Researching Ways to Improve Nitrogen-Use Efficiency on Dairies Through the Use of Condensed Tannin-Containing Forages

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A high proportion of protein in forages is often degraded to non-protein nitrogen (NPN) during ensiling and ruminal digestion in livestock, and this reduces the nitrogen use efficiency (NUE) of dairy farms. Identifying methods to conserve protein during these processes would improve the profitability and lessen the environmental impact of dairy farms.

Scientists at the U.S. Dairy Forage Research Center (USDFRC) and elsewhere are examining how condensed tannins (CTs) can be used to improve the NUE of dairy farms. CTs are a class of polyphenol compounds produced by some plants having a natural ability to bind proteins. CTs are found in forages such as birdsfoot trefoil, big trefoil, sainfoin, crownvetch, and lespedeza. Numerous studies have shown the following benefits of CT in forages:

Reduced NPN Formation during Ensiling

Losses of protein during ensiling of CT-free forages like alfalfa can range from 44-87% depending on the type of forage and the ensiling method. Although a portion of this NPN can be converted to nutritionally valuable microbial protein in the rumen, excessive levels are converted to urea and excreted in urine. The binding of CT to forage proteins helps to protect protein from degradation during the ensiling process.

Elevated Flow of Rumen Undegraded Protein to the Hindgut

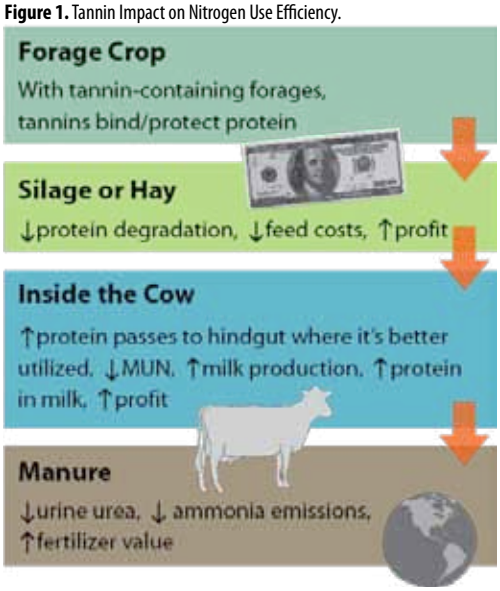
Modest amounts of CT (2-3% of dry matter) in forage often increase the amount of protein escaping the rumen into the hindgut, resulting in a boost in milk production and weight gain of livestock. Excessive amounts of CT can, however, adversely affect livestock production by depressing the intake of feed and the digestion of protein and utilization of other nutrients.

Through the use of CT-containing forages, significant impact on dairy farm incomes and NUE are likely. For example, estimates generated by the Integrated Farm System model indicate the production and feeding of an alfalfa containing modest amounts of CT would increase profits of U.S. dairy farms by at least $300 million per year and reduce nitrogen losses by up to 25%.

Current Focus of USDFRC Research…

Although CT can enhance the productivity of livestock, further research is needed to determine the optimal characteristics of CT (i.e., concentration and chemical composition/structure) needed for maximizing livestock productivity and overall NUE of dairy farms. To accomplish this, scientists at the USDFRC and other institutions are working on the following projects:

Figure 1. Tannin Impact on Nitrogen Use Efficiency.



Develop More Accurate, Routine Methods for Measuring CTs and Their Effect on Protein Digestibility

Scientists at USDFRC and the University of Reading in the United Kingdom are working to improve the accuracy of the widely-used butanol-HCl assay for measuring CT concentrations in forages. Other work is aimed at evaluating and improving laboratory assays for predicting ruminal and gastrointestinal degradable protein in CT-containing forages. Widespread use of these assays will ensure that diets are optimally formulated to make best use of CT-containing forages.

Identify Optimal CT Characteristics for Forages

USDFRC scientists, in collaboration with scientists at the University of Reading, have developed techniques to purify a wide variety of CTs from forages such as birdsfoot trefoil, big trefoil, sainfoin, crownvetch, white clover, and lespedeza. Powerful analytical techniques such as "nuclear magnetic resonance" and "thiolysis" are being used to characterize the composition and structure of isolated CTs. These CTs are being used in various laboratory assays to identify the optimal characteristics of CT for limiting NPN formation during ensiling and ruminal digestion while permitting extensive digestion of forage protein in the gastrointestinal tract.

Reduce Nitrogen Loss from Farms

Forage CT or commercial CT products added to diets of dairy cows can reduce urea excretion in urine and inhibit the enzyme urease, which is responsible for the conversion of urea to ammonia. Scientists at USDFRC and the University of Wisconsin-Madison have found that CT-containing diets reduce ammonia loss from dairy barn floors and from soils after manure slurry application. Other studies have or will examine whether CT can enhance the utilization of nitrogen in crop rotations.

Developing or Improving CT-Containing Forage Crops

USDFRC scientists will work with Forage Genetics International to characterize alfalfa that has been bioengineered to produce CT in its forage. USDFRC scientists are also using traditional breeding methods to improve birdsfoot trefoil for use on conventional or organic grazing-based farms. Best management practices will be identified to help ensure that farmers can reliably grow and feed high quality CT-containing forages to livestock and reach optimal production levels and NUE.

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