ration dry matter increases K output from 88 to 146 pounds/cow annually**.

Nitrogen Requirements, Feeding Strategies, and Excretion

Table I illustrates the N excretion from two different diet formulation approaches. One diet is high in degradable intake protein (DIP), whereas the other diet is lower in DIP, while meeting the overall protein requirement of the cow with higher levels of undegraded protein (UIP, or "bypass" protein). When cows were more precisely fed to meet UIP and DIP requirements, they excreted 223 pounds of N per year. When cows were fed simply to meet their crude protein requirement, however, they excreted 260 pounds of N per year. So, as with P, considerable dietary control of nutrient excretion is possible.

The dairy cow excretes N via milk, urine and manure. Milk N represents about 30 percent of total N intake, manure N from 30 to 40 percent and urinary N about 20 to 40 percent. In terms of amount of N excreted daily, urinary N appears to increase more than manure N with higher N intakes. Excessive intakes of dietary N can be monitored by either blood urea N (BUN) or by milk urea N (MUN). A BUN level in excess of 18 to 20 mg/dl or a MUN level in excess of 16 mg/dl can be associated with lower reproductive performance, higher feed costs, health problems and poorer milk production. *A clear relationship between BUN and conception rate does not presently exist, but high BUN values do indicate potential problems*. Also, high BUN and MUN values indicate that more N is being excreted into the environment which can lead to water quality and other environmental problems. For more information on milk urea nitrogen testing and interpretation of results, read *NebGuide G96-1298, Milk Urea Nitrogen Testing*.

Many dairy producers overfeed crude protein (i.e. nitrogen), resulting in excessively high output of N in both urine and manure. Crude protein is often fed at levels to support 20,000 pounds of milk or more, even when actual milk production of the herd is substantially less. This practice is not only expensive, but also can have a negative effect on the environment. The challenge to dairy producers, nutritionists and veterinarians is to formulate diets that meet the cow's protein requirements but also minimize N excretion. **Remember: milk yield does not need to be sacrificed to minimize N excretion into the environment**. The following feeding strategies suggest ways to control N excretion. The first major goal is to minimize purchased feed N inputs; the second is to improve the efficiency of N use by the dairy cow.

Increase Dry Matter Intake. The crude protein percentage required in the ration to provide an absolute amount of protein to support milk production varies with intake level. A 5.0 percent intake increase reduces the CP needed by about 1.0 percent. So, more CP could come from home-grown feeds, decreasing the amount of purchased feed required. Also, increasing intake level increases microbial protein synthesis which would decrease the need for dietary protein.

Improve Forage Quality. Higher quality forage contains more protein, less fiber and more energy so, it can provide more protein and dry matter to the ration. This will reduce reliance on purchased protein sources. When purchased N inputs are minimized, the degree of N introduced into the environment from sources outside the farm will be reduced.

Consider Forage Protein Fractions. Supplement highly degradable forage protein with less degradable sources of protein. Often, this will result in improved milk production at lower crude protein levels in the diet.

Consider Feeding Method. Method of feeding can alter N utilization. Feeding sequence, feeding frequency and grouping strategy all influence how the cow uses dietary N. Synchronizing the delivery of rumen degradable protein and carbohydrate can increase efficiency of N use by the cow and decrease N excretion. Grouping is especially important to avoid over-supplementing N and other nutrients. A one-group TMR may be easier to manage, but a multiple grouping approach will do a better job of minimizing protein overfeeding, decreasing N excretion and lowering feed costs.

Consider Supplemental Protein Source. Use protein supplements to allow the cow's degradable and undegradable protein requirements to be met without overfeeding crude protein. In the future we will place more emphasis on the amino acid content of various protein sources. Ultimately, an imbalance of amino acids available to the cow for digestion and metabolism will impair milk and milk protein production.

The Bottom Line:
Can I feed for High Milk Yield and Minimal Nutrient Excretion?
(Can I Make Everybody Happy?)

These feeding strategies provide a starting point for formulating diets to minimize nutrient excretion into the environment and yet still meet the requirements for high levels of milk production. As computer programs become more sophisticated, and as our knowledge of cow's nutrient requirements become more precise, we will be able to do a better job of feeding cows for high levels of performance without simply overfeeding major nutrients. Computer programs, such as the Cornell Net Carbohydrate and Protein model allow nutritionists to accurately formulate diets that meet, without exceeding the cow's nutrient requirements and provide nutrients in the proper ratios and amounts for most efficient use by the cow. The answer is, "Yes, you can feed for high performance and still minimize any negative impact of nutrient excretion on the environment." Ensuring cow comfort, maximizing intake, testing all forages and major feed ingredients, properly formulating rations, soil tests and proper soil fertilization will all lead to a more environmentally sound feeding program. **Properly formulated rations will not only support high production levels, but will also minimize nutrient excretion into the environment**.

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