HOW DAIRY DIET AFFECTS NITROGEN EXCRETION
IN MANURE AND CYCLING IN SOILS

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Introduction

The sustainability of dairy farms will depend increasingly not only on profitable milk production but also on farmers’ ability to comply with nutrient management regulations. Over the past few years, policy has focused predominately on ways to reduce phosphorus build up in soils, runoff, and the pollution of lakes, streams and other surface water bodies. The next generation of policy, however, will focus more strongly on nitrogen (N), particularly the reduction of ammonia emissions from animal feeding operations.

A recent report by the National Research Council (NRC, 2002), “Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs” cited ammonia as the most important emission from animal feeding operations. Ammonia loss to the atmosphere was ranked as having a major detrimental impact on air quality at regional, national and global scales. This loss of N from dairy and other livestock operations in the Midwest is thought to contribute significantly to excessive N loading of the Mississippi River and hypoxia (the “Dead Zone”) in the Gulf of Mexico (Burkart and James, 1999).

Most efforts to improve nutrient management on dairy farms have focused on “rear-end approaches”, such as manure handling, storage and land application. These neglect the effects of feeding practices on overall nutrient utilization on a whole-farm basis. Current policy guidelines related to nutrient management consider feed management only as a planning consideration, not as a technical standard. Feed management, however, may be the most critical element that controls nutrient build-up and loss from dairy farms. This paper provides an overview of N cycling on dairy farms and shows how diets can be manipulated to support high levels of milk production, and at the same time, produce excreta that is less susceptible to nutrient losses.

Nitrogen Excretion by Dairy Cows

Dairy cows typically convert 25 to 30% of feed N to milk N (Panel 11). Current ration formulation on many farms, however, results in much lower N conversion rates (Panel 12). Nitrogen not secreted in milk is excreted in urine and feces.

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The annual amount of N excreted by lactating cows, dry cows, and growing/replacement heifers is approximately 19.8, 16.3, and 8.6 lb N/100 lb body weight (Wilkerson et al., 1997). Nitrogen excretion can be divided into three pools: 1) urinary N, 2) fecal endogenous N of microbial and gut origin and 3) fecal undigested feed N (Mason and Frederiksen, 1979; Panel 15). Total N excretion, and the forms of N excreted are highly influenced by the amount and types of protein and energy fed, feeding method, and animal age and physiological state.

Cycling of Manure N in Soils

Of the total N excreted by a dairy cow, only 7 to 15% may actually be recycled through crops. Improving N recycling on dairy farms, particularly in the feed component would improve profitability, reduce ammonia emissions and reduce negative environmental impacts.

Each pool of excreted N has a different propensity for loss in the environment. Upon excretion, urea N (approx. 90 to 95% of total urine N) is rapidly hydrolyzed by the enzyme urease found in the feces, and is liable to be lost as ammonia to the atmosphere. Fecal endogenous N (60 to 80% of total N in feces) mineralizes quickly in soils to ammonium and nitrate and is readily available to plants. Undigested feed N in feces, however, mineralizes at a slower rate and is consequently more stable in soils.

Losses of N via ammonia volatilization may be reduced by partially shifting the excretion of N from urine to feces through diet manipulation, without sacrificing animal health or production. In addition, a shift from fecal endogenous-N (NDSN) to fecal undigested feed-N (NDIN) may allow manure N to mineralize in a pattern that corresponds more closely with crop N demand, and also enhance carbon sequestration in soils (Panel 16).

Improving Feed N Use

To reduce N excretion in urine, farmers need to know how much protein is being fed. They can dilute hay silage with corn silage; feed grains that are processed to improve rumen digestion (e.g., rolling of high moisture corn); balance Rumen Degraded Protein (RDP) & Rumen Undegraded Protein (RUP) in the diet; and feed to precisely meet animals’ requirements (Glen Broderick, USDFRC, personnel communication).

Typically, dairy nutrition research has been directed toward maximizing milk and protein yields with little or no concern for overall N efficiency or the chemical forms of excreted N. Little research has been conducted with modern high-producing dairy cows to define the response curve for milk production, protein yield and N excretions in feces and urine as a function of dietary CP level or source. Defining these responses more clearly would provide farmers, nutritional consultants, and policy makers with quantitative information about amounts of milk and protein yield that would be
sacrificed (if any) to achieve alternative targets, such as reduced manure N excretion or diversion of greater proportions of excreta N to more stable fecal versus urinary forms.

Other Related Topics

**Dairy Whole-farm Nutrient Management: The Diet Connection** is an educational slide series under development by the Nutrient and Pest Management Program, College of Agricultural and Life Sciences, University of Wisconsin-Madison. This series (some of which are presented in Panels 17 to 20) will soon be available. For more information, contact Leah-Nell Adams, Dairy Systems Outreach Specialist at (608) 265-2379.

**Enhanced Integrated Nutrient Management on Dairy Farms**, a six-part seminar series held during the winter of 2001-02, brought together researchers, students, extension professionals, federal and state agency representatives, and feed and fertilizer consultants to address issues related to dietary practices; manure handling, storage and land application; land use; and outreach. An educational CD (Panel 21) and website (http://dfrc.wisc.edu/powell/) are available that include seminar presentations and synopsis of speaker, panel and audience discussions. To obtain a copy of the CD, contact Leah-Nell Adams, Dairy Systems Outreach Specialist at (608) 265-2379.

**On Farmers’ Ground** is a project with Wisconsin dairy farmers to better understand the biophysical (climate, soil, crops) and socioeconomic factors affecting nutrient flow and losses from their farms (Panel 22). The study has been designed to expand our understanding of (1) what kinds of nutrient management practices Wisconsin dairy farmers are using, (2) opportunities and obstacles dairy farmers face in managing agricultural nutrients, and (3) innovative solutions that farmers have created and/or are available to meet nutrient management challenges. For more information contact Dan McCrory at (608) 264-5146.

References


